clasp Efficient Appliances for People & the Planet

Market Assessment Report on Residential Refrigerators and Distribution Transformers in Botswana.

28 JUNE 2020

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United Nations Nations Unies

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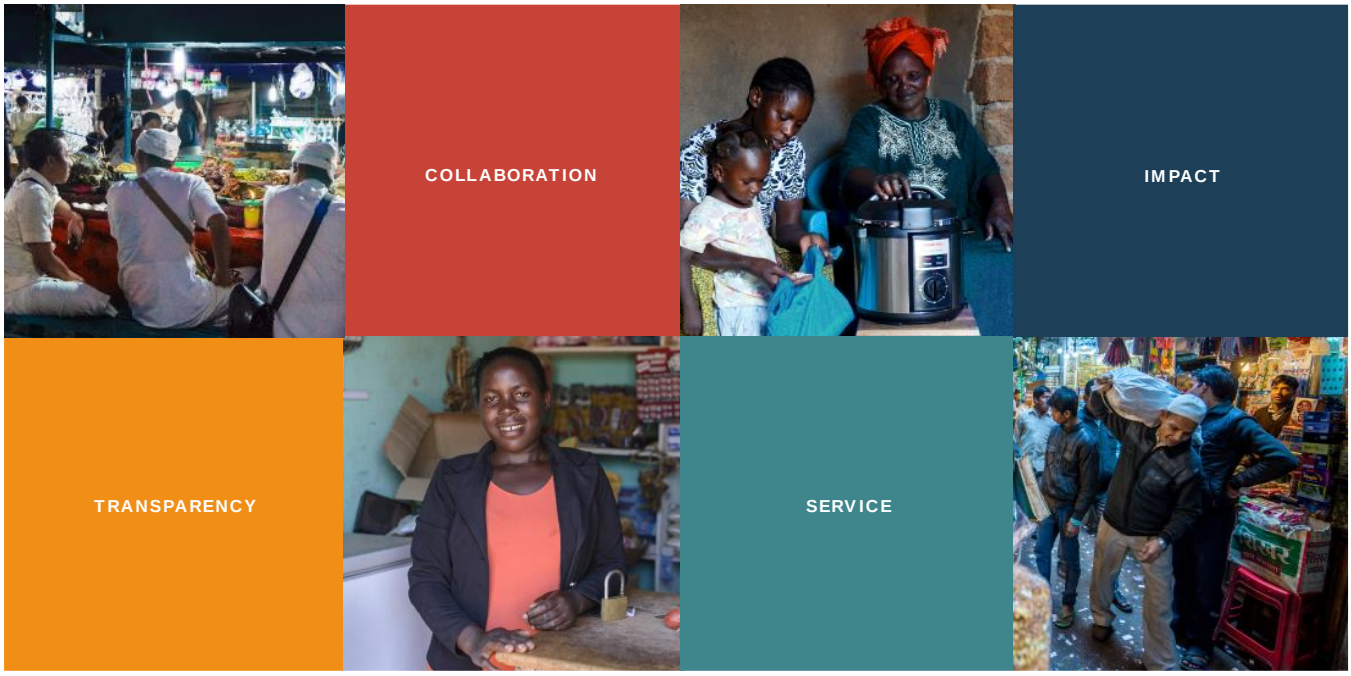

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Abbreviations & Acronyms

BAU	Business As usual
BCET	Botswana College of Engineering Technology
BERA	Botswana Energy Regulatory Authority
BEST	Biomass Energy Strategy
BOBS	Botswana Bureau of Standards
BIH	Botswana Innovation Hub
BITRI	Botswana Institute of Technology Research & Innovation
BUIST	Botswana International University of science and Technology
BPC	Botswana Power Corporation
CAGR	Compounded annual growth rate
CFL	Compact Fluorescent Lamp
DEA	Department of Environmental Affairs
DOE	Department of Energy
ESCO	Energy Services Company
EEDSM	Energy Efficiency and Demand Side Management
GEF	Global Environmental Facility
GHG	Green House Gas
GWh	Gigawatt hour
MEPS	Minimum Energy Performance Standard
MMEWR	Ministry of Minerals, Energy and Water Resources
MWh	Megawatt hour
MT	Metric Tonnes
NDC	National Determined Contributions
NDP	National Development Plan
NEES	National Energy Strategy
NEP	National Energy Policy
SACU	Southern African Customs Union
SADC	Southern African Development Community
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
SWH	Solar Water Heaters
UB	University of Botswana
U4E	United for Efficiency
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industry Development Organisation

Executive Summary

The electrification rate in Botswana is among the highest in Sub-Sahara Africa with 60.7% of the population having access to electricity [1](77.7% of the urban population while only 37.5% of the rural population) in 2016. According to the National Energy Efficiency Strategy (NEES) published in January 2018, priorities include rural electrification and energy efficiency. Furthermore, and similar to other countries in Sub-Saharan Africa, the Botswana economy is poised to grow and temperatures are also expected to rise due to climate change, in addition to the need of refrigerating essential daily items such as milk, vegetables, and meat. These will result in more people seeking comfort in cooling as they will have the economic capacity and access to electricity necessary to purchase and run refrigerating appliances. Adoption of energy efficiency policies for refrigerating appliances can significantly reduce electricity use, CO2 emissions and the operating energy cost for consumers. In addition, to the government's plans to increase electricity access, adopting higher efficiency distribution transformers (DTs) is critical since their typical lifetime is over 30years. Distribution transformers are typically responsible for 30% of distribution losses in Botswana, hence the need for regulation, to reduce the energy losses.

This project (Developing a national framework for leapfrogging to energy-efficient refrigerators and Distribution transformers) supports the development of minimum energy performance standards (MEPS) and labels for refrigerators and distribution transformers. It creates an enabling policy and regulatory environment that will catalyze market transformation to efficient refrigerators and DTs. CLASP received a grant for this project under Climate Technology Centre and Network (CTCN) through the United Nations Environment Programme (UNEP). CLASP, in collaboration with Green Issues Botswana (GIB), a local partner, conducted a comprehensive characterization of the refrigerating appliance and transformers market in Botswana. Green Issues Botswana collected product data from 359 households, 34 retailers, and 2 distributors for refrigerating appliances and 10 models for transformers. To complement the field data, they conducted in-person interviews with supply chain actors and reviewed secondary literature to gather data on the energy sector, refrigerating and transformer market size, sales, and usage. CLASP analyzed various policy scenarios (15% above business as usual and U4E reg model for refrigerators), and estimated potential energy savings, avoided emissions at the national level, and lifecycle costs (LCC) savings for end-users. This refrigerating appliance and distribution transformers market assessment and policy analysis provides the technical evidence to support the establishment of MEPS in Botswana.

KEY FINDINGS

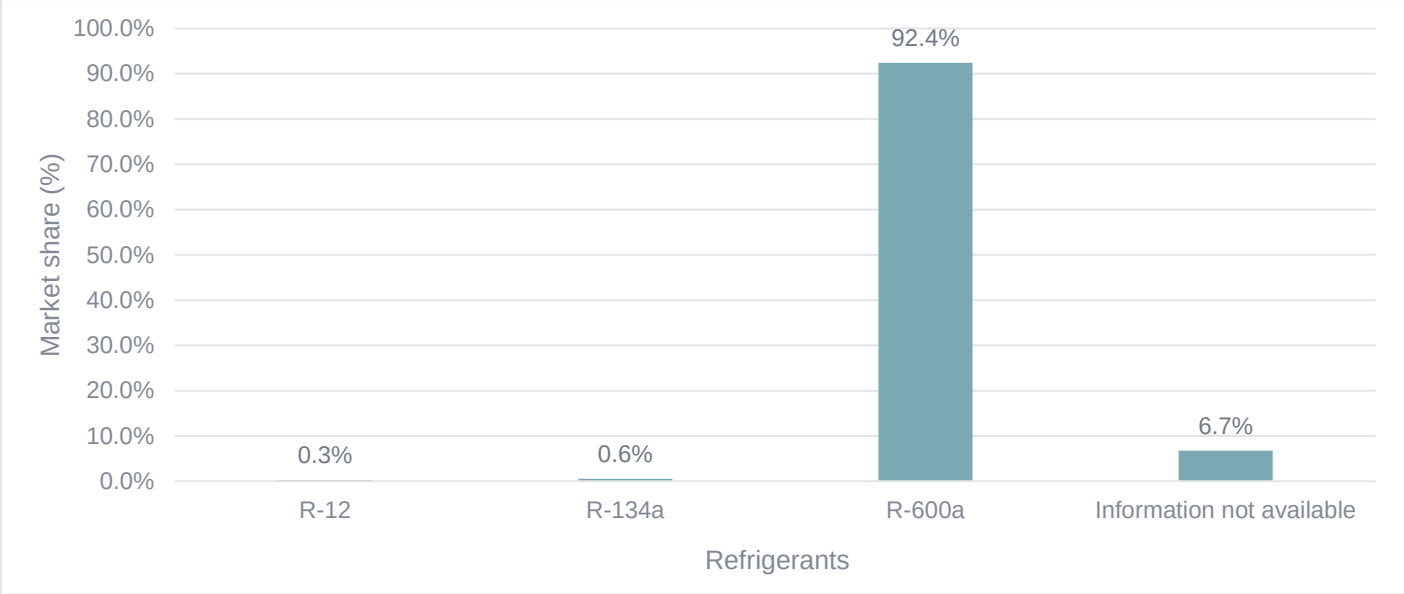
REFRIGERATING APPLIANCES

The refrigerating appliance market in Botswana is completely import-based. Imports from South Africa make up the largest share of units imported into the country (up to 99%) with some units coming from other countries such as China and Eswatini. The Botswana refrigerating market is estimated to be 100,000 annually as of 2020 based on import data. The five major brands are Defy, Hisense, KIC, Kelvinator and Russell Hobbs.

R-134a refrigerants are phased out in the market. The refrigerator current market mostly uses R-600a refrigerants. The project team found very few models that had R-134a and just one model that had R-12 refrigerant. However, in some instances the refrigerants were not declared on the appliances (Figure 1)

[1] Sustainable energy for all Africa

FIGURE 1:FIGURE 1: MARKET SHARE OF REFRIGERANT USED. N=357

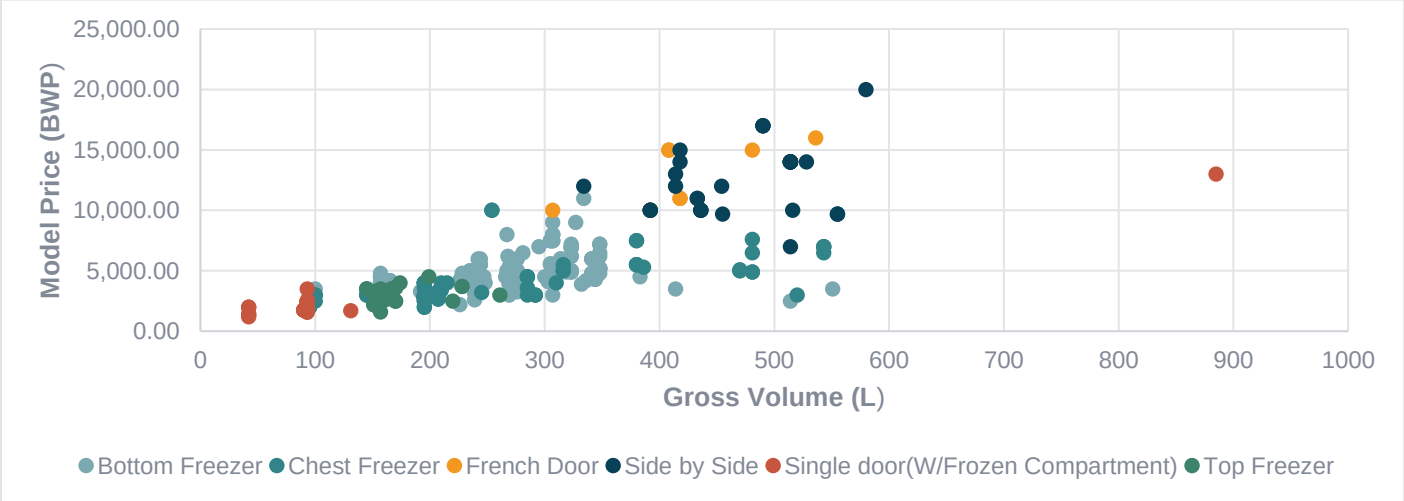


Bottom Freezer and Chest Freezer are more consistently popular in the market. While the other door types exist in the market, bottom freezers represent the largest market share (44.5%) followed by the chest freezers (24.1%).

Automatic ice makers were very scarce in the current domestic market in Botswana. Just a handful were observed in the bottom freezers, French door, side by side and top freezers. Out of the 22 Automatic ice marker that existed in the market segmentation, 12 were found in the side by side refrigerator-freezer.

Mostly, the price of refrigerators (all categories considered) is proportional to the gross volume. Figure 2 below shows the prices verses the volume for different door types.

FIGURE 2: PRICE OF REFRIGERATING APPLIANCES



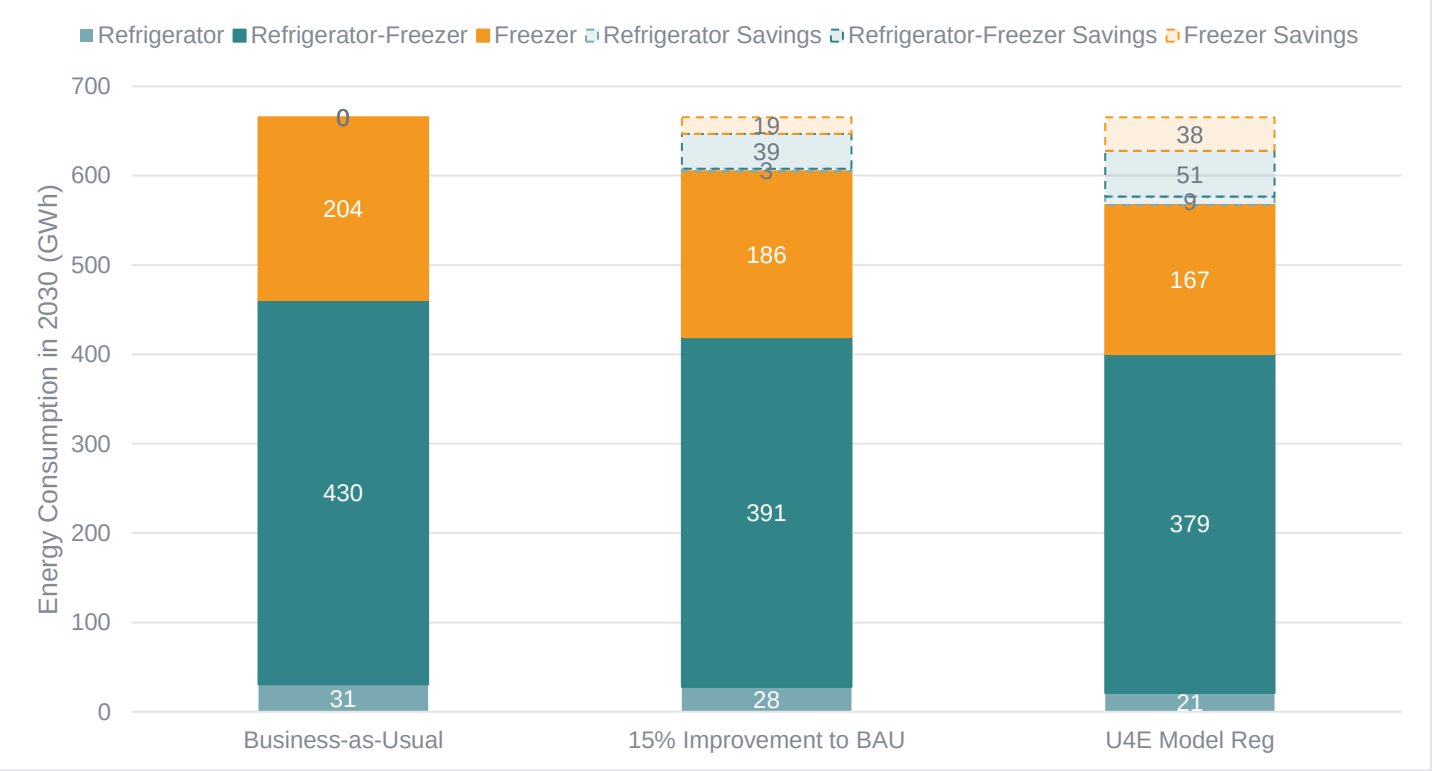
Botswana does not have Minimum Energy Performance Standards (MEPS). The labels on some of the appliances were majorly from South Africa. The typical volume, typical energy consumption, and typical price for each refrigerating type in the current market was as shown below in figure 3 below.

FIGURE 3: TYPICAL CURRENT MARKET IN BOTSWANA

Type	Defrosting Technology	Typical Total Volume (liters)	Energy consumption at typical volume (kWh/year)	Average price of models meeting both criteria (BWP)
Single door (w/frozen compartment)	Manual	90	281.5	1,816
Single door (w/frozen compartment)	Auto	93	199	2,351
Bottom Freezer	Manual	286	313.5	5,099
Top Freezer	Manual	161	193	2,721
Bottom Freezer	Auto	269	332	4,676
Top Freezer	Auto	161	254	2,850
French Door	Auto	418	329.5	12,999
Side by Side	Auto	514	411	13,299
Chest Freezer	Manual	210	387	2,993
Chest Freezer	Auto	95	220	2,385

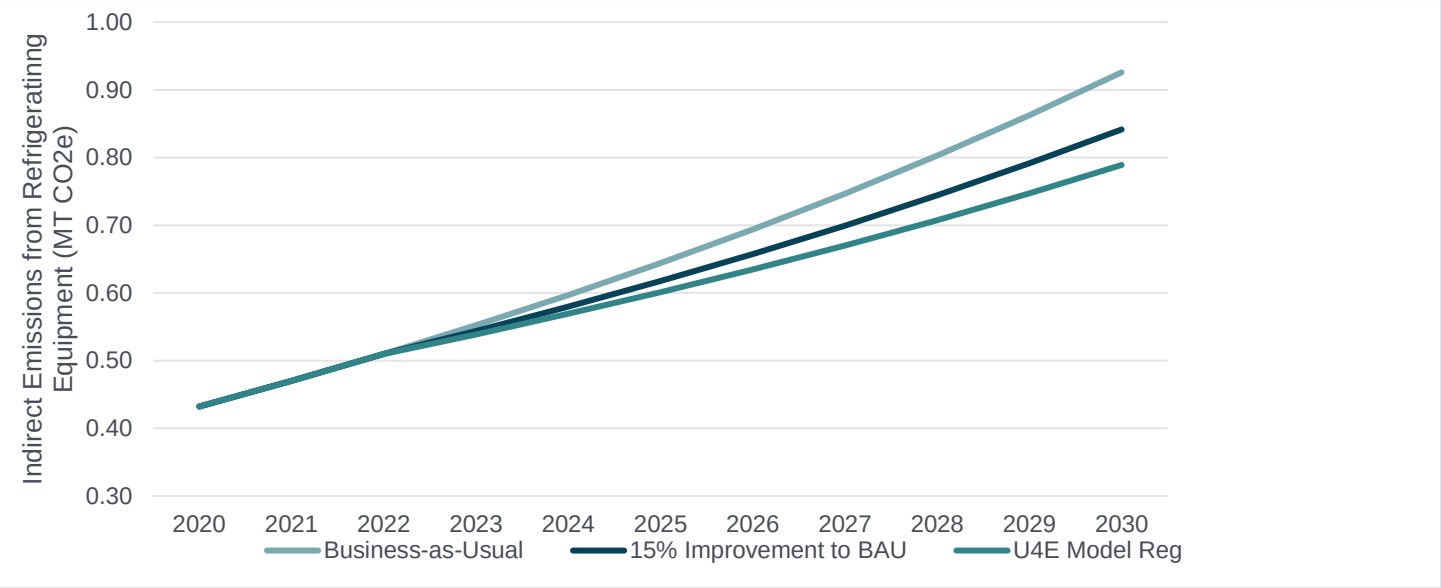
The large number of refrigerating appliances in Botswana will result in significant energy and CO2 benefits to the nation when modelled under 15% improvement to the business as usual or the U4E model. Figure 4 below shows the energy consumption and energy consumption savings over the decade (2020-2030).

FIGURE 4: ENERGY CONSUMPTION UNDER DIFFERENT SCENARIOS



Cumulative CO2 Emissions Savings through 2030 (MT) for 15% Improvement to BAU and U4E Model Regulations is 0.35MT and 0.57MT respectively.

FIGURE 5: CO2 EMISSIONS FROM REFRIGERATING APPLIANCES THROUGH 2030



DISTRIBUTION TRANSFORMERS

To be populated

1.INTRODUCTION

1.1. BACKGROUND AND INTRODUCTION

The project 'Leapfrogging to Energy Efficient Appliances and Equipment in Botswana (Refrigerators and Distribution Transformers)' through regulatory and financing mechanisms will result in Botswana having a regulatory framework, agreed MEPS and labelling scheme for Refrigerators and Distribution transformers. CLASP was contracted by UNEP through the Climate Technology Centre and Network to implement this initiative. The main objectives of this project are to:

1. Develop mandatory minimum energy performance standards and labeling schemes
2. Create a national policy roadmap and enabling environment for the implementation of standards and labels
3. Propose appropriate financing mechanisms to accelerate deployment of energy efficient refrigerators and distribution transformers; and
4. Strengthen the national capacity to develop standards and labels for other appliances in future.

Electrification rate in Botswana is among the highest in Sub-Sahara Africa with 60.7% of the population having access to electricity [2](77.7% of the urban population while only 37.5% of the rural population). According to the National Energy Efficiency Strategy (NEES) published in January 2018, priorities include rural electrification and energy efficiency. Furthermore, and similar to other countries in Sub-Saharan Africa, the Botswana economy is poised to grow and temperatures are also expected to rise due to climate change, in addition to the need of refrigerating essential daily items such as milk, vegetables, and meat. These will result in more people seeking comfort in cooling as they will have the economic capacity and access to electricity necessary to purchase and run refrigerating appliances.

Adoption of energy efficiency policies for refrigerating appliances can significantly reduce electricity use and CO_2 emissions as well as reduce the operating energy cost for consumers. In addition, to the government's plan to increase electricity access, adopting higher efficiency DTs is critical, since their typical lifetime is over 30 years. Distribution transformers are typically responsible for 30% of distribution losses in Botswana, hence the need to regulate, to reduce the energy losses.

This market assessment and policy analysis provides a comprehensive characterization of the refrigerating appliances and transformer market in Botswana and the technical evidence necessary to support the development of minimum energy performance standards (MEPS) for these products. It defines Botswana's efficiency baseline for refrigerators and transformers and evaluate impacts from various policy scenarios at the national level and to consumers. Government agencies can use this information to quantify potential energy and greenhouse gas (GHG) emissions savings in support of national energy efficiency targets commitments.

CLASP worked with its local implementation partner, Green Issues Botswana, to conduct this work. Green Issue Botswana with its enumerators collected product-level data during in-person and virtual interactions with retail stores and households, conducted a review of government reports and reached out to relevant stakeholders, such as manufacturers, importers, mines and representatives from government agencies. The market assessment includes a detailed account of the refrigerating appliances and transformers market size, product characteristics, and the energy sector. CLASP did the analysis of the products characteristics and the market. In addition, CLASP defined the current efficiency baseline and estimated potential energy savings and avoided emissions at the national level, and lifecycle cost savings for consumers from various policy scenarios.

The report is divided into two parts: *Market Assessment on Residential Refrigerating Appliances and Market Assessment on Transformers*

- **Section 1 .1 through 1.3** provides an introduction, background and objectives for the project and describes the approach including the scope, key activities and an overview of the country.
- **Section 2.1 through 2.6** provides information on the refrigerators supply chain, households, equipment's stock and projections, policies and program landscape for refrigerators, financing, and, embedding and dependencies of national markets.
- **Section 3.1 to 3.7** provides information on the transformer supply, demand, equipment stock and projections, Policies and program landscape for transformers, utilities procurement specification, financing, and, embedding and dependencies of national markets.
- **Section 3.8** concludes with the summary of the report.

[2] Source: Sustainable energy for all Africa

1.2. METHODOLOGY AND APPROACH

1.2.1. OBJECTIVE AND SCOPE

The main objective of the assessment was to understand the market size, types, characteristics, and energy performance of refrigerating appliances and distribution transformers available on the market to enable design appropriate appliance efficiency policies for refrigerators and DTs. Further, with that understanding, it is possible to make the case for setting the MEPs and High Efficiency Performance Standards (HEPS) at levels that are economically justifiable.

Green Issues Botswana conducted on-the-ground data collection activities, providing insights on the refrigerating appliances and transformers market, while CLASP analyzed the data therefore establishing the baseline technical parameters and characteristics of refrigerating appliances and DTs. The approaches used to gather quantitative and qualitative data and information on refrigerating appliances and transformers included desk research, stakeholder interviews, and field surveys. The type of data collected includes:

- Key stakeholders, sources of refrigerating appliances and transformers, and supply chain;
- Refrigerating appliances and transformers market size and characteristics;
- Refrigerating appliances and transformer types, capacities, and performance;
- Costs associated with transformer purchase, installation, operation and maintenance
- Cost associated with refrigerating appliances purchase, operation and maintenance
- Energy sector and other economic data for evaluating energy, environmental, and economic impacts of Refrigerating appliances utilization in Botswana.

1.2.2. EXISTING INFORMATION SOURCES AND GAPS

For refrigerators, data was gathered from households, distributors, retailers and government sources. Project team gathered information from 359 households, 34 retailers 2 distributors. Four government officers also responded to the questionnaires sent to them.

Transformer data is only available at the Botswana Power Corporation. Data on numbers and ratings of all DTs bought since 2018 was readily available. However, the team had challenges obtaining important data such as coil and core losses, model numbers for different types of transformers. End users proved to be hard to be obtained from the utility and the mines. The little data available has been extrapolated to the transformer population and will be improved as more data on losses becomes available.

1.2.3. INFORMATION GATHERING METHODOLOGY, MARKET SEGMENTATION & SAMPLE SELECTION ANALYSIS.

To gain understanding of the refrigerating market in Botswana, the local team interviewed the refrigerating dealers, retailers and households. The survey was conducted in major Botswana cities and Districts. These include Gaborone, Francistown, Maun, Serowe, Molepolole, Mochudi, Palapye, Lobatse, Mahalapye, Bobonong and Selebi Phikwe.

To gain understanding of the transformers market in Botswana, the team interviewed the Botswana Power Corporation and the mines. The project team gathered information on 10 DT models.

The approaches used to gather quantitative and qualitative data and information on refrigerating appliances and transformers included desk research, virtual and physical stakeholder interviews and field surveys.

Desk research

A literature review, including reports from Government Agencies and state corporations, and importation statistics from Comtrade UN data provided information related to market size.

Stakeholder interviews

Botswana does not manufacture refrigerating appliances or transformers so the local team conducted stakeholder interviews with the local representative offices of manufacturers and brand owners, importers, dealers and mines. The team from Green Issues Botswana asked stakeholders to indicate or estimate the market share of their refrigerating appliances and transformers to provide annual turnover. Comtrade data UN importation statistics were used to validate data obtained from dealers, importers and governments.
Green Issues Botswana also conducted interviews with the Botswana Power Cooperation on transformers. They collected information on purchase price, models, end users and losses.

Field surveys

The local team visited refrigerator distributors/dealers, retailers and household consumers to gather information on brands available on the market, including refrigerating appliance characteristics and prices. For most products, comprehensive technical data is provided on the product nameplates and, where labeled, on the energy labels. Hence, during the field survey, manufacturer/brand name, model numbers, refrigerating appliance type, defrost technology type, energy consumptions, labels and efficiency labels, volume, refrigerant types, voltage, climate class, country of origin were obtained from product nameplates displayed. In a few cases, model numbers and brands were searched on manufacturer's websites and online shops to verify technical information.

Besides collecting the technical information on refrigerating appliances available for sale and in households, the local team also collected, respondents' details, family size, house size, average electricity bill per month, number of refrigerating appliances owned, average annual income, efficiency labeling awareness, willingness to pay an extra cost to get an efficient appliance, registered financial institutions, experience with loans, mode of last purchase and influence on purchasing decisions.

1.3. OVERVIEW OF THE COUNTRY

1.3.1. SOCIO-ECONOMIC SITUATION.

The Republic of Botswana is a large, landlocked plateau in the center of the southern Africa. Namibia borders it to the North and West, South Africa borders it to the south and southeast, and Zimbabwe to the northeast.

Gaborone is the capital city, located in the south east of Botswana 15 kilometers from the South African border. Other major towns include Francistown, Selebi-Phikwe, Lobatse and Jwaneng.

Over the last two decades, the economy of Botswana has been experiencing significant growth. In 2000, the GPD of Botswana was approximately 5.788 Billion USD (World Bank, 2021). In 2019, the GDP of Botswana grew to 18.34 Billion USD representing a CAGR of approximately 13.7% from 2000.

GDP annual growth ranged from 2% in 2000 to a peak of 11.34% in 2013. In 2009, Botswana experienced a negative annual growth rate of -7. 65%.

FIGURE 6; GDP CURRENT USD

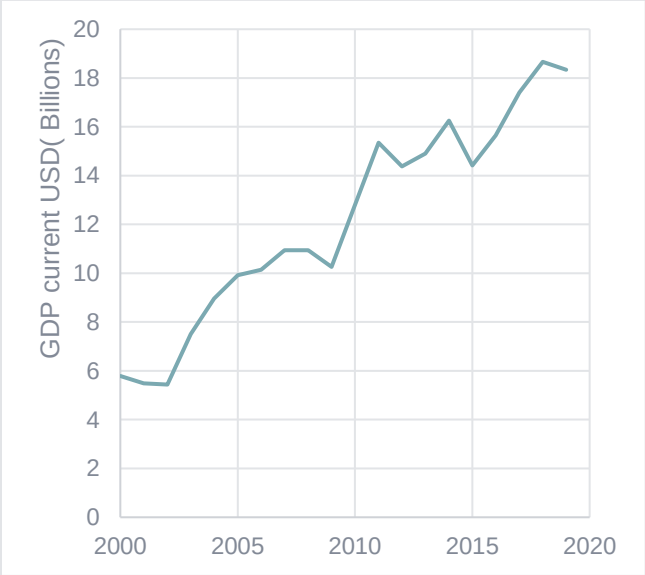
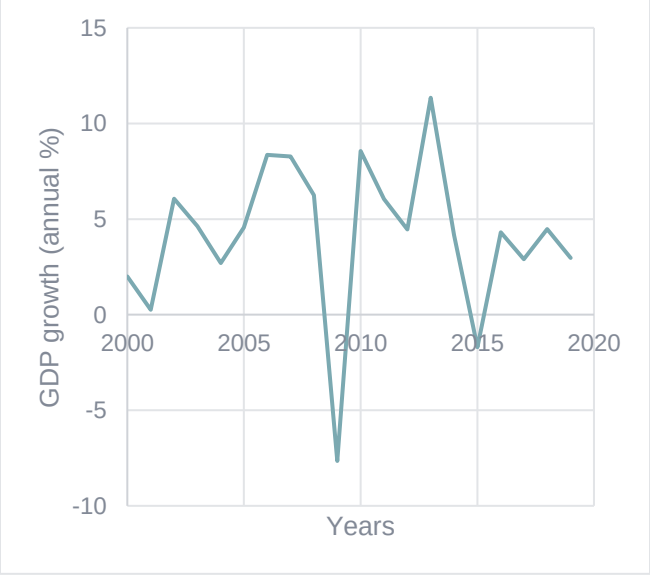


Figure 7: GDP Annual growth



The figure below presents the population of Botswana from 2000 to 2019. On the left, the curve presents the total population for the country, which was 1.6 million in 2000 and grew to 2.3 million in 2019. Population annual growth ranged from 2.03% in 2000 to 2.17% in 2019.

FIGURE 9: TOTAL POPULATION

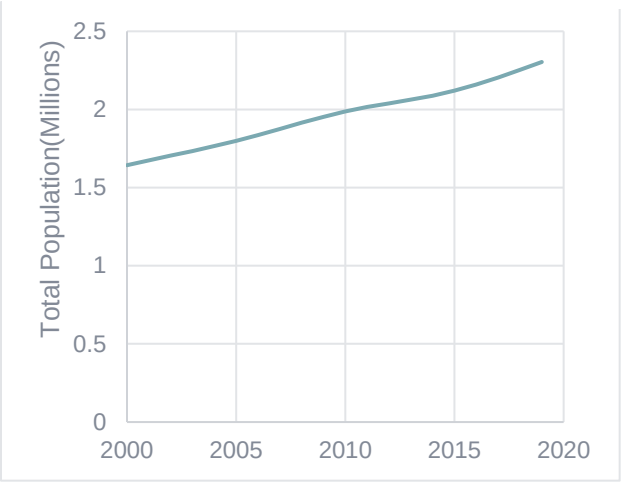
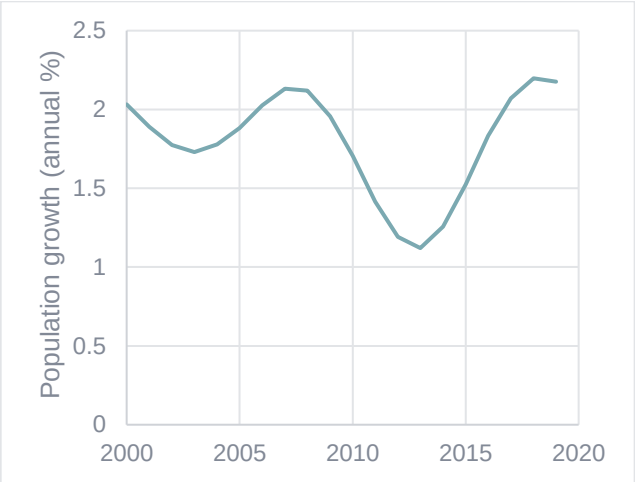


FIGURE 8: POPULATION ANNUAL GROWTH



1.3.2. ENERGY(ELECTRICITY)CONTEXT (ELECTRIFICATION RATES, PEAK ELECTRICITY DEMANDS, VOLTAGE LEVELS, I.E. SYSTEM VOLTAGE FOR SINGLE AND THREE PHASE VOLTAGE SYSTEM, DEMAND FORECAST, INSTITUTIONAL AND LEGAL FRAMEWORK, ETC.)

1.3.2.1. GENERAL ELECTRICITY SITUATION IN BOTSWANA

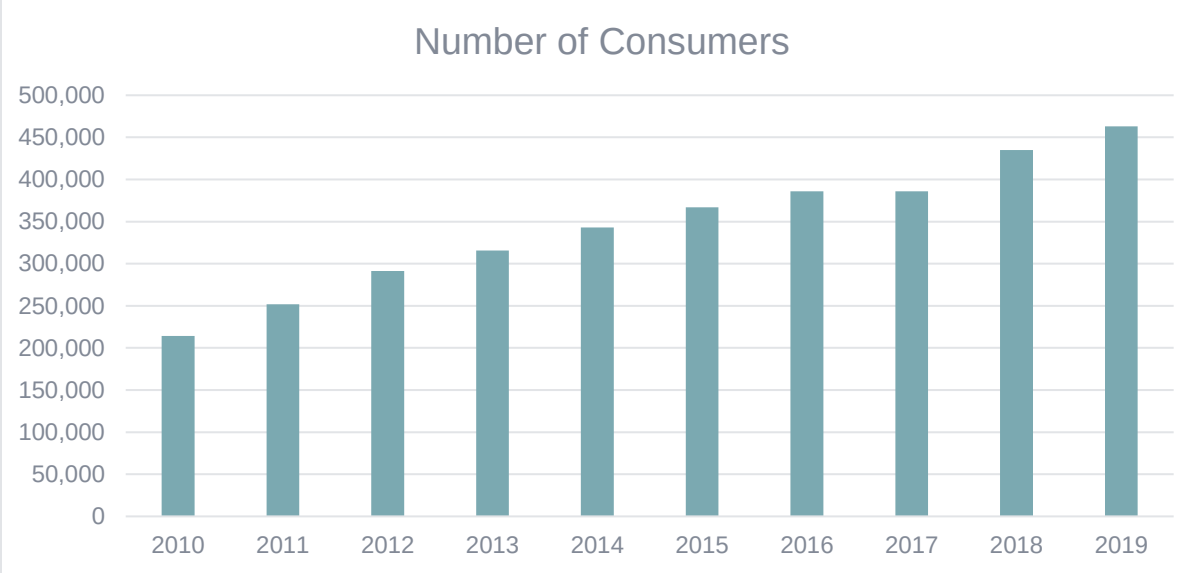
Botswana has experienced some constraints in the energy sector in recent years, which to some extent have negatively impacted the country's economic development prospects. A devastating power supply and demand mismatch was encountered between the years 2008 and 2014 and this breached the country's power supply security. (National Energy Policy 2021).

For a long time, Botswana used to import almost 80% of its electricity from neighboring countries, mainly from the Republic of South Africa. Currently, the country's installed generation capacity stands at 732MW (600 MW from Morupule B and 132 MW from Morupule A coal fired power plants) against a peak demand of 600 MW. An additional capacity of 160 MW (90 MW from Orapa Dual Fuel Power Plant and 90 MW from Matshelagabedi Diesel Peaking Plant). Both Morupule A and Morupule B power plants have not operated at full capacity since 2018 due to varying challenges hence local generation still does not meet the local demand. (National Energy Policy, 2021)

Coal is the main source of electricity generation in the country, followed by diesel. However, Botswana has abundant Solar and Methane Gas with potential to augment generation from coal resources. Despite these abundant resources, only Solar contribute to electricity generation and the contribution is significantly low estimated at less than 2 %. However, there are plans to exploit the Coal Bed Methane and wind resources (although the wind is only localized in some areas of the country). Wind resources have been exploited in the past but only as mechanical power for water pumping.

1.3.2.2. ELECTRIFICATION RATE

The figure below shows the number of customers for electricity consumption in the country from 2010 to 2019.



	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Total Number of Consumers	463,250	434,795	386,024	386,024	367,003	343,050	315,699	291,338	251,773	214,170

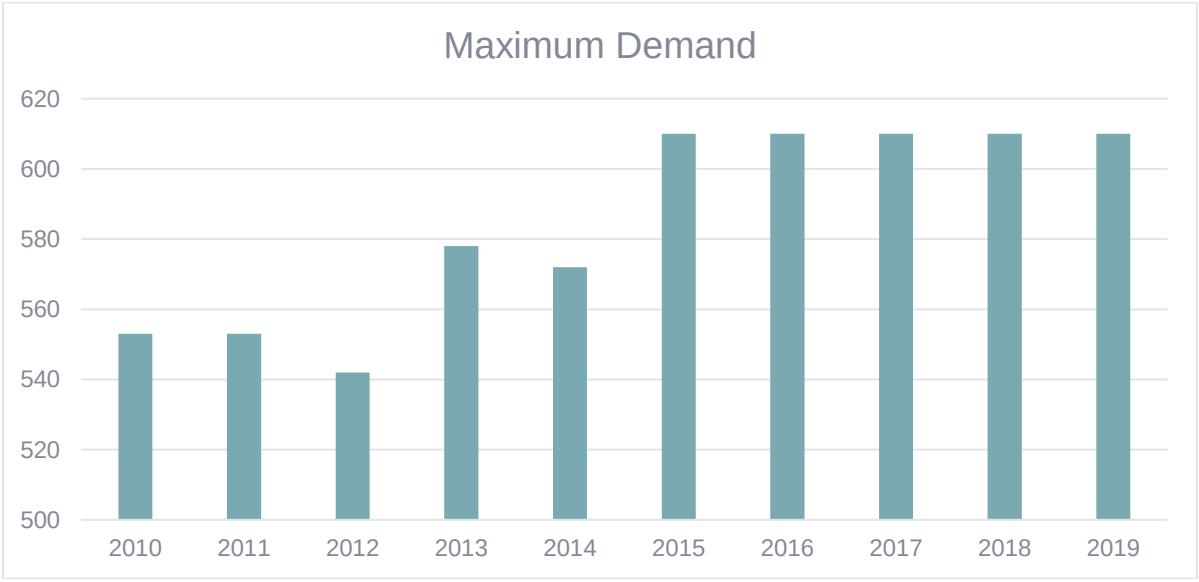
Source: BPC Annual Report 2019

In 2016, the electricity access rate in Botswana was 60.7% of the population in aggregate[3]. 77.7% of the urban population had access to electricity while only 37.5% of the rural population had access to grid electricity. By 2020, the aggregate access figure had risen to 77%. The country has a target to achieve universal access to electricity by 2030, in line with the United Nation's Sustainable Development goal number 7.

Most of the electricity in the country is generated from coal and petroleum, with only about 2% being generated from renewable sources[4]. This makes Botswana to have one of the highest grid emission factors in Africa, at 1.8 $kgCO_2$ equivalent per kWh. This makes energy efficiency projects very attractive from a global warming mitigation perspective.

1.3.2.3. MAXIMUM DEMAND

Figure below shows electricity maximum demand from 2010 to 2019.



[3] Source: Sustainable energy for all Africa
[4] https://www.upstreamonline.com/energy-transition/botswana-in-renewables-drive-but-coalbed-methane-and-coal-still-in-the-mix/2-1-933944

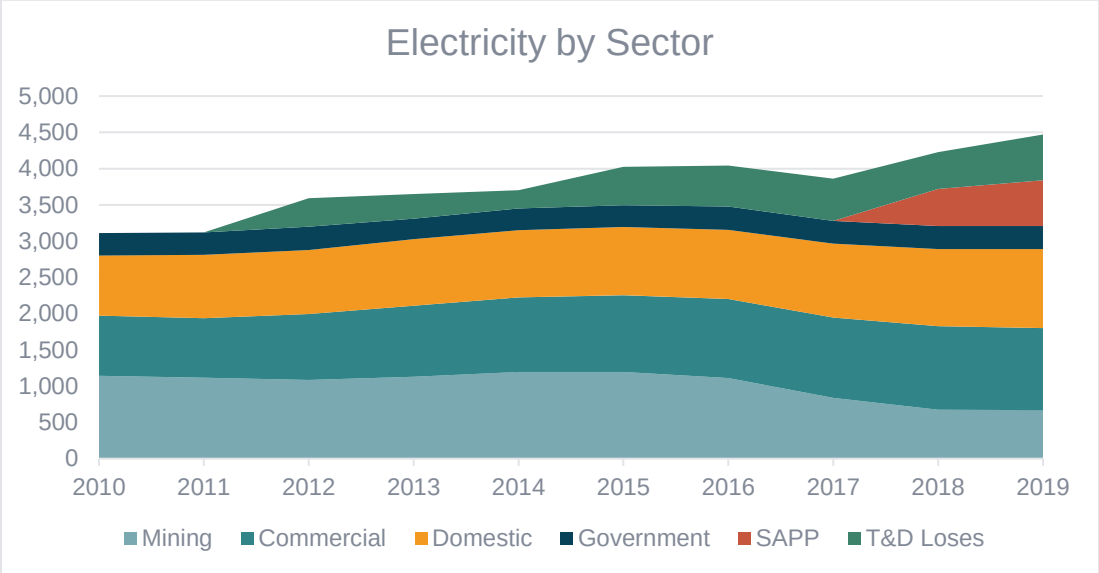
	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Max Demand(MW)	610	610	610	610	610	572	578	542	553	553

Source: BPC Annual Report 2019

The highest demand has been 610MW for the last four years.

1.3.2.4. ELECTRICITY CONSUMPTION BY SECTOR

The figure below shows the consumption in (GWh) of electricity by sector during the period 2010- 2019, together with the transmission and distribution losses.

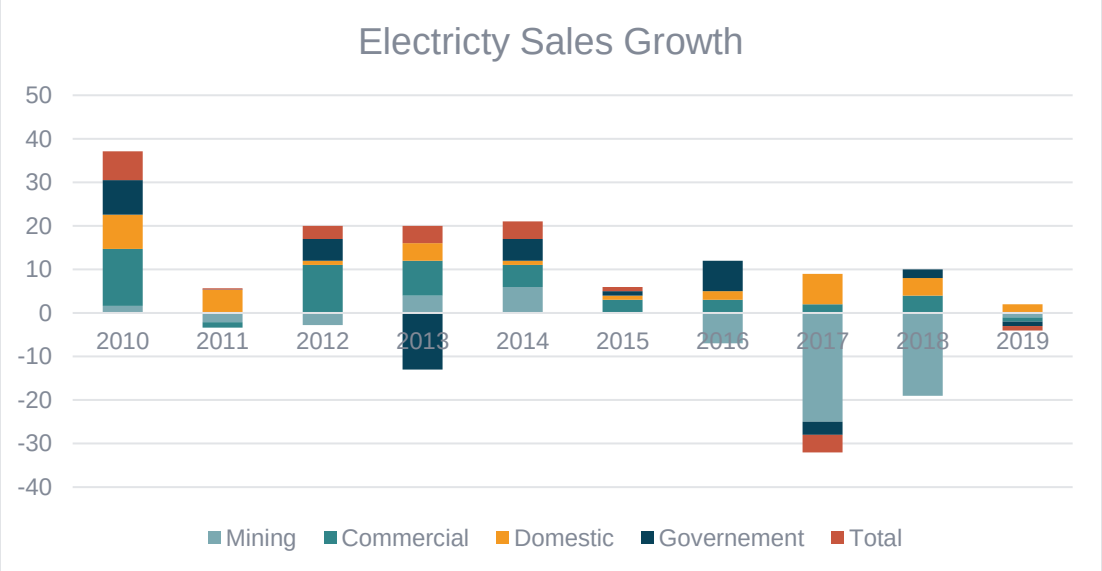


	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Mining	669	676	837	1,114	1,194	1,197	1,128	1,086	1,117	1,141
Commercial	1,132	1,149	1,107	1,087	1,059	1,028	982	910	820	831
Domestic	1,091	1,065	1,022	955	941	927	918	879	873	829
Government	316	319	314	323	301	297	282	323	308	308
SAPP	86	127	70							
Transmission & Distribution Loses	631	509	579	564	529	255	340	393	434	333
Total Electricity Consumption	3,294	3,339	3,349	3,479	3,495	3,449	3,310	3,198	3,118	3,109

Source: BPC Annual Report 2019

The commercial sector consumes the highest amount of electricity, followed by the domestic sector. The transmission and distribution losses at nearly 20% are quite significant, and indicative that the use of more efficient transformers is going to be very helpful.

The figure below shows annual sales growth by sector in the period 2010- 2019 as a percentage (%). It also shows the total growth over the same period of time.



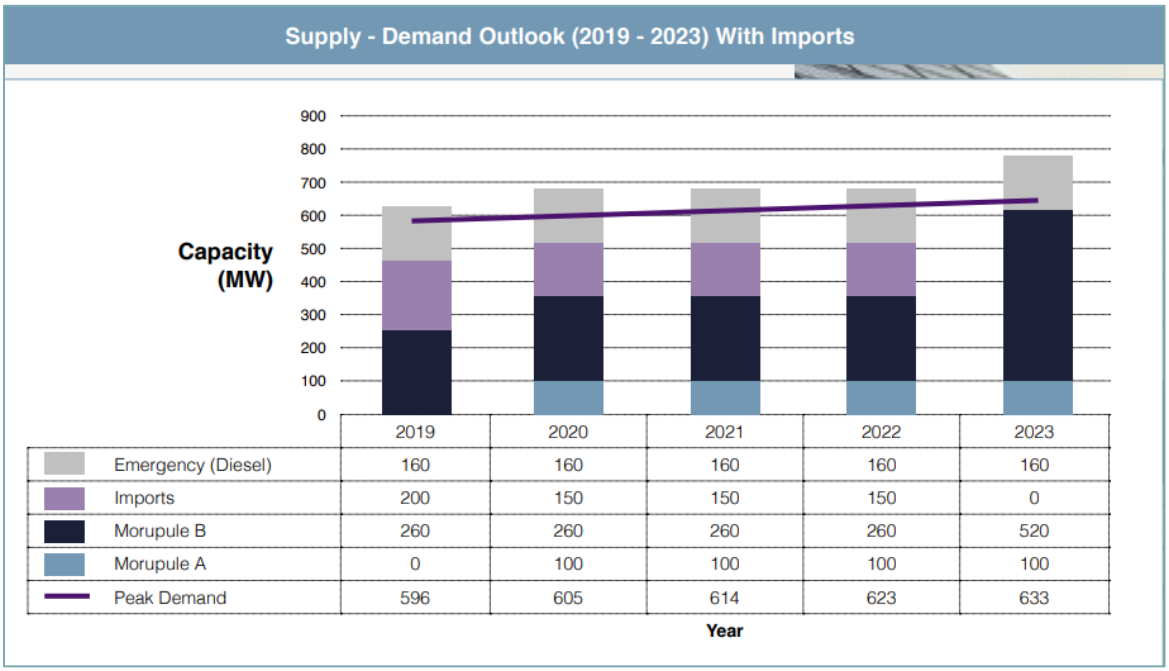
	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Mining	-1	-19	-25	-7	-0.2	6	4	-2.8	-2.1	1.6
Commercial	-1	4	2	3	3	5	8	11	-1.3	13.1
Domestic	2	4	7	2	1	1	4	1	5.3	7.9
Government	-1	2	-3	7	5	5	-13	5	0.1	5.9
Total Sales	-1	0	-4	0	4	4	4	3	0.3	6.6

Source: BPC Annual Report 2019

Growth has been sluggish, with the domestic sector being the only one to record consistent positive growth in the last 10 years.

1.3.2.5. DEMAND FORECAST

Figure 5 shows the demand forecast with imports during the period 2019 - 2023



Source: BPC Annual Report 2019

The demand is expected to grow by about 6.2% by 2023.

1.3.3. POLICY, INSTITUTIONAL AND REGULATORY FRAMEWORKS ON ENERGY EFFICIENCY

1.3.3.1. BACKGROUND

Electrical Appliances and Transmission Equipment have extensive direct and indirect impacts on the environment during their lifetime, starting from the manufacture, operation and maintenance, and disposal. They use energy, water, and raw materials, generate waste, and emit potentially harmful atmospheric emissions. These facts have prompted the creation of standards, certification, rating systems aimed at improving the overall operational performance and mitigating the impact of appliances on the natural environment through sustainable design, construction, operation, maintenance, and disposal.

The development of Minimum Energy Performance Standards (MEPS) for distribution transformers and electrical appliances requires a review of the frameworks within which the MEPS will be developed, implemented, monitored, and enforced. The global best practice is to divide these frameworks according to the must factors that will affect this initiative. The MEPS are controlled by the following frameworks:

I. The legal framework, these are mainly concern with the requirements for regulation, laws & By-laws, and directives. This framework plays the role of ensuring that the MEPS are enforced or obliged to.
II. The financial framework looks into available financing mechanisms for implementing the MEPS and roll-out of the technologies
III. The fiscal framework will review existing fiscal instruments and incentives related to the importation and sale of appliances and distribution transformers. These includes applicable taxes, exemptions, penalties, etc.
IV. The institutional framework ensures that there are the necessary supporting organization and institutions to implement the MEPS.e.g. educational institutions, standards regulators, planners, and policymakers

1.3.3.2. TRENDS AND CURRENT ENERGY EFFICIENCY MEASURES

1.3.3.2.1. RECENT TRENDS IN ENERGY EFFICIENCY POLICY IN BOTSWANA

Over the past years, the Botswana Government put strategies and programmes in place to reduce barriers to the adoption of energy efficiency practices. This was mainly driven by the realization that improving energy efficiency is cost-effective, delays new investment in energy infrastructure and helps reduce energy consumption and related pollution. There has also been increased awareness that energy efficiency and demand side management can play in reducing electricity demand since the start of the electricity supply shortage in 2008. The country participates in various Global initiatives on climate change and this has helped the country to benefit from global initiatives such as the GCF.

The Government of Botswana has recently approved two (2) important policy documents, the National Energy Policy 2021 and National Climate Change Policy 2021. These instruments are essential for Botswana's transition to a cleaner and sustainable energy system.

1.3.3.2.2. CURRENT AND PAST ENERGY EFFICIENCY MEASURES

The recent initiatives on energy efficiency across the energy and environment sector include the following activities:

I. Green Certificate Framework for Botswana:

Botswana, through the Ministry of Environment, Natural Resources Conservation and Tourism (MENT) is developing green building protocols with financial assistance from the United Nations Development Programme (UNDP) to support green certification on water and energy efficiency. The development of the Green Certification Framework will incentivize industries to implement wastewater quality and energy management in Botswana. It proposes appropriate incentives for industries to participate in this programme and identify potential sources of funding other than the government. At the end of the study, recommendations and requirements for successful implementation of the framework will be made.

II. Building Codes

Botswana published a set of energy-efficient design guidelines for buildings in 2010 and has made progress in improving energy efficiency in existing and new buildings. The Ministry of Minerals, Green Technology & Energy Security in collaboration with the Ministry of Infrastructure and Housing has recently completed the development of the Building Codes. A chapter on energy efficiency standards has been incorporated in the building codes. The standards specify requirements for establishing, implementing, maintaining, and improving an energy management system. They will enable organizations to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use, and consumption. The standards also specify requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes, and personnel that contribute to energy performance. The various standards are listed in Annex1

III. Hydro-chlorofluorocarbon Phase-out programme:

Botswana is a signatory to the Montreal Protocol the country ratified the Montreal Protocol on 4 December 1991, and the London and Copenhagen Amendments on 13 May 1997. It further ratified the Kigali Amendment on 19 September 2020. Botswana is working towards meeting the specific Protocol control measures, although the country's Chlorofluorocarbons (CFC) emissions are low. Botswana specifically commits itself, to reducing Ozone Depleting Substances (ODS) consumption and to phasing out Chlorofluorocarbons.

IV. Other Energy Efficiency Measures

In 2009 Botswana developed the Biomass Energy Strategy (BEST) plans. To date, more than 820,000 Compact Fluorescent Lamps (CFL) have been distributed to replace incandescent bulbs. In 2013 implementation of ripple control to remotely turn on and off domestic hot water heaters were introduced. In December 2016, the Government of Botswana, through support from the World Bank, completed a National Energy Efficiency Strategy document with key short and medium-term initiatives required to achieve 10–15% energy savings. Botswana was also selling imported high-efficiency stoves through the BPC Lesedi programme from 2009 -2015. The country also hosted major donor-funded projects on energy efficiency in commercial and institutional buildings in 2010 and 2011 and has developed guidelines for energy-efficient design.

1.3.3.3. LEGAL AND REGULATORY FRAMEWORK

There are several pieces of legislation and policies as well as regulations that are related to energy efficiency and are of significant importance to this study and its eventual implementation. Table 1. summarizes the key statutes that were analyzed in the energy and environmental sector. The energy sector is currently guided by the Energy Policy, subsector strategies, and several laws and regulations. Since energy is a contributor to emissions, policies on environmental protection are also analyzed. The Energy Policy and Climate Change Policy were recently approved by parliament and these will act as the high-level guiding documents for the implementation of this project. In addition to these policies, the latest National Energy Efficiency Strategy was approved in 2018 and has been reviewed and its recommendation adopted for this study.

Table 2-1: Relevant key legislations, policies, and regulations

INSTRUMENT	GOALS AND OBJECTIVES	RELEVANCE
ENERGY POLICY		
Botswana National Energy Policy,2021	To ensure energy security and to improve access to a reliable and adequate supply of energy to facilitate a low carbon and sustainable economic development for Botswana. This goal will be achieved through twelve (12) objectives and three (3) of these address energy efficiency and standards; • To support the modernization and expansion of energy infrastructure to meet the growing energy demand. • To provide effective governance and improve the overall management of the energy sector • To minimize the impacts of energy supply and consumption on the environment through an increase of renewable energy in the supply mix and improved efficiency in energy use.	There are twenty statements attached to the policy and out of these three are on the Electricity subsector (P1- P3). All three statements have a bearing on the implementation of the MEPS for Equipment and Appliances. • P1- Electricity will be generated optimally from locally available resources to meet local demand to ensure self-sufficiency. • P2- Transmission and Distribution infrastructure will be enhanced to facilitate growth and universal access to electricity. • P3- Electricity tariffs will be cost-reflective to balance the interests of the investors, consumers, and the environment. The implementation of the MEPS on DT's will address statements P2 and P3 while the Standards for appliances are related to P1 as they result in optimal use of energy.
National Energy Efficiency Strategy for Botswana, 2018	To put the Government of Botswana on the right path to achieving saving goals.	Lists actionable recommendations that GOB can implement in the short term and long term. The document recommend tightening of the building standards and capacity building for enforcement of standards. It also emphasizes the introduction of MEPS for equipment and standards and labeling of appliances as short term measures. The strategy goes further by

		recommending the introduction and tightening of MEPS in other sectors of the economy such as in the Mining & Manufacturing, Agriculture, and Transport sector.
CONVENTIONS AND PROTOCOLS		
Botswana's Sustainable Energy for All Action Agenda, 2017	The SE4ALL Action Agenda (AA) sets out the GOB strategy for achieving SDG 7, together with formally adopted national targets for each SE4ALL pillar.	This Global initiative was developed based on existing policies and strategies such as the Energy efficiency strategy of 2018 Key relevant action required to help technology include: adoption and application of new building standards for residential, improve product labeling and energy performance standards, promoting behavioral change, Increasing Technical and Regulatory capacity in key institutions.
Botswana's SE4ALL Investment Prospectus (2017)	The instrument is an operational counterpart to Botswana's SE4ALL Action Agenda (AA). It will assist to advance investment opportunities to achieve the goals of the Agenda Action by identifying and developing projects and programmes that can attract potential investors.	The investment requirements are also outlined and stated in this document. The issues covered by this document provide an overall picture of investment opportunities in the Energy sector and will influence the type or model of investment in these new technologies.
ENVIRONMENTAL POLICIES		
Botswana National Policy on Climate Change,2021	To mainstream sustainability and climate change into development planning and in so doing, enhance Botswana's resilience and capacity to respond to existing and anticipated climate change impacts.	Promotes low carbon development pathways and approaches that significantly contribute to socio-economic development, environmental protection, poverty eradication, and reduction of Green-House-Gases (GHG) from the atmosphere.
Botswana's National Determined Contributions.	The Botswana Intended Nationally Determined Contributions were developed based on the United Nations Framework Convention on Climate Change guidelines for GHGs emission inventories and INDCs guideline. The objective of the INDCs was to highlight Botswana's GHGs emission trajectory and the intended reduction by the year 2030 based on 2010 emission estimates.	The proposed measure is a clean energy initiative, which will result in GHG emission reductions of 15% by 2030.

1.3.3.4. OVERVIEW OF EXISTING APPLICABLE REGULATIONS AND LAWS

The implementation of the MEPS for Equipment and Appliances must comply with the following;

- **Electricity Supply Act;** enacted in 1973 (Electricity Supply Act, 1973), with a provision which necessitated the minister to consult the Botswana Power Corporation before issuing a generation license above 25 kW. The Act did not specify the energy source, and it established BPC as a vertically integrated monopoly, operating generation, transmission, distribution and retail.

- **Botswana Power Corporation Act, 1970:** Formed in 1970 by an Act of Parliament and is responsible for the generation, transmission, and distribution of electricity within Botswana. The current electricity regulations and the licensing regulations and rules do not provide for energy efficiency and demand-side management as envisaged in this policy. It only imposes power factor correction on consumers with a power factor of more than 0.85

- **Botswana Energy Regulatory Authority Act**: The Authority is responsible for providing an efficient energy regulatory framework for electricity, gas, coal, petroleum products, solar, and all forms of renewable energy with the primary mandate of providing the economic regulation of the sectors. The implementation of the MEPS and Standards influence electricity tariffs set by BERA.
- **Botswana Power Corporation Standards for Distribution Systems (SDS):** The Standards Requirements for Distribution Systems (SRDS) document is used to carry out all of the design and construction of the BPC distribution systems. Scope standards specifications, rating, and class, terminators, color, and information on the type of certification demonstrating compliance with specifications used by BPC for specification during procurement and installation works.
- **Environmental Assessment Act, 2011:** The envisaged project cannot be implemented without an approved EMP as directed by DEA. Monitoring of the implementation and operation activities of the project should be undertaken (by the project proponent/developer). DEA will also do the monitoring for compliance purposes.
- **Environmental Assessment Regulations of 2012:** The regulations guide how exercises such as scoping should be presented (Form B, Regulation 5), including the content of the report.
- **Atmospheric Pollution Prevention and Control (Chapter 65:03):** Empowers Director of Environment to deny environment permits to undertakings that do not conform to national laws and regulations, as well as global protocols.
- **Directive CAB18 (B)/2015:** Implementation of water and energy demand management measures and practices.
- **Building Design Guidelines for Botswana, 2007:** This is intended to be a resource that will help improve energy and energy conservation in the building sector.

1.3.3.5. REVIEW OF FISCAL AND INCENTIVES

There are no specific fiscal policies dedicated to the energy sector. However, this issue is addressed through other policy instruments. Financing is a barrier to the deployment of energy-efficient technologies. The project will address this by working with the government and utility to investigate the feasibility of fiscal measures (such as import duty reduction) and financing mechanisms (such as on-the-bill payment), but also provide support to liaise with international finance (potentially bulk procurement programs, loans for DT procurement).

1.3.3.6. REVIEW OF INSTITUTIONAL FRAMEWORK

The institutional framework in the energy efficiency sector involves policymaking, regulation, standards development, and enforcement of laws. The institutional framework in Botswana is also going through a transformation process. The Botswana Energy Regulatory Authority was only established in 2018 and the organization is still at an infant stage.

The institutions that are most relevant to the development of MEPS for domestic appliances and transformers are the Ministry of Minerals Resources, Green Technology and Energy Security (MMGE), Ministry of Environment, Tourism and Natural Resources (MENT), Botswana Energy Regulatory Authority (BERA), Botswana Power Corporation (BPC) and Botswana Bureau of Standards (BOBS).

The Ministry of Minerals Resources, Green Technology, and Energy Security through the Department of Energy (DOE) is responsible for directing and coordinating the overall developments in the energy sector. The DOE is therefore the leading Policymaker in the Development of the MEPS for Equipment and Appliances. However, the Botswana Bureau of Standards is the custodian of all national and international standards that are applicable in Botswana. The BPC is also empowered to develop standards and can enforce them through by-Laws.

Table 2.2 Institutions involved in the implementation of MEPS for Equipment and Appliances and the role that they play in this project.

Institution	
Ministry of Minerals Resources, Green Technology, and Energy Security (MMGE)	• Set the Government over strategy and targets on ALL energy efficiency matters • Formulate/solicit for, screen, and approve energy initiatives • Develop a policy on the Standard Offer with differentiated approaches for the approved energy efficiency initiatives. • Develop implementation procedures for each initiative • Endorse standards on energy efficiency and Demand Side Management. • Monitor, evaluate, and report on the achievement of energy efficiency interventions by various implementation agents using the approved protocol and accredited teams; • Ensure sufficient communication and understanding of energy efficiency among all stakeholders. • Serve as the single point of contact for concessionary funding for project developers with initiatives.
Ministry of Environment, Tourism and Natural Resources	• Formulate and execute policies that promote the use of environmentally friendly technologies

Botswana Energy Regulatory Authority (BERA)	• Determine Energy Efficiency tariff component following prevailing law • Determine the generation avoided cost concerning the energy efficiency intervention, to determine the level of standard offer rebate; • Determine and publish each EEDSM initiative rebate level • Develop a verification protocol for each initiative • Ensure that a cost recovery mechanism is in place for all disbursements by BPC/System Operator according to the Energy Efficiency and Demand Side Management rules;
Botswana Power Corporation (BPC)	• Implement government policies and the regulator's rules relating to energy efficiency and Demand Side Management in its tariff applications to the regulator. • May implement by-laws on energy efficiency to ensure the security of supply
BOBS	• Understand the initiative policy and procedures • Source the required capital expenditure, at risk, to implement the EEDSM intervention • Implement an intervention that complies with Energy Affairs Department and Regulator rules • Submit a claim to the Regulator to redeem the capital investment over the life of the investment

1.3.3.7. OTHER STAKEHOLDERS

Several other stakeholders are to some involved in the Equipment and Appliances market activities.

Table 2.3: Other stakeholders and players in the Equipment and appliances market

Theme	Organizations
Technology centres/institutes and training bodies	Key technology centres/institutes include BITRI, BCET, BIH, UB, and BIUST, etc. These institutes are actively involved in the energy efficiency sub-sector and will have an interest in the implementation of this project. E.g., BIUST has an Energy Degree Programme which incorporates energy efficiency. Vocational training institutes such as BCET train students in Refrigeration maintenance and electrical system operation and maintenance.
Importers, distributors and retailers	Some notable importers, distributors, and retailers include Ray Morgan, Distron & Kruger Agencies (Importers & Distributors), Furniture shops, such as Hi-FI-Corp, Western, Lewis, and Furnituremart. Etc.
Financial institutions	The National Development Bank has a loan facility that caters to energy projects for farmers, particularly Renewable Energy Technologies. NDB and other Banks will likely have an interest in this project. BPC also offers a Transformer Scheme where the customer can gradually pay for the installation of a distribution transformer. Several retail shops sell the domestic appliances either on layby purchase or hire- purchase model.
Repair and maintenance workshops	There are some repair and maintenance workshops which are run by individuals and companies. The distributors of refrigerators also have in-house maintenance workshops to cater for units that are still under warranty. There is only one (1), known distribution transformer maintenance company (ZISMO) and they have shown interest in this project during the survey.
Development partners	GIZ, UNDP, WBG, UNIDO, SIDA, SACREE, SADC, and the EU, among others, have all been active over the years in Energy programmes in Botswana. They have provided financial and technical support to the government to develop programmes including the development of energy policies and Strategies, capacity building in energy efficiency, and energy planning.
Association and Technical partners	There are a few associations specific to the energy industry excluding the petroleum sector. The Solar Industry Association is the most active in renewable energy and energy efficiency sector and has an interest in the

	implementation of the MEPS. The association participates in the development of solar systems standards.

1.3.4. REVIEW OF EXISTING CAPACITIES AND SKILLS GAPS

A review of previous studies shows that there is a lack of capacity in all the above key implementing institutions in terms of planning, financing, operation, and monitoring of energy efficiency initiatives. This is also shown by long delays in implementing policies and strategies that have been developed over the years.

1.3.5. CHALLENGES IN IMPLEMENTATION OF EXISTING LEGAL AND REGULATORY FRAMEWORK

There are several challenges that may impede the implementation of the MEPS and Standards for Equipment and Appliance within the legal and regulatory framework. The National Energy Efficiency Strategy which was approved in 2018, provides a good analysis of the barriers that hinder the implementation of energy efficiency programmes. The challenges identified are common in most countries and it is envisaged that the implementation of the MEPS and Standards will face similar barriers. They include:

i. Lack of information on overall energy consumption and information to energy consumers
ii. Capacity constraints for key stakeholders and include institutional, skills, and capital costs
iii. Lack of motivation at all levels
iv. Lack of legislation
v. Lack of standards and testing facilities

In addition to the above challenges, it was necessary for the market survey to conduct interviews to assess the level of shortfalls in areas of planning, financing, operation, and monitoring for MMGE, MENT, BERA, BPC, and BOBS. The NEP 2021, recognizes there is a need for improvement and capacity building in the above areas.

1.3.6. OPPORTUNITIES

Based on the National Energy Efficiency strategy 2018 some measures can be adopted to increase the uptake of energy efficiency in a systematic approach. The development of MEPS for equipment is recommended in some sectors. The measures are divided into three (3) phases of short-term (5year), mid-term (6-10 years), and long-term (11-15 years) for various sectors. The table below provides the recommended measures and in particular identified the introduction of MEPS for equipment and standards and labeling of appliances in the short-term period supporting the current project.

Table 2. 4: National Energy Efficiency Strategy Road Map Energy Efficiency Measures

Sector	Short- term (0-5 years)	Medium (6-10 years)	Long- term (11-15 years)
Cross-cutting measures	• Tightening of building standards • Development of capacity for enforcement of MEPS • Introducing MEPS for equipment and standards and labeling of appliances • Phase-out incandescent lighting products • Public awareness-raising campaign on energy efficiency benefits and opportunities. • Moving to a cost-reflect tariff for electricity	• Tightening of building standards • Enforcement of MEPS • Tightening of MEPS for equipment and appliances • Regular re-runs of public awareness-raising	• Tightening of building standards • Enforcement of MEPS • Tightening of MEPS for equipment and appliances • Regular –reruns of public awareness-raising campaigns

Public buildings	• Continuation and scaling up of energy audits of public buildings. • Implementing priority energy efficiency projects • Introducing green procurement procedures and life-cycle costing into public procurement • Develop the public sector 'Leading by Example' brand	• Demonstration project with support • ESCO market-working with financial institutions, developing standardized contracts	
Residential	• Support research and design of cookstove technologies • Incentivize shift to more efficient cooking technologies • Incentivize implementation of energy efficiency retrofits to dwelling • Develop market supply for solar water heaters • Incentivize adoption of SWHs in existing buildings	• Improve infrastructure for accessibility of improved technologies • Promote shift to LPG and regulation of LPG market • Incentivize implementation of energy efficiency retrofits to dwelling • Incentivize adoption of SWHs in the existing buildings.	
MEPS in Other Sector;			
Mining & Manufacturing	• Develop and Introduce MEPS for equipment (Industrial boilers, motors, pumps, compressors, and HVAC)	• Broadening and tightening of MEPS	• Broadening and tightening of MEPS
Agriculture	• Raising awareness of opportunities for energy and water-saving in agriculture	• Introduction of MEPS for water pumping and irrigation equipment	• Broadening and tightening of MEPS
Transport		• Roll out MEPS for vehicles and car dealerships	

1.3.7. SUMMARY

This section reviewed the most recent and relevant policy and legal regulatory instruments that are relevant to energy efficiency in Botswana within the energy, financial, environmental and economic sectors. The analysis went further by viewing the institutional and regulatory framework that is relevant to the implementation of equipment and appliances in particular to the domestic refrigerators and distribution transformers. The analysis has also recognized some challenges that exist and is likely to impede the implementation and tightening of the MEPS equipment and Standards for Appliances. The recommendations that follow provide ways that can assist to address these challenges. The recommendations are not only for the Appliances but are equally applicable to MEPS for other technologies.

The review and the analysis show that the country has made significant progress in terms of Policy and Strategy. The NEES 2009 was a good first step as it was concern with raising awareness on Policy Makers. In the NEES 2018, the policy direction was towards preparing for the

development of the Standards. The NEES 2018 highlighted the need for MEPS in various important sectors of Botswana's economy, including the transport, mining, and agriculture sector.

Therefore, the development of the MEPS is in line with the Energy Efficiency Strategy, 2018. The recently adopted National Energy Policy acknowledges that the country can be self-sufficient in supply if electricity is used optimally and the country is bound to formulate policies that protect the environment and improves human lives. The NEP also acknowledges that there is inadequate energy planning in the country and seeks to support the development of an energy data management system that is required to facilitate the desired integrated energy planning. In conclusion, the current legal and regulatory framework supports the implementation of the MEPS and standards for equipment and appliances. Past shortcomings are acknowledged and recommended remedies suggested, these efforts enhance the success of the current initiative.

2

3.Market Assessment on Residential Refrigerators.

3.1. REFRIGERATOR SUPPLY CHAIN

3.1.1. SUMMARY OF SUPPLIERS, END-USERS, OFFICIALS AND OTHER STAKEHOLDERS-- SUMMARY OF WHO WAS INTERVIEWED, HOW MANY STORES/HOUSEHOLDS WERE SURVEYED

To gain understanding of the refrigerating market in Botswana, the local team interviewed the refrigerating dealers, retailers and households. The survey was conducted in major Botswana cities and districts. This includes; Gaborone, Francis town, Maun, Serowe, Molepolole, Mochudi, Palapye, Lobatse, Mahalapye, Bobonong and Selebi Phikwe.

The local team visited refrigerator distributors/dealers, retailers and household consumers to gather information on brands available on the market, including refrigerating appliance characteristics and prices. For most products, comprehensive technical data is provided on the product nameplates and, where labeled, on the energy labels. Hence, during the field survey, manufacture/brand name, model numbers, refrigerating appliance type, defrost technology type, energy consumptions, labels and efficiency labels, volume, refrigerant types, voltage, climate class, country of origin were obtained from product nameplates displayed. In a few cases, model numbers and brands used were searched on manufacturer's websites and online shops to verify technical information.

Besides collecting the technical information on refrigerating appliances in households and available for sale, the local team also collected respondents details, family size, house size, average electricity bill per month, number of refrigerating appliances owned, average annual income, efficiency labeling awareness, willingness to pay an extra cost to get an efficient appliance, registered financial institutions, experience with loans, mode of last purchase and influence on purchasing decisions.

Project team gathered information from 359 households, 34 retailers 2 distributors and 4 government officials.

FIGURE 10 STORES COVERED BY RETAILERS AND MODELS IN EACH STORE:

Stores Surveyed	Number of models surveyed
BEARES SELIBE PHIKWE	14
BEARS	11
Bears Maun	10
Bears Serowe	11
BRADLOWS MAHALAPYE	14
BRADLOWS PALAPYE	10
Canival Maun	7
Canival serowe	5
CASH CRUSADERS PALAPYE	10
Charlics Molepolole	6
FURNMART	12
Furnmart BOBONONG	17
FURNMART LOBATSE	8
furnmart mahalapye	17
FURNMART MALL	9
Furnmart Maun	10
FURNMART Mochudi	5
FurnMart Molepolole	10
Furnmart PALAPYE	10
FURNMART SELIBE PHIKWE	18
Furnmart Serowe	7
LEWIS	18
LEWIS MAHALAPYE	12
LEWIS PALAPYE	10
Lifestyle Range Furnitures Mochudi	5
MOTLAKASE SQUARE	5
Ok FURNITURE	10
OK Furniture Molepolole	10
OK Furniture Pilane	4
OK FURNITURES PALAPYE	10
OK FURNITURES SELIBE PHIKWE	13
OK Serowe	8
SEFALANA MAHALAPYE	15
SHOPRITE	16
Grand Total	**357**

To supplement the primary data and get a more comprehensive picture of the refrigerating appliance market, secondary data was collected from the sources listed.

TABLE 1: SOURCES OF SECONDARY DATA

Sources of secondary data	Data collected
Department of Energy-energy efficiency section	Policies, regulation and standards; product supply and distribution chain; annual refrigerator market size.

Department of Energy-Head of Policy	Policies, regulation and standards; product supply and distribution chain; annual refrigerator market size.
Ministry of Infrastructure and Housing Development	Policies, regulation and standards; product supply and distribution chain; annual refrigerator market size.
Botswana Unified Revenue Service (BURS)	Policies, regulation and standards; product supply and distribution chain; annual refrigerator market size.

3.1.2. MANUFACTURING OF REFRIGERATING APPLIANCES

Botswana does not manufacture or assemble refrigerating appliances.

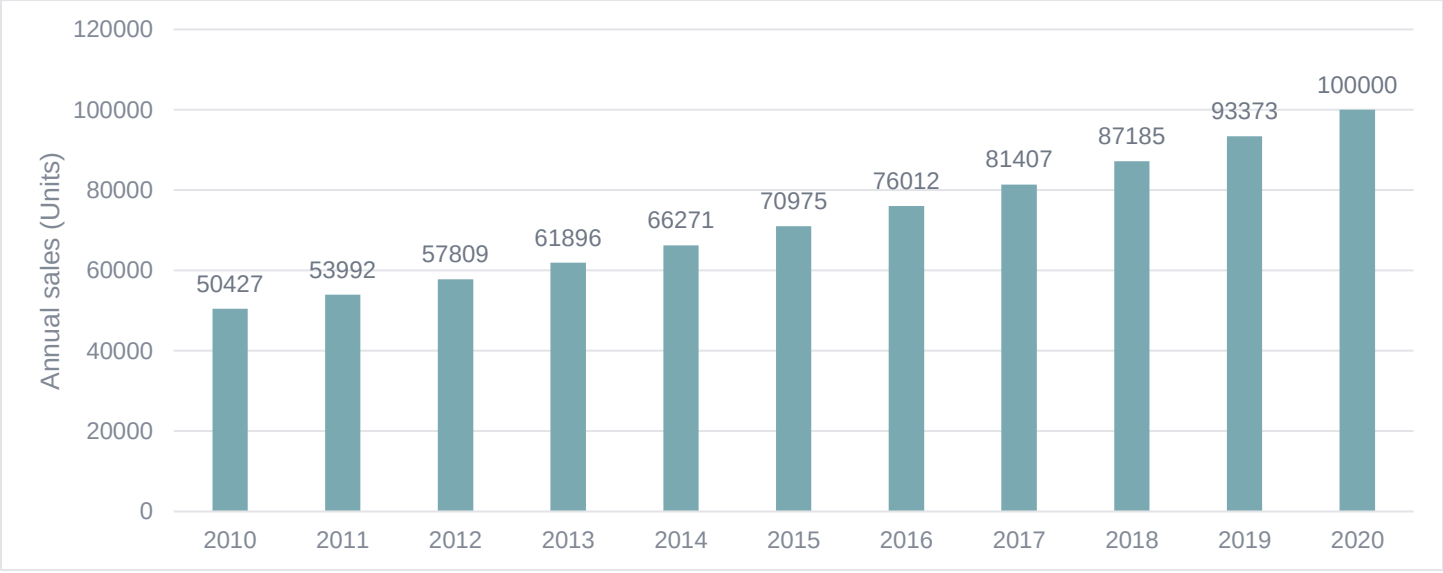
3.1.3. OVERVIEW OF THE SUPPLY CHAIN (ACCESS TO LOW-GWP REFRIGERANTS, KEY IMPORT CONDITIONS/QUANTITIES, ETC.)

a) Import

Botswana imports all of its refrigerating appliances. Refrigerating appliance imports in 2019 were 93373[5]units. The import of refrigerating appliances has grown with compounded annual growth rate (CAGR) of 6.4% from 2010 to 2020. One of the key drivers for the increase in imports is the increase in the demand of the household refrigerators therefore making it economical for brands such as Defy, Hisense, KIC, Kelvinator among others which completely depend on import to meet the demand in Botswana.

The import data of the past 10 years from Comtrade UN is presented in the figure 1 below.

FIGURE 11: HISTORICAL IMPORTS OF REFRIGERATING APPLIANCES (2010-2020)

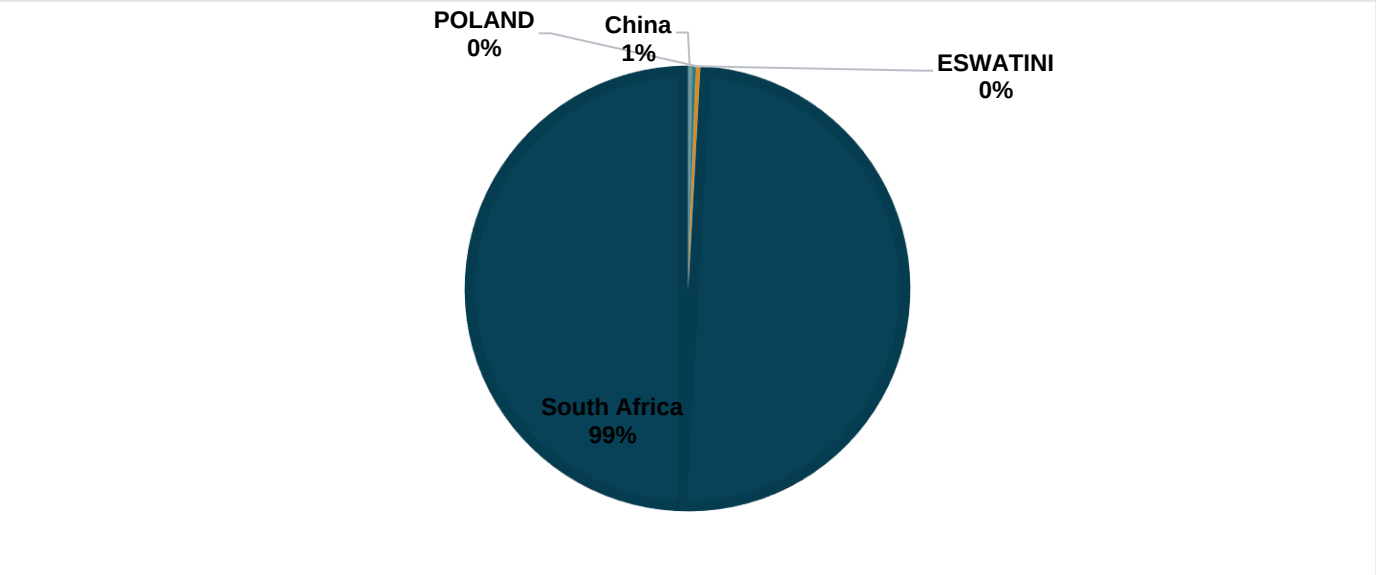


[5] UN Comtrade. https://comtrade.un.org/Data/ for the following Harmonized System (HS) commodity codes:
841810 (Refrigerators and freezers; combined refrigerator-freezers, fitted with separate external doors, electric or other);
841821 (Refrigerators; for household use, compression-type, electric or other);
841829 (Refrigerators; household, electric or not, other than compression-type);
841822 (Refrigerators; for household use, absorption-type, electrical)
841830 (Freezers; of the chest type, not exceeding 800l capacity)
841840 (Freezers; of the upright type, not exceeding 900l capacity)

The Compounded Annual Growth Rate (CAGR) is 6.4%

According to the current market data, refrigerating appliances were majorly imported from South Africa as shown in Figure 2 below. Refrigerating appliances from South Africa accounts for 99% of the total imports.

FIGURE 12: COUNTRIES REPRESENTING REFRIGERATOR IMPORTS IN BOTSWANA



Interviews with suppliers and distributors indicated that the distribution channel mostly used in Botswana is as follows.

FIGURE 13:: THE OVERVIEW OF THE SUPPLY CHAIN OF RESIDENTIAL REFRIGERATORS IN BOTSWANA

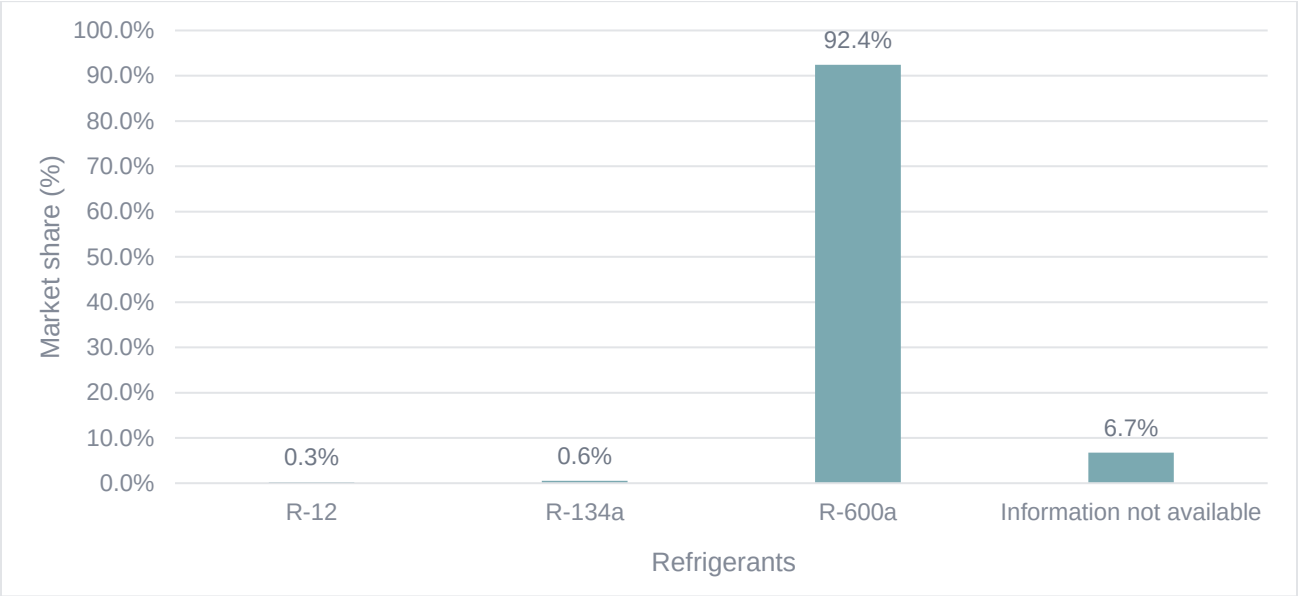
b) Refrigerant

Botswana has Meteorological Service Act and the Ozone Depletion Substance Regulation. In addition, the country ratified the Kigali Amendment to the Montreal Protocol in September 2020.

The project team found that refrigerator current market mostly uses R-600a refrigerants. This refrigerant has zero Ozone Depletion Potential (ODP), similarly, the Global Warming potential (GWP) for R-600a is very low. The project team found very few models that had R-134a and just one model that had R-12 refrigerant. In some instances, the refrigerants were not declared on the appliances.

R-600a is used in 92% of the refrigerator models found in the current market, as can be seen in Figure 5 below. The models analyzed include all types of refrigerators across a wide range of volumes.

FIGURE 14: FIGURE 1: MARKET SHARE OF REFRIGERANT USED. N=357



3.1.4. BEST-SELLING EQUIPMENT (BRAND, TYPE, FEATURES, CAPACITY, ETC.)- REFER TO THE RETAILER DATA AND THE HOUSEHOLD DATE (TO A LESSER EXTENT)

a) Brands

The five major brands are Defy, Hisense, KIC, Kelvinator and Russell Hobbs. Together, these brands hold nearly 93% of the market share by volume as shown in the figure below. Defy and Hisense are the market leaders with 31.1% and 25.5% of the market share respectively.

FIGURE 15: MARKET SHARE BY DIFFERENT BRANDS

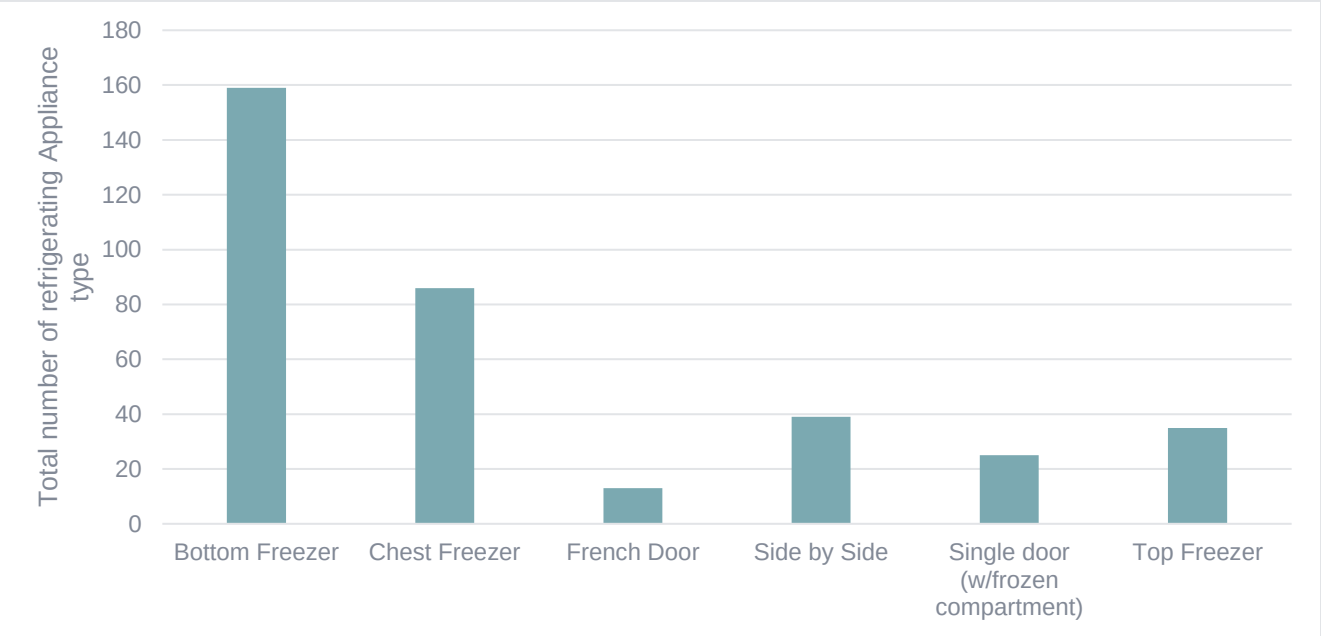
b) **Refrigerator Type**

The Botswana domestic refrigerator market in most common forms can be broadly segmented based on product type (refrigerator only, freezer or refrigerator-freezer), air circulation, door type.

i. DOOR TYPE

The domestic refrigerator market is segmented as single-door, double-door (top-freezer or bottom-freezer), side-by-side and French-door model types. Generally, the single-door refrigerators (including those with a frozen food compartment) are mostly manual defrost. From the retailer's data, bottom freezers represented the largest market share (44.5%) followed by the chest freezers (24.1%) as shown in the figure below.

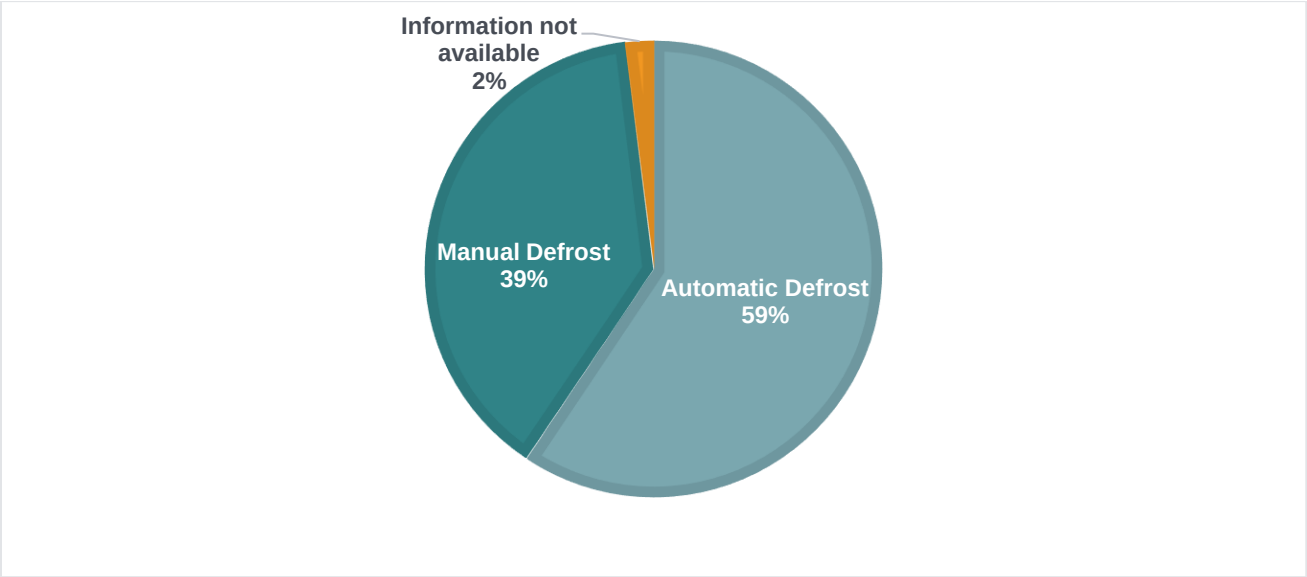
FIGURE 16: MARKET SHARE OF REFRIGERATING APPLIANCE TYPE



ii. Defrosting technology

Domestic refrigerating appliance in the Botswana market are characterized by both manual /direct cooling and auto defrost. In direct cooling refrigerating appliances, the air is cooled through a natural convection process. Consequently, frost is formed over the coils and manual defrosting is required. Separately, a refrigerator may have a heating system integrated into the cooling coils to avoid the buildup of frost on the cooling coils. These products are called frost free or automatic defrost. Both auto defrost and manual defrost were found in retailers Botswana market, with auto defrost more than the manual defrost as shown in the figure below.

FIGURE 17: DEFROSTING TECHNOLOGY. N=357

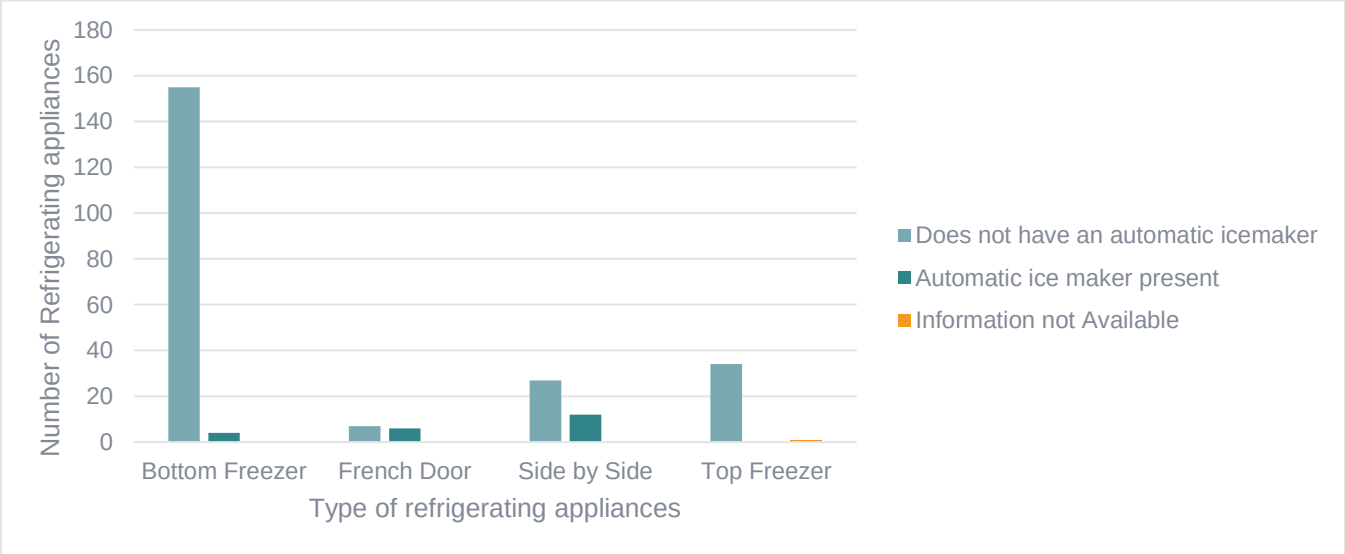


c) Automatic ice maker

Automatic icemakers in modern refrigerators are a popular convenience feature. They use electric motors, valves, timers and thermostats to control filling, freezing and emptying the ice-making trays. Once ice has been frozen, the icemaker dumps it into a holding bin where people can take it out for use. In domestic refrigerating appliances, automatic ice makers are commonly found in refrigerator-freezers appliances.

Automatic ice makers were very scarce in the current domestic market in Botswana. Just a handful were observed in the bottom freezers, French door, side by side and top freezers as shown in figure 4 below. Out of the 22 Automatic ice marker that existed in the market segmentation, 12 were found in the side-by-side refrigerator-freezer.

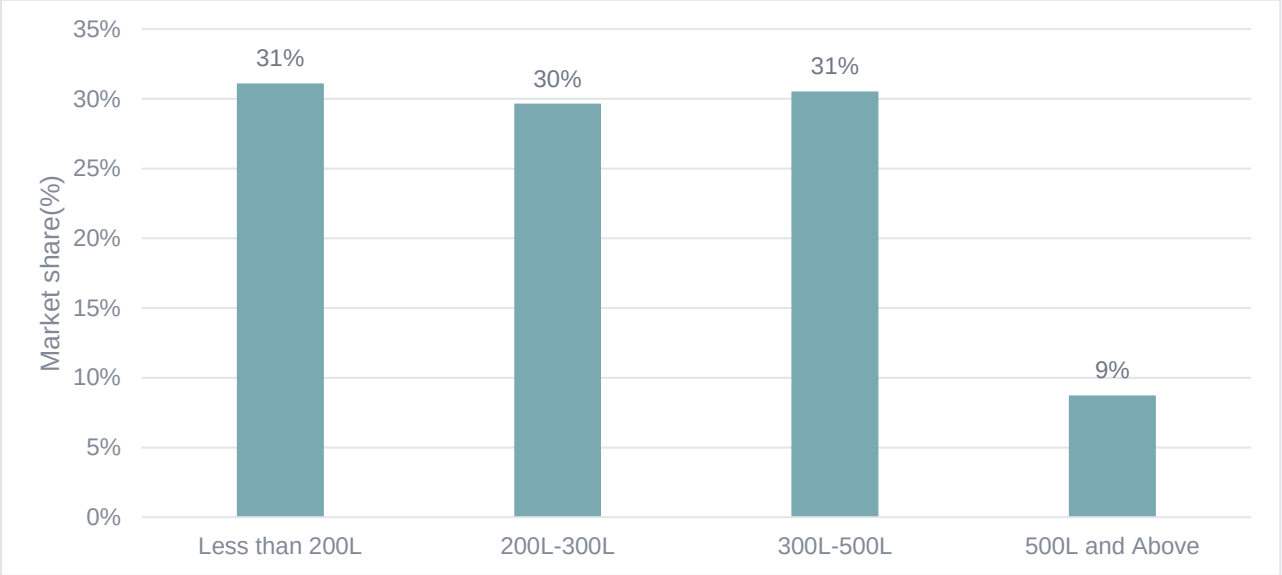
FIGURE 18: AUTOMATIC ICEMAKER FEATURE. N=246



d) Capacity

Figure 19 shows the distribution of current market by capacity (Gross volumes of both the refrigerators and freezer compartments). There is almost an equal market share for appliances with less than 200L (31%), 200-300L (30%), and 300-500L (31%). With merely 9% of retailer's data with adjusted volume of above 500L.

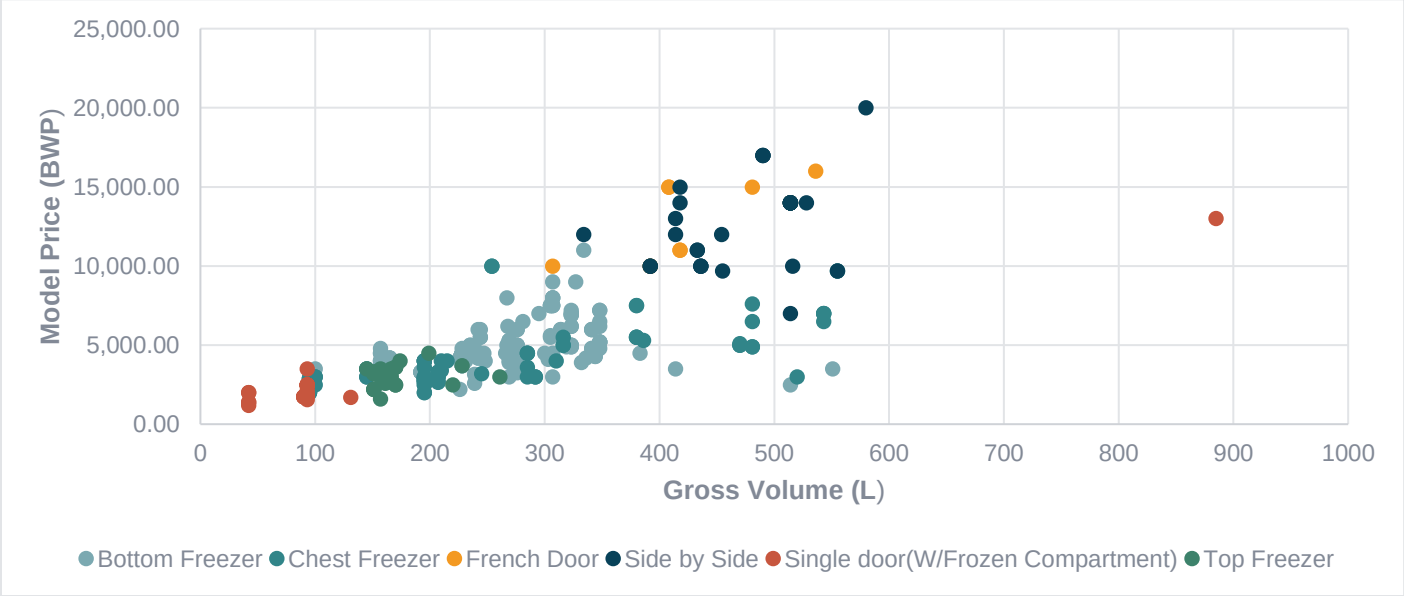
FIGURE 19: DISTRIBUTION OF REFRIGERATOR SALES BY CAPACITY (GROSS VOLUME. N=344



e) Price Analysis

The team collected price and volume information for 321 refrigerating appliances models at retailers' stores. The price data was then analyzed to determine a price range by door type and volume/capacity. This information is shown in Figure 20 and Figure 21 below.

FIGURE 20: PRICE OF REFRIGERATING APPLIANCES



Key observations related to price in Botswana market:

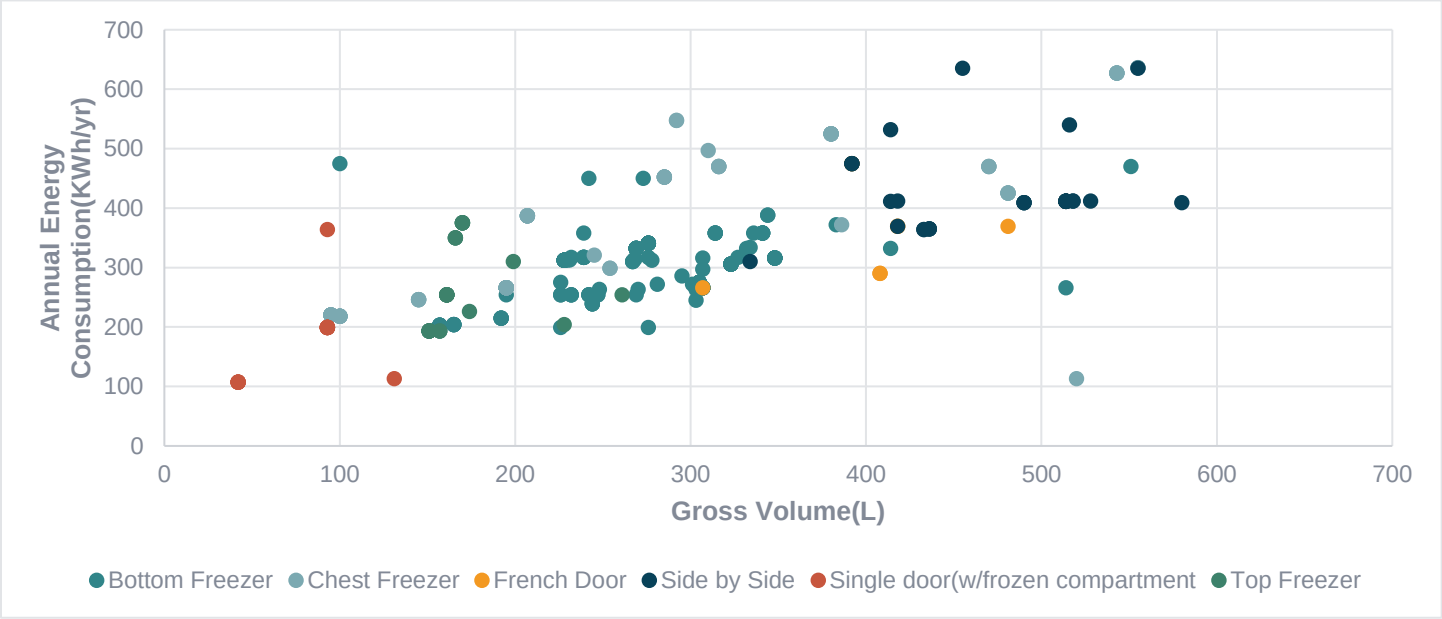
- The price of single door (w/frozen compartment) ranges from 1199 to 12999 BWP and these are available from the range of 42L to 885L Capacity and the price of chest freezer ranges from 1999 to 9999 BWP and these are available from 95L to 555L capacity. Whereas double-door refrigerators price ranges from 1599 to 19999 BWP

- In the case of double-door refrigerators, the price range is very wide because these refrigerators are available across the varied capacity range.
- Mostly, the price of refrigerators (all categories considered) is proportional to the gross volume.
- The double-door bottom-freezer refrigerators are more expensive when compared to double-door top-freezer refrigerators.
- Side-by-side-door refrigerators are usually available in bigger capacity ranges i.e., beyond 300L, and their cost ranges from 6999 to 19999 BWP

f) Energy Consumption/Energy efficiency.

Botswana does not have an energy labeling scheme, therefore the labels on some of the appliances were majorly from South Africa. The team collected annual energy consumption and volume for 311 for refrigerating appliances models at retailers. The annual energy consumption data was then analyzed to determine the annual energy consumption range by door type and volume/capacity as shown in the figure below.

FIGURE 21: ANNUAL ENERGY CONSUMPTION OF REFRIGERATING APPLIANCES



Key observation related to energy consumption in Botswana market include:

- The annual energy consumption of single door (w/frozen compartment) refrigerators ranges from 107 to 364Kwh/year and chest freezers range from 113 to 636Kwh/year.
- The annual energy consumption for double door ranges from 193 to 635Kwh/year.

3.1.5. BARRIERS TO THE SALE OF EFFICIENT RESIDENTIAL REFRIGERATORS (GROUPED INTO FINANCIAL, AWARENESS & CAPACITY BARRIERS)

Due to generally high levels of poverty in southern Africa, the markets are extremely price sensitive. Energy efficiency typically comes at a cost and any additional costs have large impacts on short term cash flows. High cost of energy efficient units drives consumers to purchase lower quality and entry levels units at the expense of efficiency.[6] Additionally, Botswana does not have regulatory framework and consumer awareness programs for refrigerator energy efficiency.

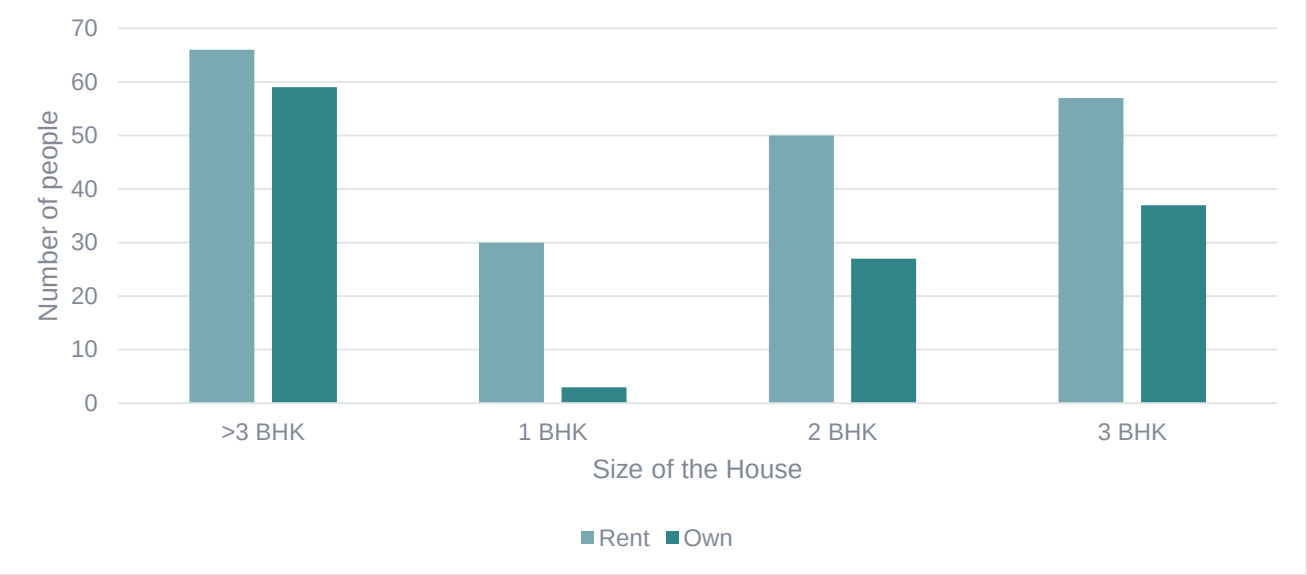
3.2. REFRIGERATOR DEMAND-HOUSEHOLDS

[6] Country Profile Botswana. https://www.ctc-n.org/system/files/dossier/3b/country_profile_-_botswana_0.pdf

3.2.1. GENERAL CONSUMER INFORMATION (HOUSEHOLD SIZE, HOME OWNERSHIP, SALARY INCOME BRACKET, TYPE OF EMPLOYMENT ETC).

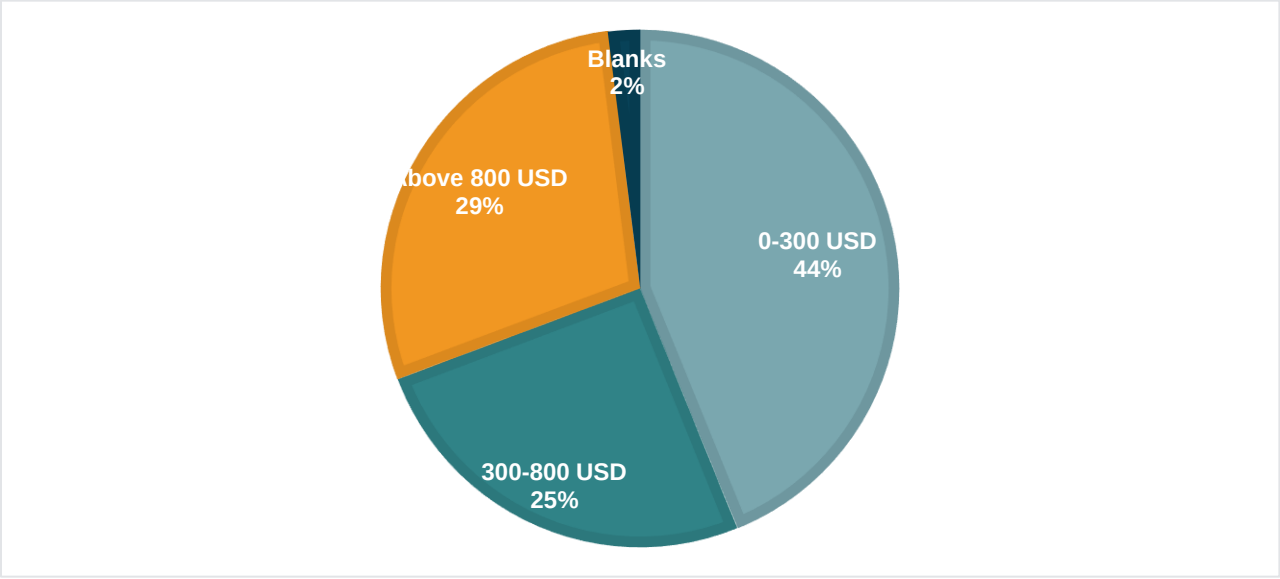
As of 2019, the average household size in Botswana was 3.3 people per household. [7] During the survey, the information collected from the household indicated that the majority of the families in Botswana consist of 1-6 family members who are above the age of 8 years. Most of the families reported they lived in more than three bedrooms and two-bedroom houses. Additionally, majority of the respondents indicated they did not own the houses they lived in.

FIGURE 22: HOUSE SIZE AND OWNERSHIP OF THE HOUSE. N=329



Majority of the respondents interviewed indicated they work. The type of employment varied widely from accountants, business owners, carpenters, nurses, lectures, chefs among other professions. Most of the respondents indicated their average monthly household income ranged from 0-300 USD.

FIGURE 23: AVERAGE MONTHLY HOUSEHOLD INCOME (N=359)



[7] Average Household Size in Botswana. https://www.africageoportal.com/datasets/923a57e6b48f42af8a0ba6e9dd2d9180

3.2.2. LEVEL OF FINANCIAL INCLUSION (MOBILE MONEY, MICROFINANCE CUSTOMER, BANK ACCOUNT OWNERSHIP, CREDIT CARD OWNERSHIP, PRECIOUS LOAN RECIPIENT AND TYPE, ETC.)

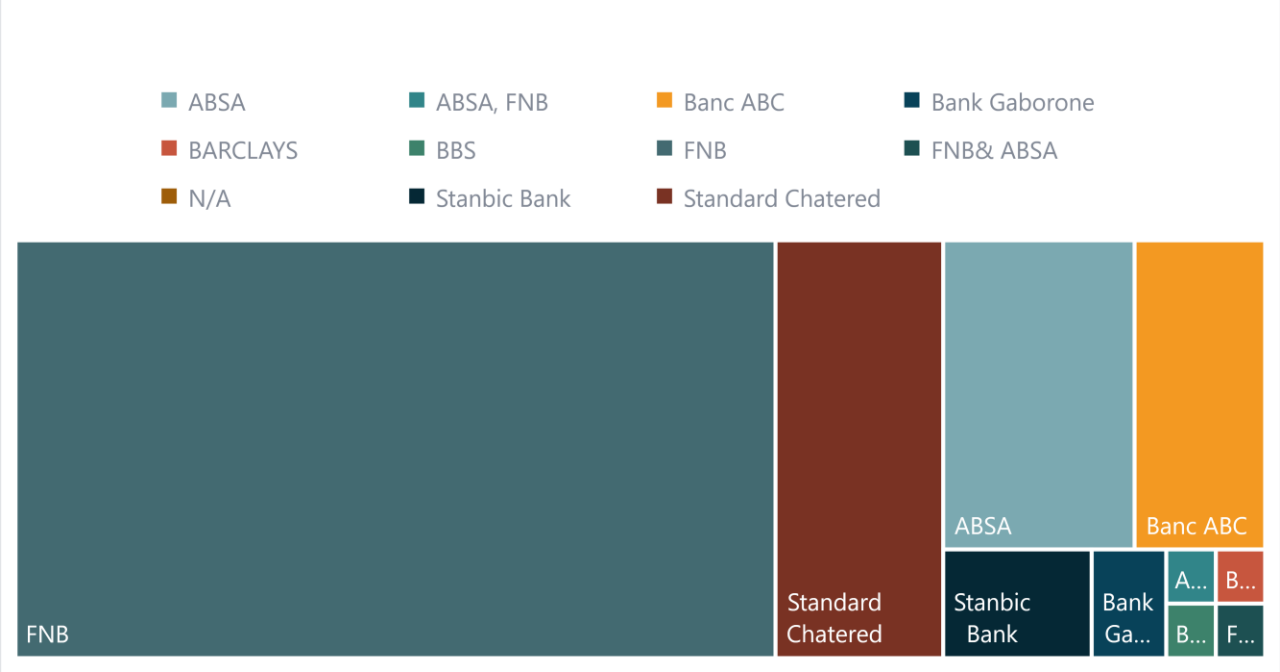
The share of mobile money users has been increasing in Botswana over the past years. As of January 2021, 24.4% of population aged 15years and older had a mobile money account in Botswana.[8] Existing mobile money services in Botswana include Smega by BTC, Orange Money by Orange Botswana and Myzaka by Mascom.[9]

10

Botswana registered rate of bank account ownership has also been increasing over the past years, As of January 2021, account ownership was at 51% of the population aged 15years and older. [11] Of the surveyed respondents, majority (196) indicated they owned a back account. However, only 49 respondents said they have ever taken a loan from their financial institution. Majority of the respondents who indicated they ever took a loan, the duration of their loan repayment was 5 years.

The most common financial institution in Botswana is the first National Bank of Botswana Limited (FNB). However, significant other financial institutions are common in Botswana. Of the respondents that indicated they had bank account, 118 of them said they have accounts with FNB.

FIGURE 24: BANK ACCOUNT OWNERSHIP IN FINANCIAL INSTITUTIONS



Credit ownership in Botswana is still low. As of January 2021, approximately 7.2% of the population aged 15years or older owned at least one credit card in Botswana. The share declined in comparison to 2018, when the rate of card ownership was measured at 10%.

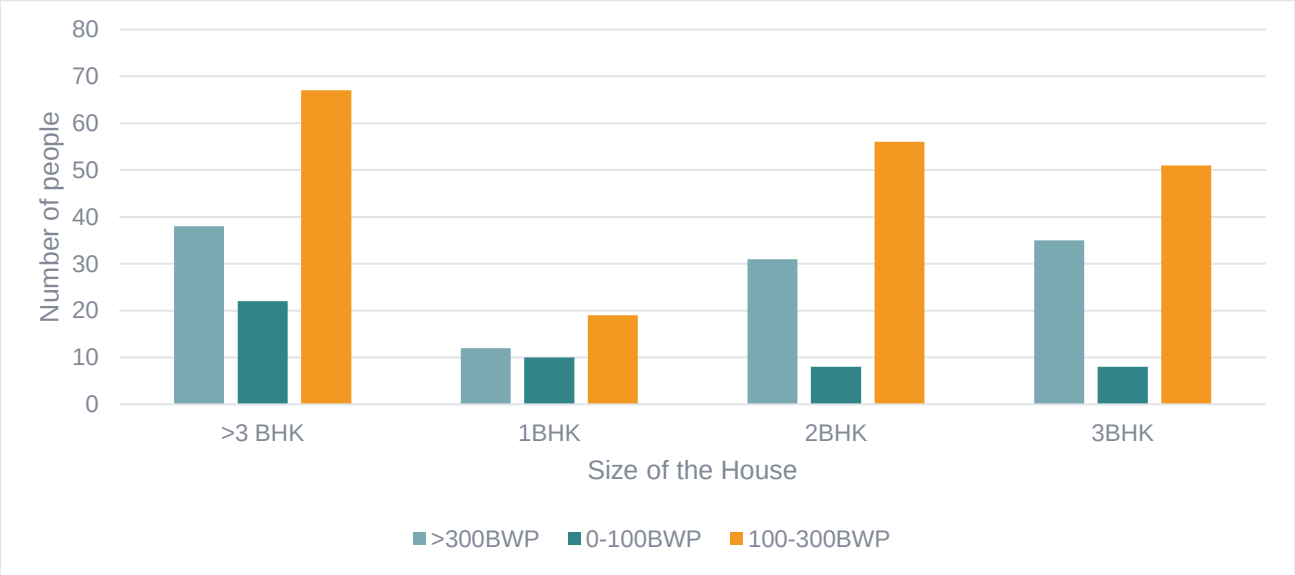
[8] Julia Faria, (2021). mobile money accounts In Botswana 2018-2021. https://www.statista.com/statistics/1155782/mobile-money-accounts-botswana/
[9] Tsa Tuelano ,(2020). The Botswana National Payment System Newsletter. https://www.bankofbotswana.bw/sites/default/files/publications/BOB%20Newsletter%202020.pdf

[11] Julia Faria,(2021) Bank account owners In Botswana 2018-2021. https://www.statista.com/statistics/1155784/bank-account-owners-botswana/#:~:text=As%20of%20January%202021%2C%20Botswana,population%20had%20a%20bank%20account.

3.2.3. CURRENT EXPENDITURE ON ELECTRICITY (METERING TYPE, PRE/POST PAID, PAYMENT METHOD, MONTHLY/WEEKLY EXPENDITURE, ETC.)

The Botswana power Corporation (BPC) is the main electricity distributor and retailer. Its customers are connected through postpaid and prepaid systems with majority of the household connections being through prepaid systems. [12] From the household data, majority (196) of the consumers average monthly electricity expenditure was 100-300BWP. However, there was a significant high number as well of consumers (116) whose average monthly electricity expenditure was above 300BWP. The size of the house influenced the monthly electricity expenditure. In most cases, electricity expenditure increased with the size of the house. Nevertheless, it was interesting to note that in some cases, monthly electricity expenditure was high even in small size house.

FIGURE 25: MONTHLY ELECTRICITY CONSUMPTION PER HOUSE SIZE. N=357



3.2.4. OWNERSHIP OF REFRIGERATING EQUIPMENT (TYPE, CAPACITY-ADJUSTED VOLUME, TECHNOLOGY-MANUAL FROST OR FREE FROST, REFRIGERANT, TYPICAL AGE, PURCHASED NEW/SECOND HAND, PURCHASE CHANNEL-INSTORE OR ONLINE, PURCHASE PRICE, ENERGY CONSUMPTION/EFFICIENCY LABEL CLASS/PROXY ETC.

a) Refrigerating Types

The installed stock of refrigerating equipment in Botswana can be broadly segmented based on product type (refrigerator-freezers, freezer and refrigerator) and door type. The most common owned appliance among the household consumer in Botswana is the refrigerator-freezer (figure 26) and while products that are solely refrigerators exist in households, they are few in numbers.

The household refrigerating market can also be segmented as, single-door with small interior frozen compartment, double door (bottom freezer, top freezer) French door, side-by-side and chest freezer types. Out of the overall household appliance ownership, bottom freezer accounts for 68% while french-door, side-by-side and single-door with small interior frozen compartment accounts for 6.3% ownership.

[12] GSMA. https://prepaidenergyhub.com/gsma-highlights-benefits-mobile-enabling-services-sub-saharan-utilities/

FIGURE 26:OWNERSHIP OF APPLIANCES

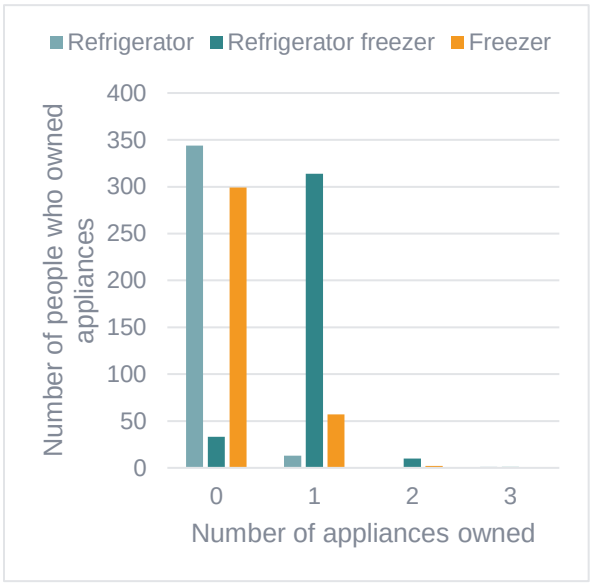
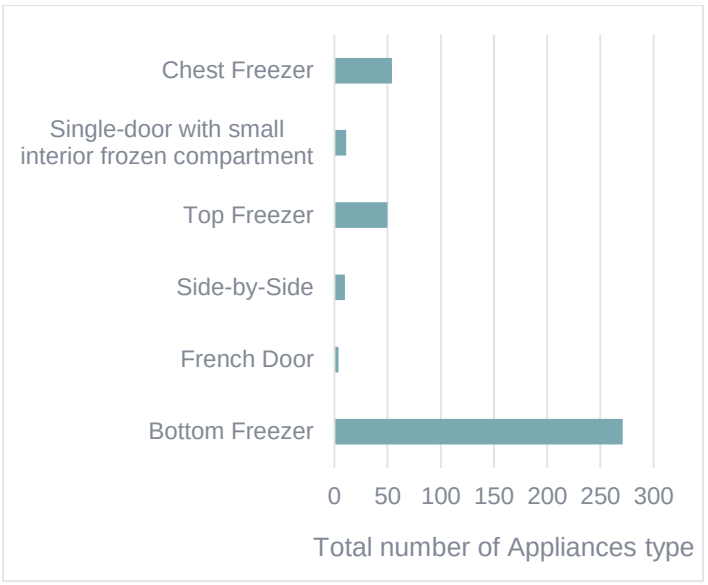


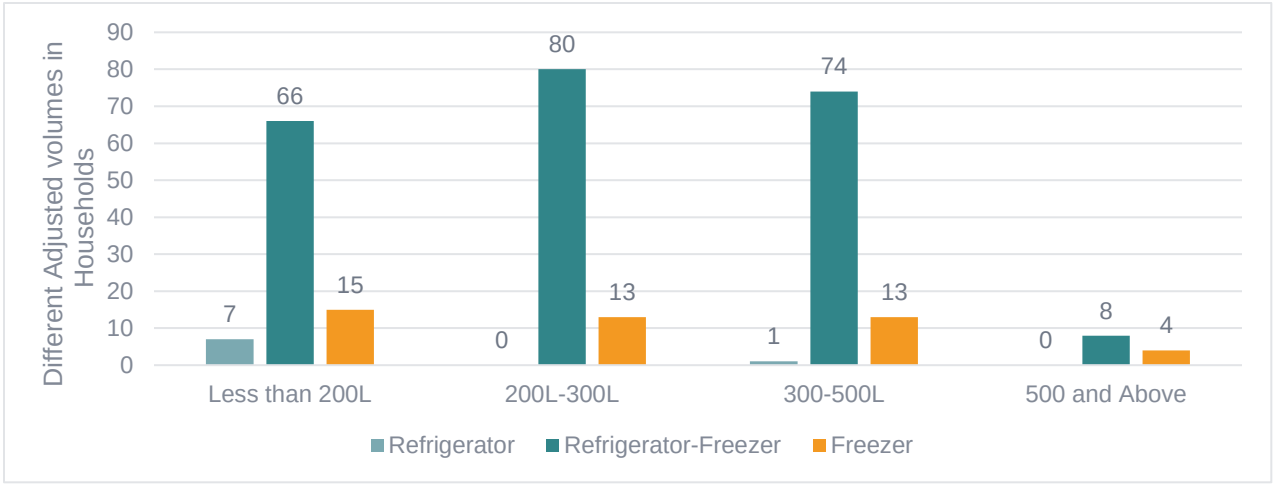
FIGURE 27: SHARE OF OWNERSHIP OF DIFFERENT DOOR TYPES



b) Capacity-Adjusted volume

Figure 28 shows the distribution of household ownership by capacity (adjusted volumes of refrigerators, refrigerator-freezer and freezers). There is an equal household market share for appliances with less than 200L (31.32%), 200-300L (33.10%), and 300-500L (31.32%). With merely 4.27% of households with adjusted volume of above 500L. This finding matches the distribution of models in retailer's stores shown in Figure 10 above, where we had an almost equal share of capacity of less than 200L, 200-300L, 300-500L, with very few models with capacity of 500L and above in the market.

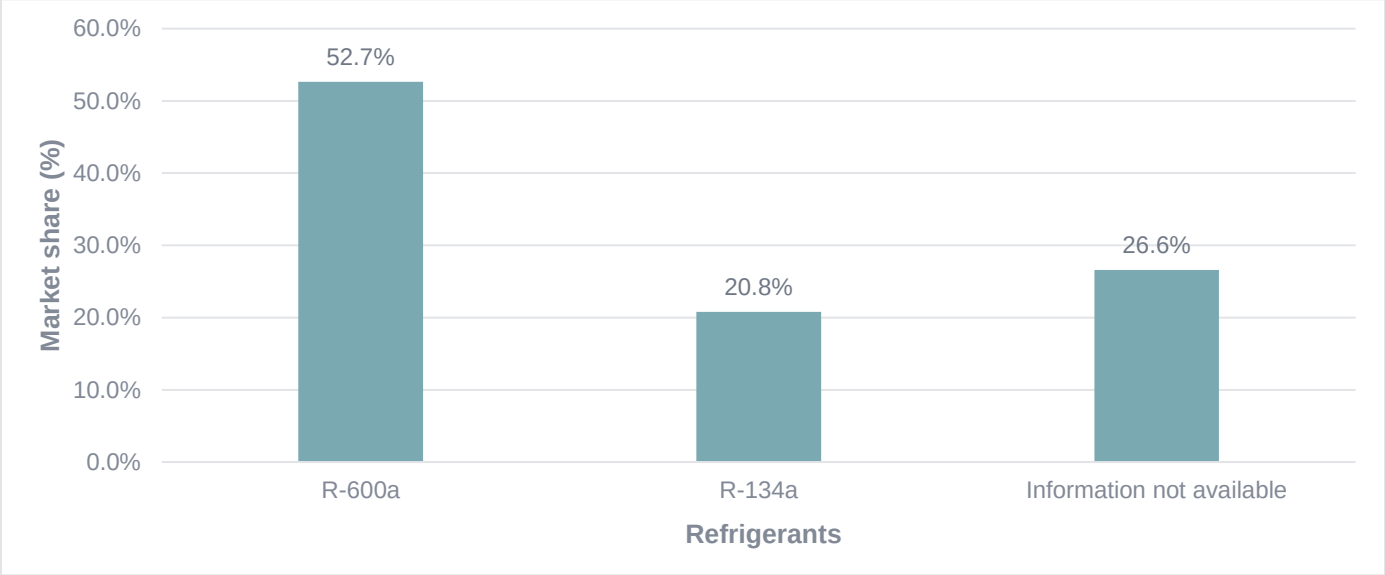
FIGURE 28: DISTRIBUTION OF REFRIGERATING APPLIANCES BY CAPACITY.



c) Refrigerants

The project team found that the household refrigerating appliances in Botswana use both R-600a and R-134a. In some instances, the refrigerants were not declared on the appliances. R-600a was used in 52.7% of the household while R-134a accounted for 20.8% of the household refrigerators. This was slightly different compared to the current market, as nearly almost all the refrigerating appliances had R-600a as their refrigerant. This is not surprising given that the country has actively discouraged Ozone depleting and high GWP refrigerants as a signatory to the Montreal protocol and all its subsequent amendments.

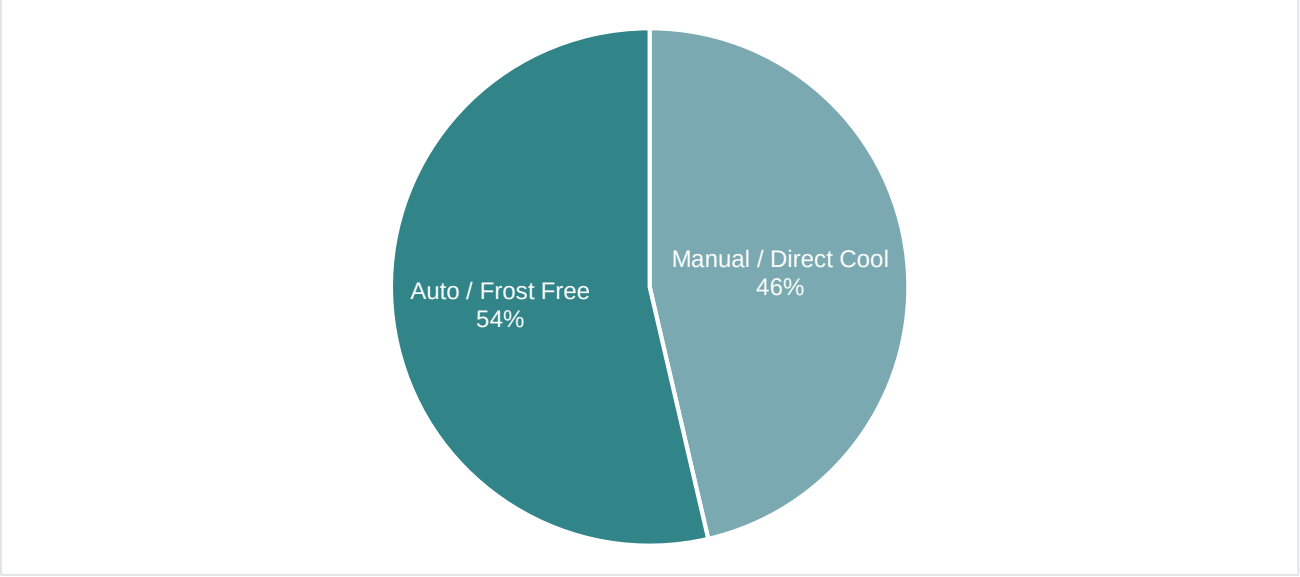
FIGURE 29: 19: OVERALL HOUSEHOLD SEGMENTATION OF REFRIGERANTS. N=358



d) Technology-Manual or Auto Defrost

The project team found out that the household refrigerating appliances in the Botswana market are characterized by both Manual /direct cooling and auto defrost with Auto defrost slightly more than the manual. This was similar to the retailer's data where the project team found out that the Auto defrost technology was more than the manual defrost technology.

FIGURE 30: D) TECHNOLOGY-MANUAL OR AUTO DEFROST



e) Typical Age & Purchased New/Second-Hand

The project team found that majority of households in Botswana purchased new refrigerating appliances. While products that were bought second hand exist, they are few in numbers. Additionally, the typical age of these appliances varied widely, but with majority of appliances having a typical age of less than 3years and between 3-7years.

FIGURE 31: WHETHER APPLIANCES WERE PURCHASED NEW OR SECOND HAND

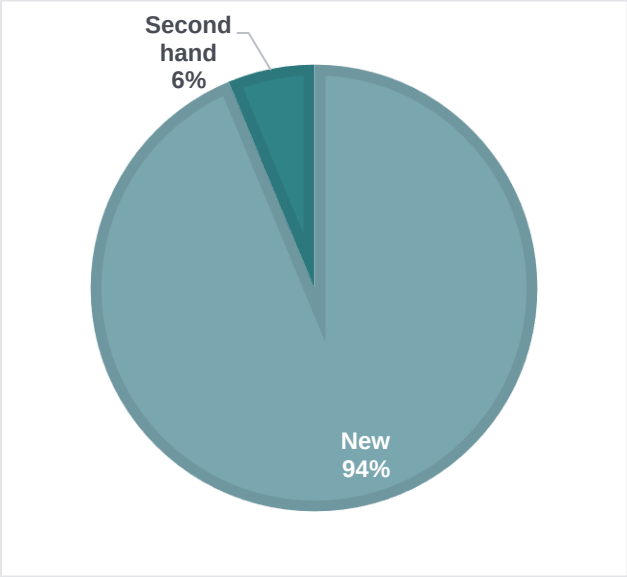
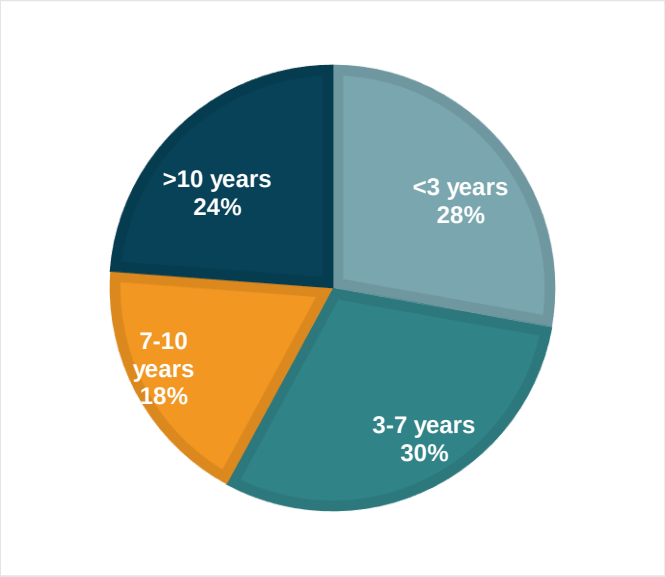
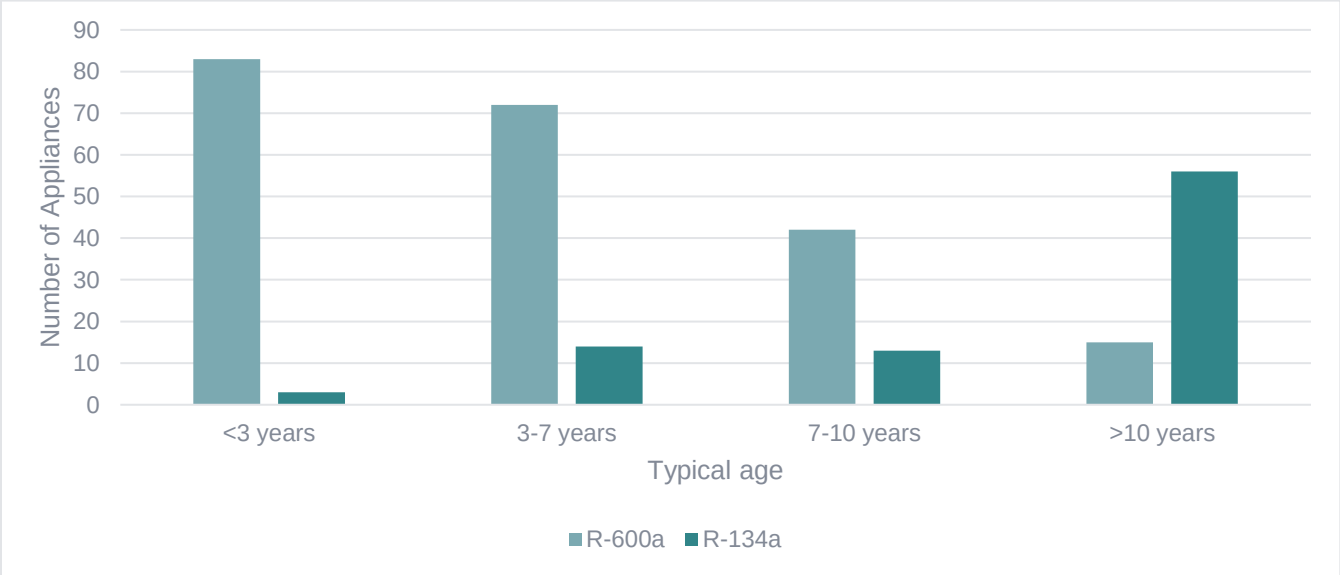


Figure 32: TYPICAL AGE OF APPLIANCES



The data was analyzed according to the typical age of a refrigerating appliances and their respective refrigerants used. The project team found that older refrigerating appliances used R-134a while newer appliances used R-600a as shown below.

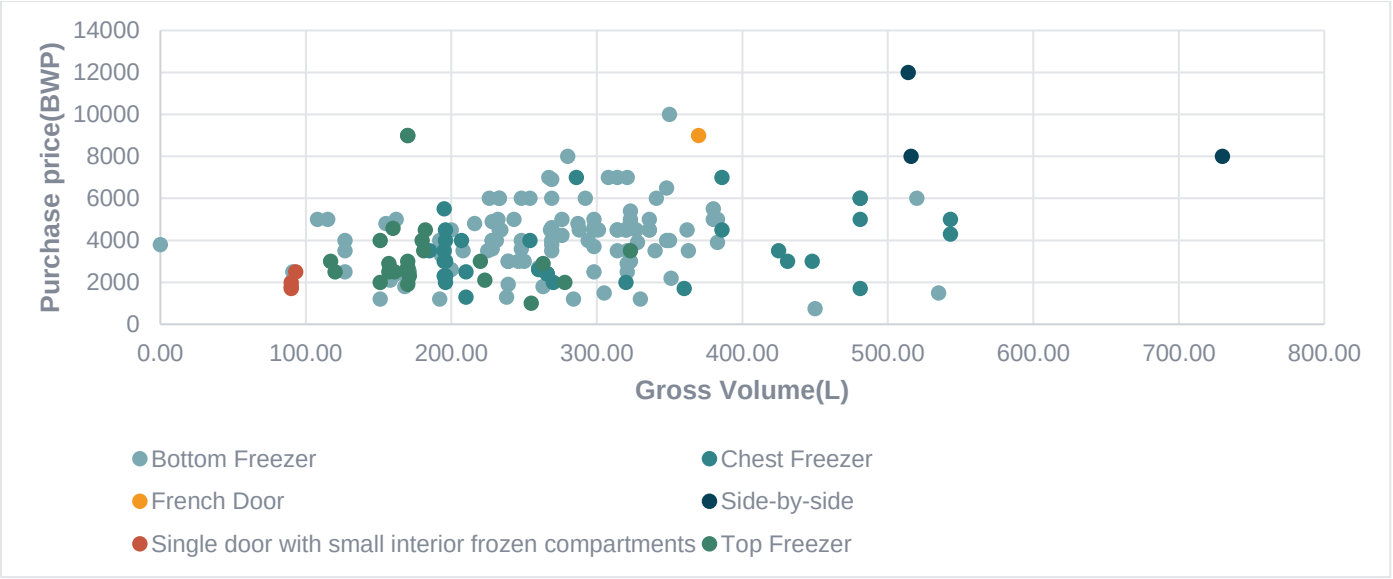
FIGURE 33: AGE OF REFRIGERATING APPLIANCES VERSES THE TYPE OF REFRIGERANT USED.N=298



f) Purchase price

The team analyzed the purchase price of the refrigerating appliances in households based on the volume and the door type as shown below.

FIGURE 34 PURCHASE PRICE. N=183



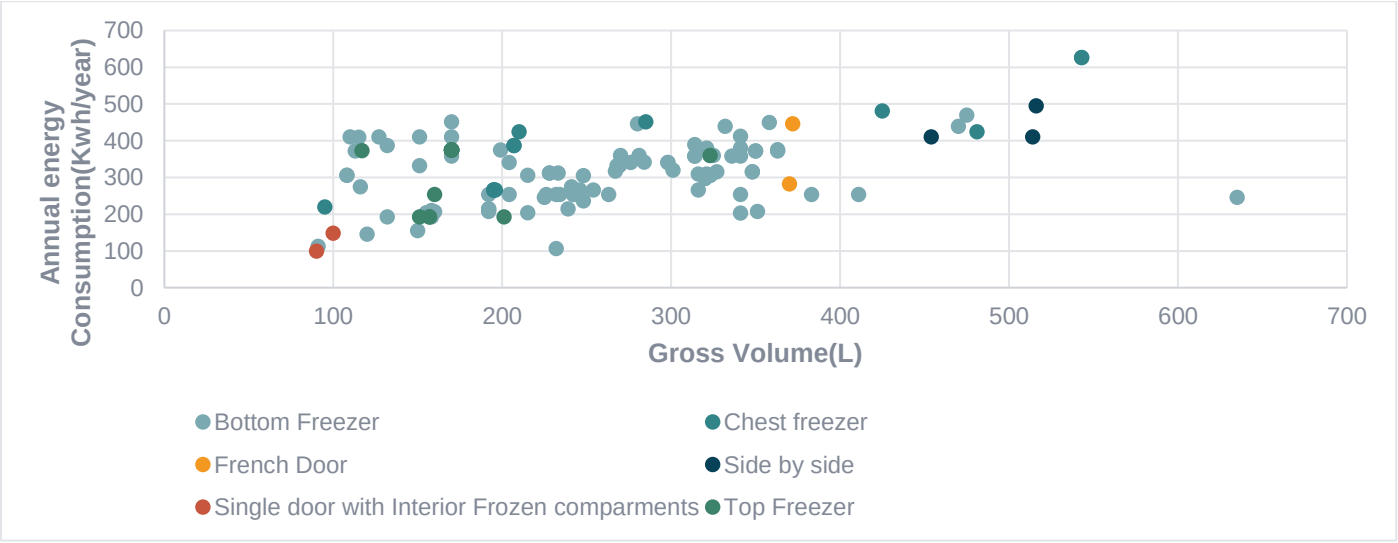
Key observations related to purchase price in Botswana households:

- The price of new single door with small interior frozen compartment refrigerators ranges from P1700 to P2500 and this are available in the range of 90L to 200L capacity, and price of chest freezer ranges from P2300 to P7000. While double -door refrigerators range from P1200 to P15000.
- In the case of the double-door refrigerators, the price range of refrigerators is very wide because these refrigerators are available across the varied capacity range and this was similar to the current installed market.

g) Energy consumption/efficiency level

Botswana does not have an energy labeling scheme, therefore the labels on some of the appliances were majorly from South Africa. While product that had an energy label from other regions such as South Korea, EU, China, Swaziland existed, they were few in numbers. The table and figure below show the energy consumption of different refrigerators by the door type.

FIGURE 35: ANNUAL ENERGY CONSUMPTION. N=138



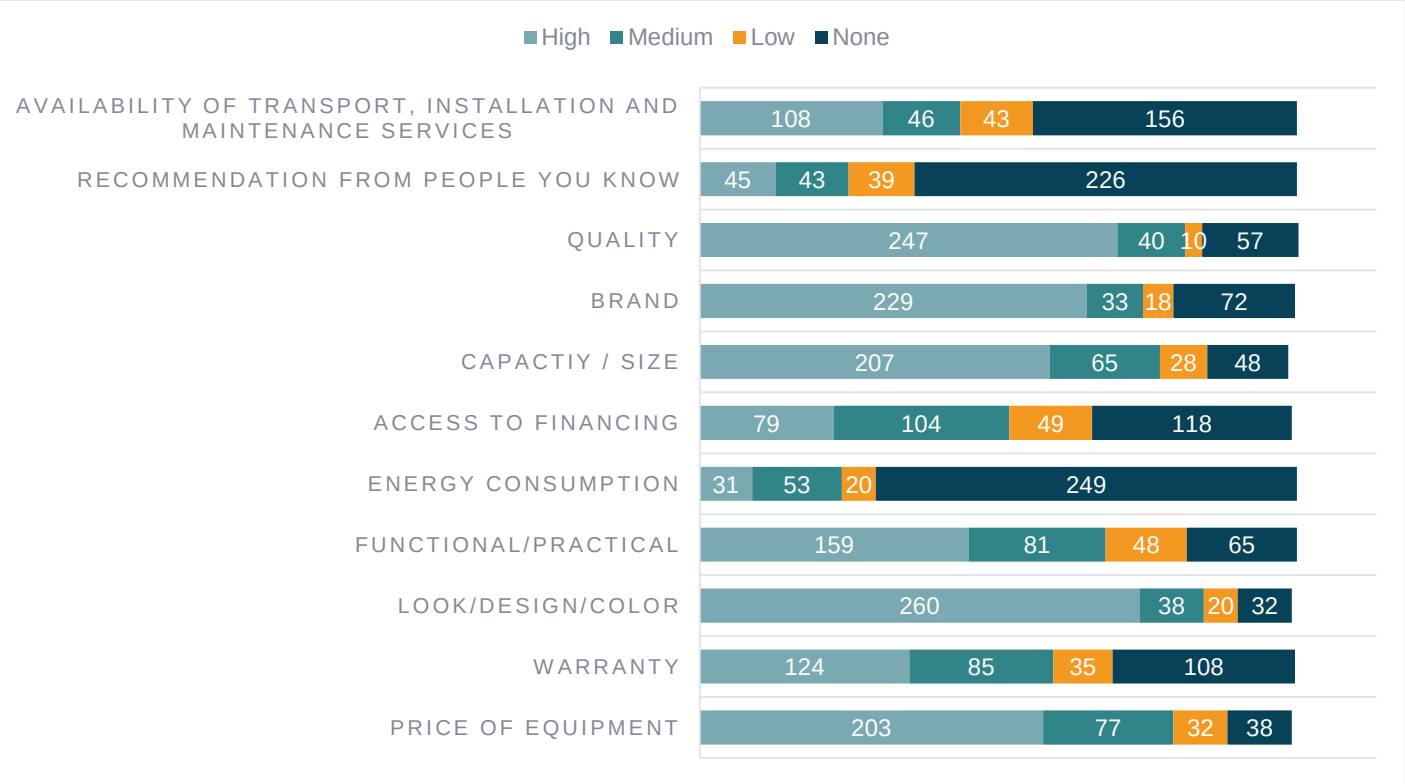
Key Observation related to energy consumption in Household Botswana:

- Energy consumption for single door with small interior frozen compartment ranges from 100Kwh/year to 148Kwh/year and chest freezer ranges from 220Kwh/year to 627Kwh/year. Whereas energy consumption for double doo ranges from 107Kwh/year to 495Kwh/year.
- Energy consumption of refrigerating appliances was not directly proportional to the age of the equipment.

3.2.5. DESIRED FEATURES OF EQUIPMENT

During the household survey, the team questioned household representative about factors that influence their purchasing decisions. In the questionnaires, the households were given a list of parameters and told to rank if they considered those factors as high, medium, low or none during the purchase of their refrigerating appliance. There were variations found across all household respondents, however, most of the respondents indicated they did not consider energy consumption as an influence while purchasing appliances.

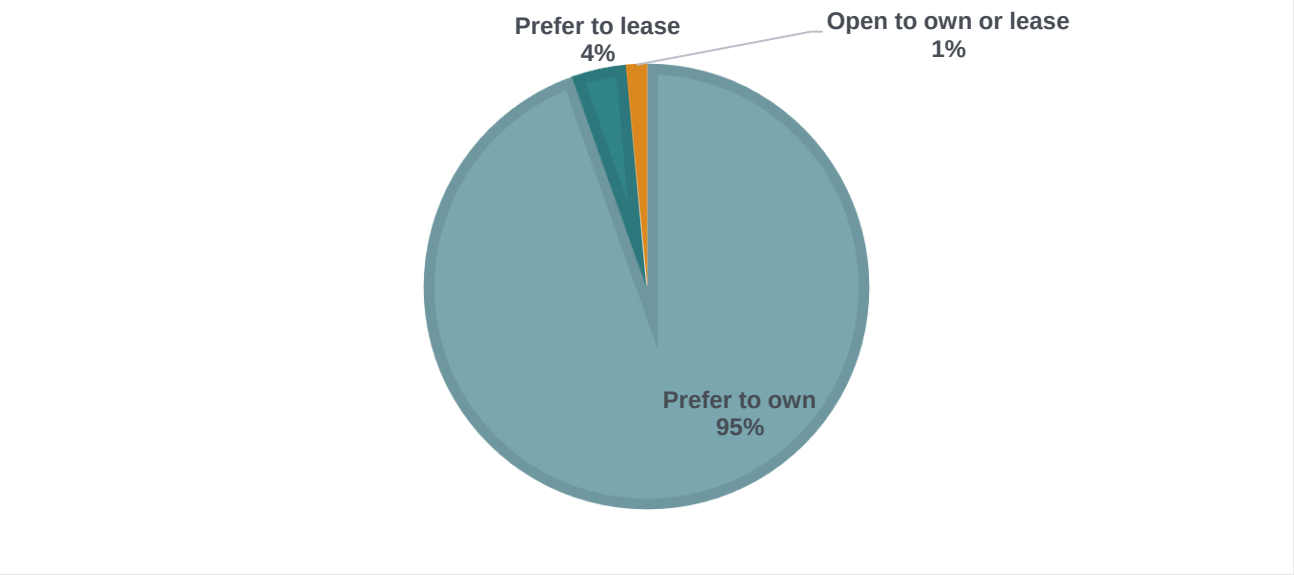
FIGURE 36: FACTORS HOUSEHOLDS CONSIDER WHEN PURCHASING REFRIGERATING APPLIANCES



3.2.6. CONSUMER PREFERENCE ON PURCHASE OF A REFRIGERATOR- REFER TO HOUSEHOLD SURVEY RESULTS AND CONDUCT ADDITIONAL ONLINE RESEARCH TO CROSS-CHECKS SURVEY DATA AGAINST

The project team asked the household's representative if the next time they purchase refrigerating appliance they would prefer to own or lease the refrigerating appliances. From the survey, majority of the households indicated they would prefer to own their refrigerating appliances.

FIGURE 37: CONSUMER PREFERENCE ON PURCHASE OF REFRIGERATING APPLIANCES



3.2.7. BARRIERS TO THE PURCHASE OF EFFICIENT REFRIGERATORS (GROUPED INTO FINANCIAL, AWARENESS & CAPACITY BARRIERS)

Due to generally high levels of poverty in Southern Africa, the markets are extremely price sensitive. Energy efficiency typically comes at a cost and any additional costs have large impacts on short term cash flows. High cost of energy efficient units drives consumers to purchase lower quality and entry levels units at the expense of efficiency. [13] Additionally, Botswana does not have regulatory framework and consumer awareness programs for refrigerator energy efficiency. Consumer awareness on the benefits of energy efficient appliance is generally low as shown in figure 27 above where majority indicated they do not consider energy consumption while purchasing refrigerating appliances.

3.3. EQUIPMENT STOCK AND PROJECTIONS

3.3.1. SUMMARY OF RESIDENTIAL REFRIGERATORS IN THE MARKET BASED ON HOUSEHOLD DEMAND (PRODUCT TYPES, FEATURES, AVERAGE ANNUAL ENERGY CONSUMPTION, REFRIGERANTS ETC.)

The typical current market of the refrigerator in Botswana consists of the single door (W/frozen compartment), bottom freezer, top freezer, french door, side by side, and chest freezer. The refrigerators comprise of either manual or automatic defrost technology except for french door and side by side, which consist of only auto defrost technology. The R-134a refrigerant is phased out and the R-600a refrigerant is what is currently available in the market. The typical volume, typical energy consumption, and typical price for each refrigerating type in the current market is shown below in figure 38

[13] Country Profile Botswana. https://www.ctc-n.org/system/files/dossier/3b/country_profile_-_botswana_0.pdf

FIGURE 38: TYPICAL CURRENT MARKET IN BOTSWANA

Type	Defrosting Technology	Typical Total Volume (liters)	Energy consumption at typical volume (kWh/year)	Average price of models meeting both criteria (BWP)
Single door (w/frozen compartment)	Manual	90	281.5	1,816
Single door (w/frozen compartment)	Auto	93	199	2,351
Bottom Freezer	Manual	286	313.5	5,099
Top Freezer	Manual	161	193	2,721
Bottom Freezer	Auto	269	332	4,676
Top Freezer	Auto	161	254	2,850
French Door	Auto	418	329.5	12,999
Side by Side	Auto	514	411	13,299
Chest Freezer	Manual	210	387	2,993
Chest Freezer	Auto	95	220	2,385

3.3.2. TECHNOLOGY TRENDS AND MARKET PROJECTIONS.

1. Technology Trends

The project team observed the following in the current market.

- R-134a refrigerants are phased out in the market.
- Bottom freezer and chest freezer are more consistently popular in the market
- French door and side-by-side available in the current market have auto defrost technology.
- Automatic ice makers were very scarce in the current domestic market in Botswana.
- The refrigerators come in varied capacity with very few models with gross volume of above 500L
- Side-by-side-door refrigerators are usually available in bigger capacity ranges i.e., beyond 300L

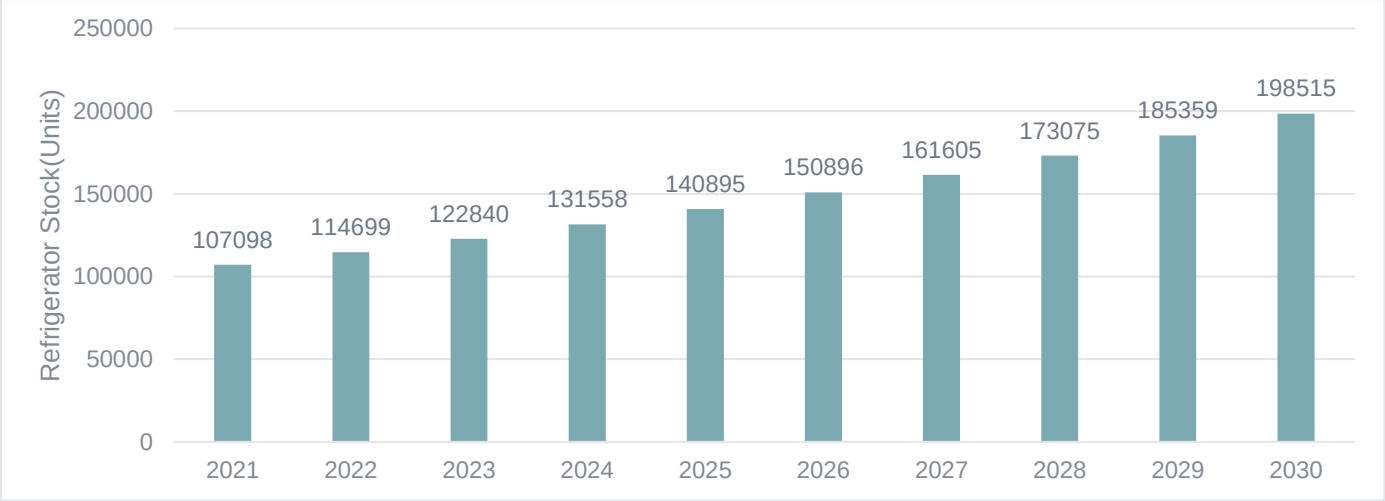
2. Sales and Market Forecast

The current market size is estimated to be around 100000 units per year as indicated from the product suppliers and distributors' interviews as well as Comtrade import and export. As can be seen in Figure 39 below, over the last 10 years (from 2010 to 2020) refrigerator sales have increased with a CAGR of 6.4%. The refrigerator is considered an essential household appliance because of the climatic conditions and the need for refrigerating essential daily items such as milk, vegetables, and meat. This increase in the ownership rate of refrigerators is consistent with CLASP's experience in other developing countries with high electrification rate and population and income growth: as people grow richer, a refrigerator is one of the first appliances they buy.

CLASP looked at Comtrade imports and exports, as well as our interviews with importers and estimated a 7%[14] growth rate in sales which was the used to forecast the stock in future as shown below. The stock in 2030 is estimated to be 198,515 units.

[14] CLASP back-calculated an approximate average growth rate based on UN Comtrade net imports values in 2007 and 2014, and importers' estimates of the market size in 2020. This growth rate was then applied across the period from 2005-2030, to create an approximation of annual sales.

FIGURE 39REFRIGERATOR STOCK FORECAST, TAKING INTO ACCOUNT NEW SALES AND RETIREMENTS



3. Policy Analysis

CLASP used the findings from this market study and developed U4E policy scenarios for Botswana. CLASP used MEPSY, a tool recently developed by CLASP to generate assessments that can be used by key stakeholders in the policymaking process.

MEPSY is a tool that helps policymakers assess the benefits of energy efficiency policies and identify the most attractive targets for MEPS levels. The model can also be used to perform robust technical analysis to support the development of MEPS, by customizing the tool with any available country-specific data.

MEPSY can estimate savings potential from implementing policies that improve the energy efficiency of products in any economy. The impacts are examined from two perspectives – the consumer and national perspective:

- At the consumer level, savings are estimated using life-cycle cost (LCC) metric - the total costs of owning the appliance, including the purchase price and the electricity cost throughout its life between business as usual and the improved policy scenario.
- At the national level, energy savings are expressed in terms of the reduction in national energy consumption due to more efficient appliances as well as in terms of avoided CO2 emissions resulting from reduced electricity consumption.

MEPSY estimates the impacts of implementing policies that improve energy efficiency of new equipment by calculating the difference between a business-as-usual scenario (i.e., no policies implemented) and a policy scenario (i.e., U4E policy scenario). The model uses a bottom-up approach, based on a stock model and sales forecasts considering first purchase (increase in number of households and ownership levels) and replacement of retired appliances.

In the model, total energy consumption is estimated per year for the stock in use under each policy scenario. Emissions are estimated using an electricity CO_2-intensity emissions factor, CO_2/kWh. Costs consider appliance prices (defined for each scenario using a cost-efficiency curve reflective of the market) and local electricity prices to estimate total life cycle cost (purchase price and cost of electricity bill over appliance lifetime).

CLASP used the following data inputs and assumptions to estimate the impacts under different scenarios for refrigerators

- Electricity price of 1.1205 BWP/Kwh based on the most recent price of the tariff for both rural and urban areas.
- Transmission and distribution (T&D) losses at 1.52268161% as listed in MEPSY
- CO_2 emissions factor 1.179467533kg/kWh was applied, as listed in MEPSY
- The standard year or year when policy is implemented is set at 2022.
- Consumer discount rate of 1.6%.
- Lifetime of the product 17.68 as listed in MEPSY
- Shipment sales and forecast (2020-2030)

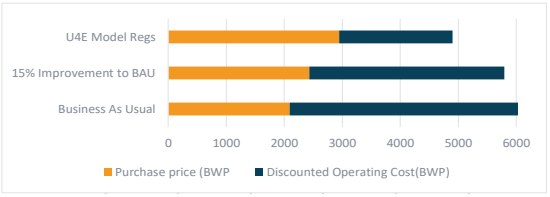
A. IMPACTS TO CONSUMERS

The impacts to consumers from U4E policy scenario and 15% improvement to business as usual are shown in Figure 40 below. The results show a minimal purchase price increase of approximately 339BWP under the 15% improvement to business as usual and 850BWP under the U4E model for refrigerators. There is minimal purchase price increase of approximately 333BWP under the 15% improvement to business as usual and 418BWP under the U4E model for refrigerator-freezer. The impact to consumers for freezers under the 15% improvement and the U4E policy scenario show a minimal purchase price increase of approximately 689BWP and 1552BWP respectively.

FIGURE 40: CONSUMER IMPACTS UNDER DIFFERENT POLICY SCENARIOS

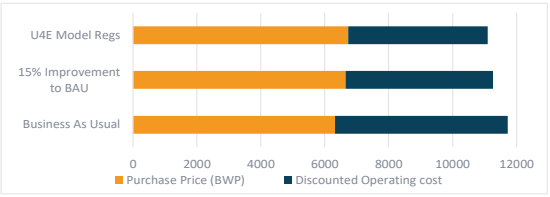
REFRIGERATOR

	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	2095	2434	2945
Unit Energy Consumption (kWh	238	203	118
Annual Operating Cost (BWP/y	267	227	132
Lifetime Operating Cost (BWP)	3944	3364	1956
Life Cycle Cost (BWP)	6039	5798	4901
Life Cycle Cost Savings (BWP)	0	241	1139
Payback Time (Years)	0	9	6



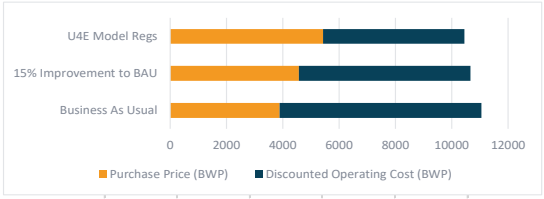
Refrigerator -Freezer

	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	6321	6654	6739
Unit Energy Consumption (kWh	326	278	263
Annual Operating Cost (BWP/y	365	311	295
Lifetime Operating Cost (BWP)	5403	4607	4359
Life Cycle Cost (BWP)	11724	11261	11098
Life Cycle Cost Savings (BWP)	0	463	626
Payback Time (Years)	0	6	6



Freezer

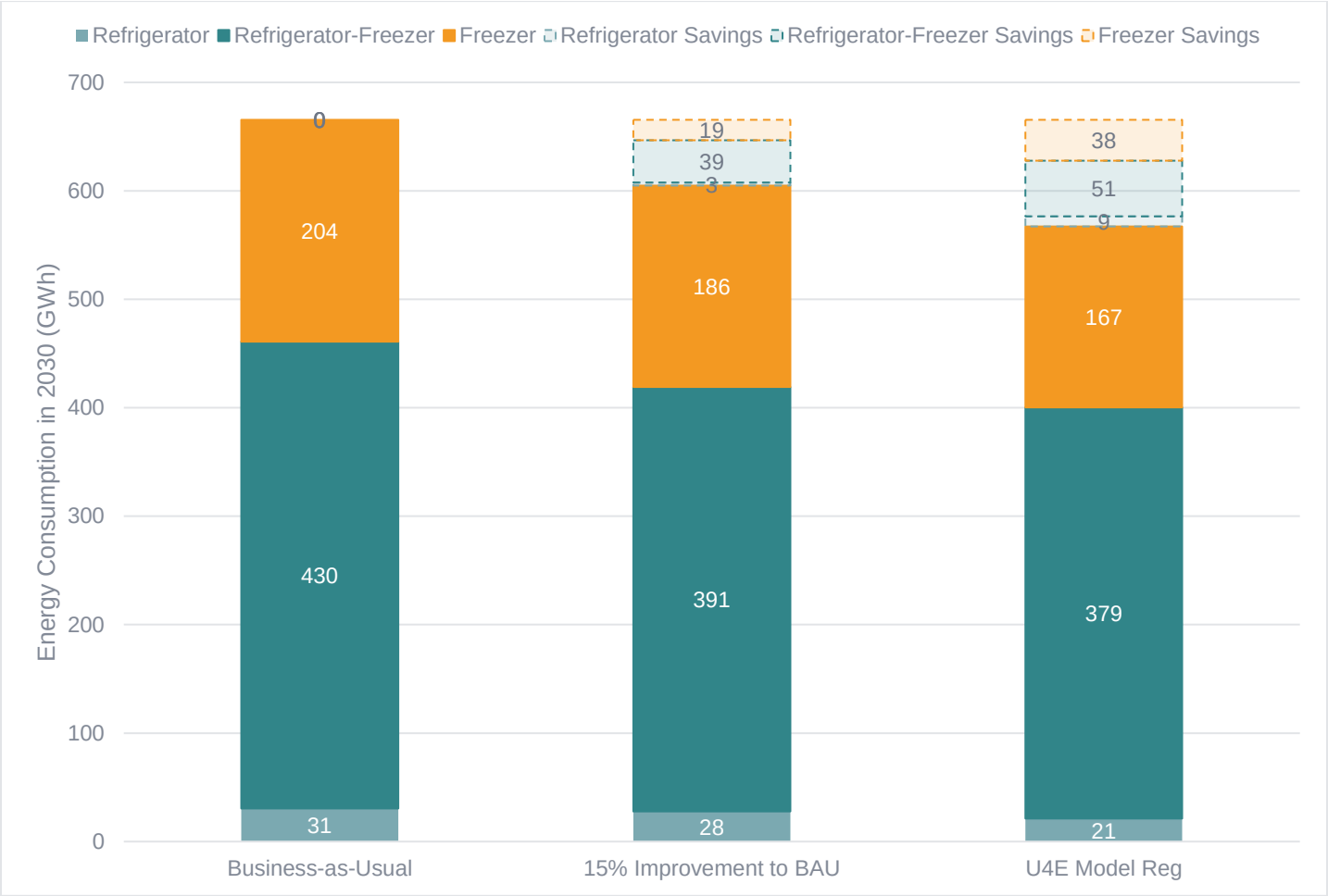
	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	3885	4574	5437
Unit Energy Consumption (kWh	433	368	303
Annual Operating Cost (BWP/y	485	412	340
Lifetime Operating Cost (BWP)	7176	6099	5022
Life Cycle Cost (BWP)	11061	10673	10459
Life Cycle Cost Savings (BWP)	0	388	603
Payback Time (Years)	0	9	11



B. IMPACTS AT NATIONAL LEVEL.

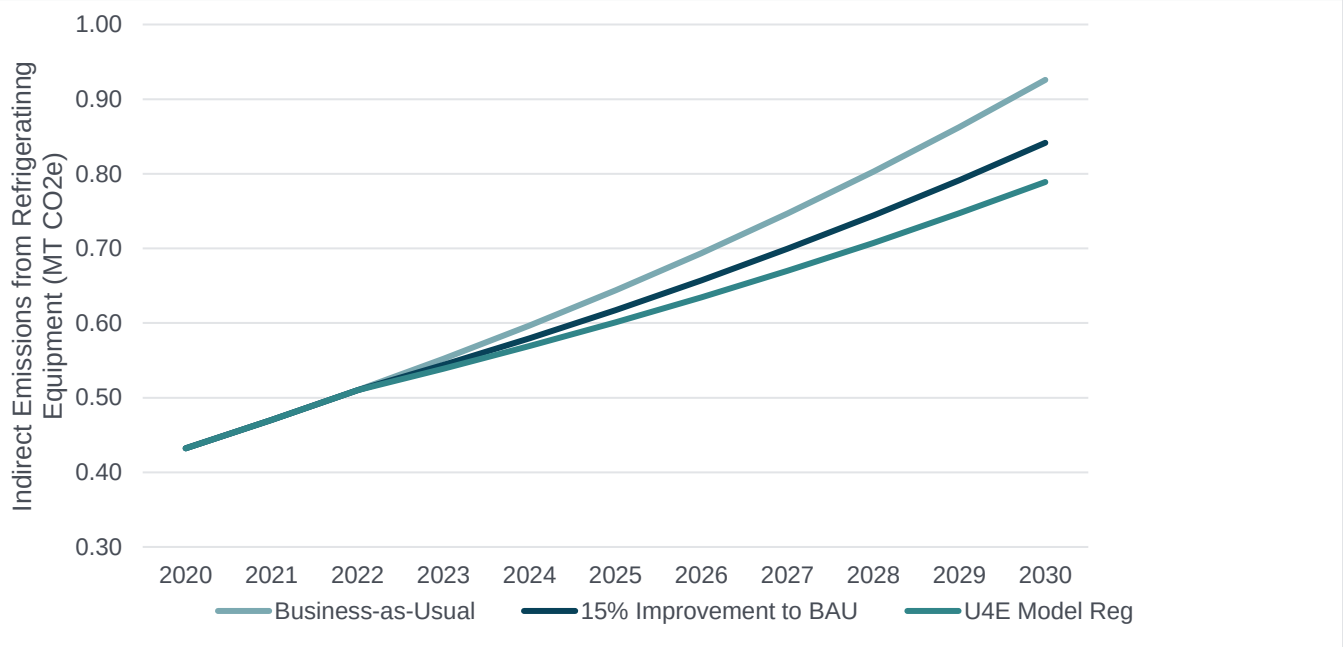
While consumer impacts of the policies are small, the large number of refrigerating appliances in Botswana results in significant energy and CO_2 benefits to the nation. Figure 41 below shows the energy consumption and energy consumption savings over the decade (2020-2030).

FIGURE 41: ENERGY CONSUMPTION UNDER DIFFERENT SCENARIOS



While figure 33 below shows the CO2 emissions from refrigerants under different policy scenarios. Cumulative CO2 emissions savings through 2030 (MT) for 15% Improvement to BAU and U4E Model Reg is 0.35MT and 0.57MT respectively.

FIGURE 42: CO2 EMISSIONS FROM REFRIGERATING APPLIANCES THROUGH 2030



3.4. POLICIES AND PROGRAMME LANDSCAPE

3.4.1. CURRENT AND PLANNED REFRIGERATOR POLICIES AND PROGRAMS

There are no current refrigerating policies and programs. However, UNIDO is implementing the Energy Efficient Lighting and Appliances (EELA) in EAC and SADC. EELA aims to support the development of vibrant markets for lighting and appliances across East and Southern Africa. Under the project, minimum energy performance standards for refrigerating appliances will be developed for the region.

3.4.2. STATUS OF ELECTRONIC-WASTE MANAGEMENT IN THE COUNTRY

In Botswana there are no specific regulations that deals specifically with e-waste although Waste Management Act was passed in 1998 after the ratification of the Basel Convention to deal with issues such as hazardous waste (management and handling). Due to the lack of "e-waste policy," there are no formal take-back systems, economic incentives, and adequate environmental standards, or separate collection channels for E-waste management[15]. The project team did not find estimate of used refrigerators within the country, where it is and where it is moving to. As a consequence, it was difficult to know the flow of secondary refrigerator equipment and waste products, and the contribution of e-waste generated by individual households, corporate sectors, public institutions, government departments, and others.

On the other side, Interviews with the government stakeholders indicated that, currently there is no evidence to suggest that Botswana is facing any challenges related to used refrigerating appliances. However, research initiatives to establish what happens to these appliances when they become obsolete should be considered.

3.4.3. STAKEHOLDER PERSPECTIVES ON OPPORTUNITIES AND BARRIERS TO TRANSFORM THE MARKET TOWARD MORE ENERGY EFFICIENT AND CLIMATE-FRIENDLY REFRIGERATORS

Department of Energy, energy efficiency section identified the following areas as an opportunity which will help in rising the appliance energy efficiency profile in Botswana.

1. Development of regulatory frameworks for appliances which includes; (MEPS, energy labelling, National Energy Efficient Register for appliances, National Energy Efficiency Act- for enforcement of energy efficiency policies.)
2. Campaigns – energy efficiency awareness
3. Development of the Energy Saving Performance Contractor (ESPC) model in order to engage private sector participation in implementing energy efficiency measures e.g., energy audit activities.

[15] Waste Electrical and Electronic equipment management In Botswana. Prospects and Challenges. https://www.tandfonline.com/doi/full/10.1080/10962247.2014.892544

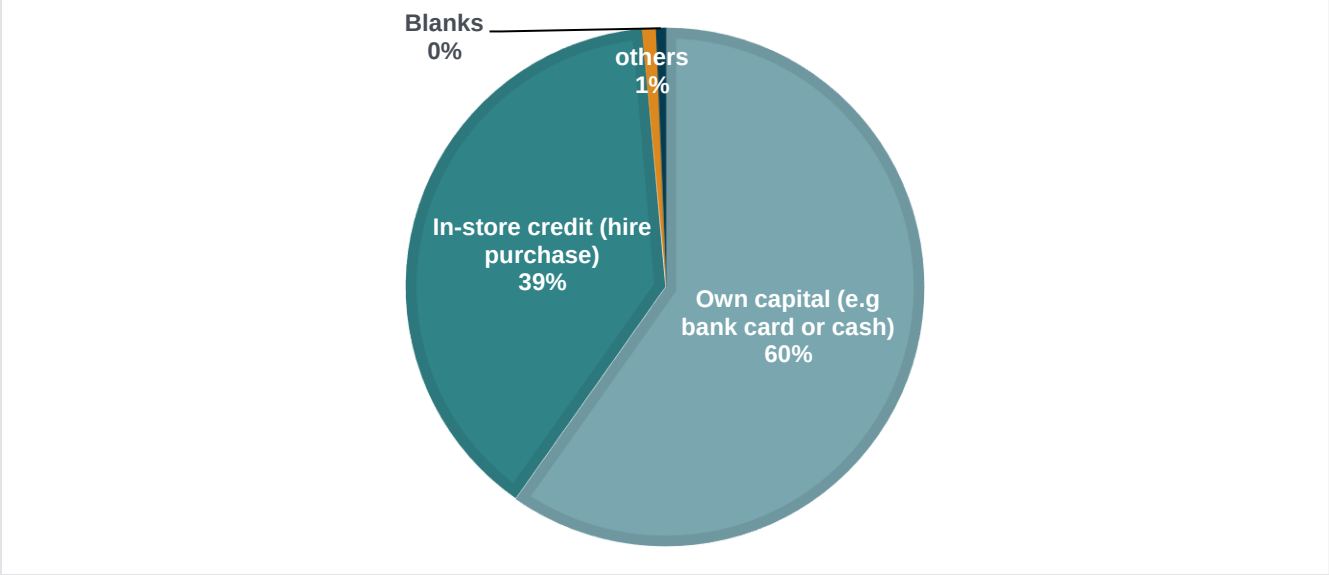
4. Incentives to the private sector selling the refrigerators.

3.5. EXISTING FINANCIAL INSTITUTIONS AND FINANCING INSTRUMENT FOR APPLIANCES

The main financial institutions in Botswana include first National Bank of Botswana Limited, Standard Chartered, ABSA Bank Botswana Limited, Stanbic Bank Botswana Limited, Banc ABC, Bank Gaborone Limited, Bank of Baroda Limited as shown in figure 15 above.

Based on the interviews from household surveys, most common mode of purchase of refrigerators, refrigerators-freezers and freezers was through Own capital (e.g., bank card or cash). However, a significant number of household consumers also indicated to have bought these appliances through In-store credit (hire purchase).

FIGURE 43: MODE OF APPLIANCE PURCHASE IN BOTSWANA



3.6. EMBEDDING AND DEPENDENCIES OF THE NATIONAL REFRIGERATOR MARKET IN THE REGIONAL CONTEXT

Botswana imports most of its refrigerating appliances from South Africa. Comtrade data showed that Botswana exports refrigerating appliances to its neighboring countries such as Eswatini, Zambia, Zimbabwe, Malawi, Lesotho, and Namibia.

4.Market Assessment on Distribution Transformers

4.1. TRANSFORMER SUPPLY

4.1.1. SUMMARY OF SUPPLIERS, OFFICIALS AND OTHER STAKEHOLDERS (I.E., AS DETAILED IN THE GUIDANCE NOTE) AS WELL AS MARKET SIZE BASED ON CAPACITY AND VOLTAGE

In Botswana, distribution transformers are ordered through the only power utility the country, the Botswana Power Corporation (BPC). For this study, officials of the BPC were approached for information to build a picture on the distribution transformer landscape of Botswana.

Data provided by the utility identifies 20 different transformer types each of which has a different energy capacity and power output. The table below indicates these transformers and the number of each purchased from 2018 - 2020. The most common of the transformers is the 50 KVA 11/0.4 KV transformer.

FIGURE 44 BREAKDOWN OF TRANSFORMER PURCHASES BY YEAR AND BY MODEL FROM 2018-2020

TRANSFORMER DESCRIPTION	ORDER QUANTITY			
	2018	2019	2020	TOTAL
50KVA 11/0.4 KV TP	1,410	26	440	1876
100KVA 11/0.4 KV TP	85	20	250	355
1000KVA 22/11KV TP	1	0	0	1
200KVA 11/0.4 KV TP	70	29	150	249
315KVA 11/0.4 KV TP	22	15	60	97
800kVA 11/0.4 KV TP	4	0	0	4
500kVA 11/0.4 kV TP	3	0	0	3
MINISUB 315KVA C/W FUSED RMU	3	0	70	73
MINISUB 500kVA C/W FUSED RMU	12	10	71	93
MINISUB 500KVA WITHOUT RMU	5	10	75	90
1000KVA 33/11KV TP	3	0	44	47
200KVA 33/11kV	10	0	0	10
500KVA 33/11 kV TP	38	4	50	92
800KVA 33/0.4 KV	4	0	0	4
50kVA 33/0.4 kV TP	55	15	55	125
100kVA 33/0.4 kV TP	10	1	77	88
200KVA 33/0.4 KV TP	26	0	40	66
MINISUB 1000kVA 11000/400 VOLT C/W RMU	0	1	2	3
MINISUB 200KVA C/W FUSED RMU	0	0	1	1
MINISUB 315kVA WITHOUT RMU	0	0	50	50
TOTAL	**1761**	**131**	**1437**	**3329**

The list of government institutions and other stakeholders directly involved in the legislation of distribution transformers is shown in the table below.

Figure 45 *Stakeholders involved in the regulation of distribution transformers*

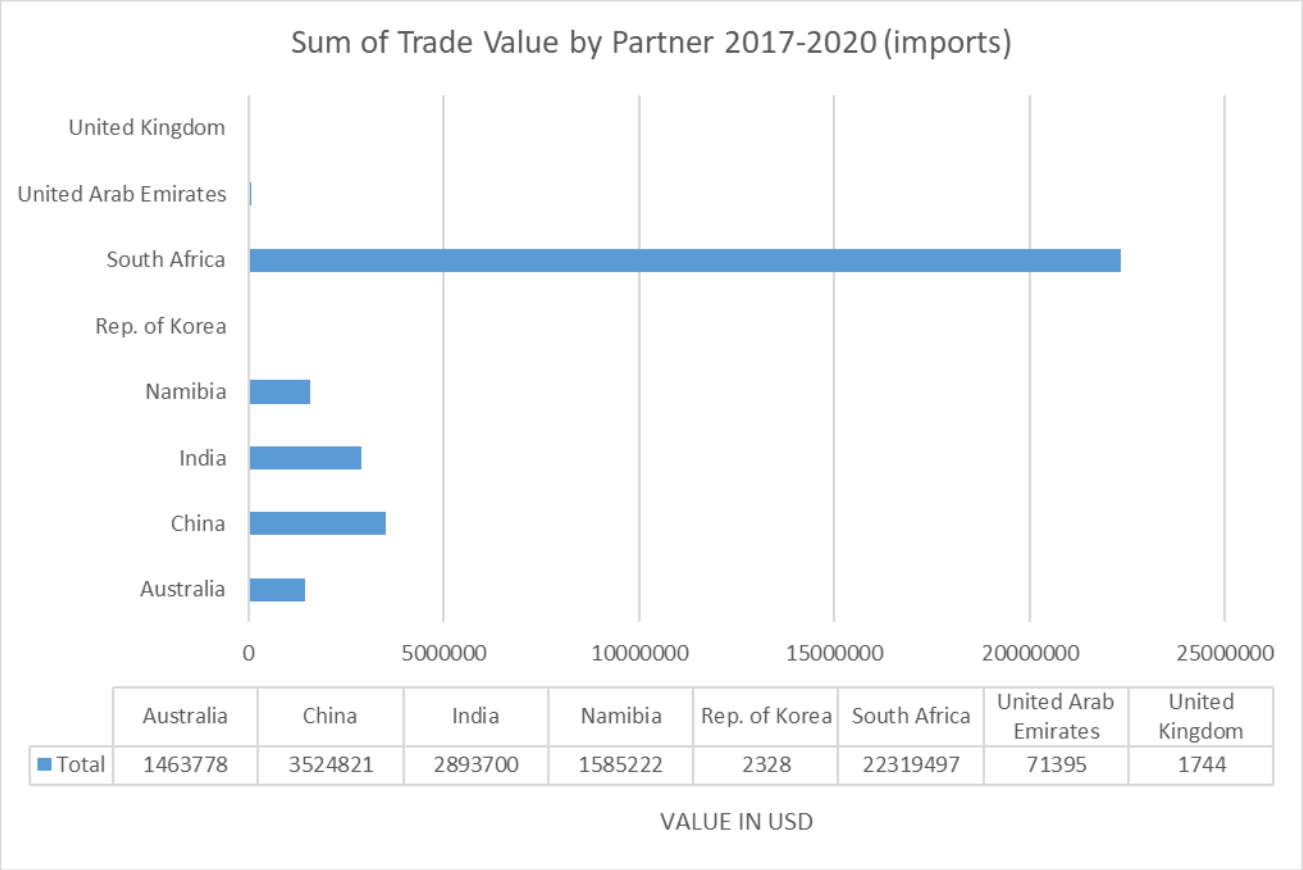
Category	Institution
Government Institutions	**Department of Energy (DoE)** - Ministry of Mineral Resources, Green Technology and Energy Security (MMGE) **Department of Local Government, Technical Services –** Ministry of Local Government and Rural Development

	Department of Environmental Affairs - Ministry of Environment, Natural Resources Conservation and Tourism (MENT)
	Department of Meteorological Services - Ministry of Environment, Natural Resources Conservation and Tourism (MENT)
	Department of Infrastructure Development - Ministry of Infrastructure and Housing Development (MIHD)
	Botswana Energy Regulatory Agency (BERA)
	Botswana Power Corporation
Parastatals	Statistics Botswana
	Botswana Bureau of Standards (BOBS) - Convener
	Botswana Institute for Technology Research and Innovation (BITRI)
	Botswana Innovation Hub (BIH)
	University of Botswana (UB) /Clean Energy Research Center (CERC)
	Botswana International Institute of Science and Technology (BIUST)
Academia	Solar Industrial Association of Botswana (SIAB)
	Botswana Chamber of Mines
NGOs and Associations	ZISMO Engineering
Private Sector for Distribution Transformers	Elolam Manufacturing
	Morupule Coal Mine

4.1.2. OVERVIEW OF THE SUPPLY CHAIN, INCLUDING FINISHED PRODUCTS AND MAJOR COMPONENTS LIKE CORE, WINDING, INSULATION, ETC. (LOCAL MANUFACTURERS, IMPORTS INCLUDING COUNTRY OF IMPORT, AVAILABILITY/EXPERIENCE WITH HIGH-EFFICIENCY MATERIALS E.G., AMORPHOUS CORE MATERIALS, ETC.)

According to data provided from the BPC, it is evident that transformers are imported into Botswana as complete sets of equipment.

FIGURE 46 *IMPORT TRADE VALUES OF TRANSFORMERS INTO BOTSWANA 2017-202*

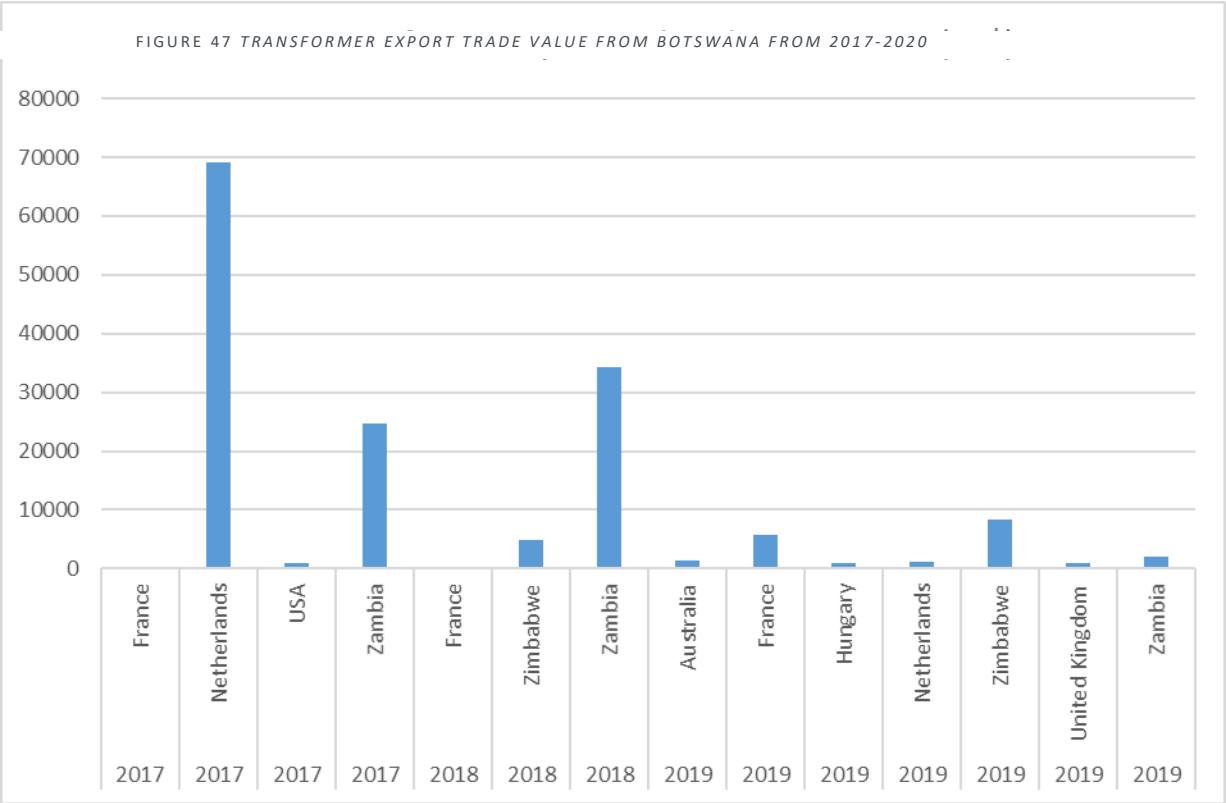


	Australia	China	India	Namibia	Rep. of Korea	South Africa	United Arab Emirates	United Kingdom
Total	1463778	3524821	2893700	1585222	2328	22319497	71395	1744

Data from COMTRADE[16], a United Nations (UN) global trade data repository indicates that in the period between 2007 -2020, South Africa remains the largest import partner with Botswana for transformers and related equipment at a value of $22,319,497. In the same period, Botswana exported transformer and transformer part to several countries as shown in the graph below.

[16] https://comtrade.un.org/data

FIGURE 47 *TRANSFORMER EXPORT TRADE VALUE FROM BOTSWANA FROM 2017-2020*



Further observation of data, six main suppliers/manufacturers of transformers are noted. These are:

- Actom Electrical Products
- Anhui Huaikai Transformers
- PAK Elektron Limited
- Rockwell China
- SGB SMIT Power Matla LTD
- Yueqing Yuebian Electric China LTD

In the period 2018-2020, 8,646 transformers of 21 different designations were shipped into Botswana with the breakdown as shown in the table and chart below.

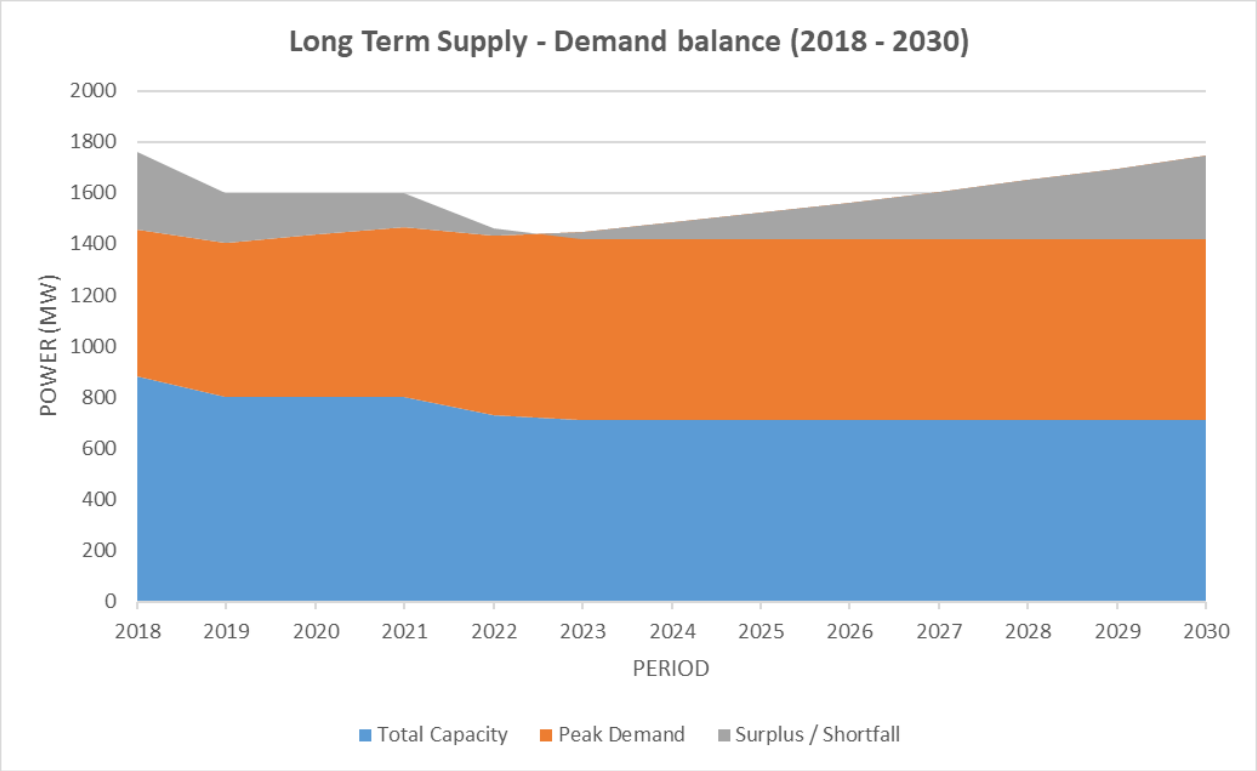
FIGURE 48 *DISTRIBUTION OF TRANSFORMER IMPORTS BY MANUFACTURER AND YEAR*

Manufacturer	**2018**	**2019**	**2020**
Actom Electrical Products	109	51	1231
Anhui Huaikai Transformers	1210	150	0
PAK Elektron Limited	3	874	126
Rockwell China	56	0	0
SGB SMIT Power Matla LTD	367	50	80
Yueqing Yuebian Electric China	16	0	0

FIGURE 49 *DISTRIBUTION OF TRANSFORMERS BY MANUFACTURERS*

4.2. TRANSFORMER DEMAND

Figure 50: *Supply vs demand projection for Botswana power 2018 – 2030*



Transformer demand is driven by the increase of electricity demand. In the previous section, a table indicates the trend of supply of transformers. Between 2018 and 2019, a significant dip is seen in the import numbers that denotes a decrease in demand. The following year shows an increase in imported transformers, which would indicate a demand increase. Below is a projection from the BPC that denotes the long-term supply vs demand of power from 201-2030.

The graph projects that there will be a spike in demand that will not be met by the current capacity starting in 2022. This implies as well that there will be a necessity for BPC and other stakeholders to shore up supply of transformers.

4.2.1. ASSESSMENT OF MAIN PURCHASERS OF DISTRIBUTION TRANSFORMERS

BPC is the only purchaser of Distribution Transformers in Botswana

4.2.2. TECHNICAL STANDARDS/REGULATIONS FOR DISTRIBUTION TRANSFORMERS IN PUBLIC UTILITY

Botswana sets the technical standards and specifications for distribution transformers to SANS-780, IEC – 76 and IS – 2026. These test specifications are shown in the table below:

Figure 51: *: Distribution Transformers as per SANS-780, IEC-76 & IS-2026*

KVA	Voltage ratio (kV)	Phase	Overall dimensions in mm			No load loss (W)	Load losses at 75°C(W)	%Z at 75°C	Wt. of Txs. kg)
			Length	Width	Height				
16	11/0.240	1	705	405	1130	80	400	3.0-4.5%	215
25	11/0.240	1	760	525	1110	110	530	3.0-4.5%	245
25	33/0.240	1	830	580	1380	160	530	3.0-4.5%	335
50	11/0.240	1	810	590	1210	180	900	3.0-4.5%	370
50	33/0.240	1	920	620	1470	250	900	3.0-4.5%	485
16	11/0.415	3	905	530	1035	95	410	3.0-4.5%	280
25	11/0.415	3	960	550	1130	120	570	3.0-4.5%	400
50	11/0.415	3	1045	580	1200	180	1000	3.0-4.5%	515
100	11/0.415	3	1120	660	1290	300	1700	3.0-4.5%	705

200	11/0.415	3	1425	815	1370	520	2700	4.0-5.0%	1095
315	11/0.415	3	1590	910	1580	720	3800	4.0- 5.0%	1500
500	11/0.415	3	1750	970	1690	1100	5400	4.5- 5.5%	2025
630	11/0.415	3	1785	1010	1780	1300	6400	4.5- 5.5%	2260
800	11/0.415	3	1935	1135	1840	1600	8000	4.5- 5.5%	2670
1000	11/0.415	3	2035	1200	1910	1900	9500	4.5- 5.5%	3100
1250	11/0.415	3	2380	1440	1950	2250	11000	5.0- 6.5%	3740
1600	11/0.415	3	2385	1555	2390	2750	13500	5.0- 6.5%	4785
2000	11/0.415	3	2560	1650	2500	3250	16000	5.0- 6.5%	5700
25	33/0.415	3	1035	610	1400	170	570	3.0-4.5%	520
50	33/0.415	3	1130	680	1345	250	1000	3.0-4.5%	655
100	33/0.415	3	1315	605	1515	400	1700	3.0-4.5%	905
200	33/0.415	3	1500	730	1680	650	2700	4.0- 5.0%	1350
315	33/0.415	3	1645	1020	2135	890	3800	4.0- 5.0%	1850
500	33/0.415	3	1765	1140	2220	1230	5400	4.5- 5.5%	2410
630	33/0.415	3	1805	1175	2290	1450	6400	4.5- 5.5%	2705
800	33/0.415	3	1880	1230	2380	1700	8000	4.5- 5.5%	3160
1000	33/0.415	3	2090	1330	2400	2000	9500	4.5- 5.5%	3680
1250	33/0.415	3	2205	1390	2510	2350	11000	5.0 - 6.5%	4330
1600	33/0.415	3	2385	1585	2615	2820	13500	5.0 - 6.5%	5215
2000	33/0.415	3	2545	1680	2755	3300	16000	5.0- 6.5%	5970

Distribution transformers follow the standards and specifications defined in the Botswana standard BOS 563:2013[17]. The standard covers transformers that have any combination of rated primary and secondary voltages.

4.2.3. ELECTRICAL CONNECTION REGULATIONS FOR DISTRIBUTION TRANSFORMERS APPLICABLE TO PRIVATE MV USERS

All distribution transformers are procured, installed, operated and maintained by the Botswana Power Corporation. There is no private ownership of DTs and no private mini-grids in Botswana. Hence no applicable connection regulations.

4.3. EQUIPMENT STOCK AND PROJECTIONS

4.3.1. DATA ON AVAILABLE DISTRIBUTION TRANSFORMERS IN THE MARKET

As indicated previously, the most common distribution transformer in the Botswana market is the 50 KVA 11/0.4 TP transformer. Though there was a dip in demand in 2019, it picked up again and data from 2021 should indicate an upsurge in this particular type of transformer.

Figure 52: *Breakdown of transformer purchases by year and by model from 2018-2020*

TRANSFORMER DESCRIPTION	**ORDER QUANTITY**		
	2018	**2019**	**2020**
50KVA 11/0.4 KV TP	1,410	26	440
100KVA 11/0.4 KV TP	85	20	250
1000KVA 22/11KV TP	1	0	0
200KVA 11/0.4 KV TP	70	29	150
315KVA 11/0.4 KV TP	22	15	60

[17] https://www.gobotswana.com/sites/default/files/botswana_standards_catalogue_june_2018.pdf

800kVA 11/0.4 KV TP	4	0	0
500kVA 11/0.4 kV TP	3	0	0
MINISUB 315KVA C/W FUSED RMU	3	0	70
MINISUB 500kVA C/W FUSED RMU	12	10	71
MINISUB 500KVA WITHOUT RMU	5	10	75
1000KVA 33/11KV TP	3	0	44
200KVA 33/11kV	10	0	0
500KVA 33/11 kV TP	38	4	50
800KVA 33/0.4 KV	4	0	0
50kVA 33/0.4 kV TP	55	15	55
100kVA 33/0.4 kV TP	10	1	77
200KVA 33/0.4 KV TP	26	0	40
MINISUB 1000kVA 11000/400 VOLT C/W RMU	0	1	2
MINISUB 200KVA C/W FUSED RMU	0	0	1
MINISUB 315kVA WITHOUT RMU	0	0	50

4.3.2. TECHNOLOGY TRENDS AND MARKET PROJECTIONS.

To be populated

4.4. POLICIES AND PROGRAMME LANDSCAPE

4.4.1. CURRENT AND PLANNED ELECTRIFICATION POLICIES AND PROGRAMS

Botswana has several policies that govern the electricity and energy sector. These are as listed below.

- Electricity is regulated through the Botswana Energy Regulation Authority (BERA) Act of 2016 in conjunction with the Electricity Supply Act and the Botswana Power Corporation Act. These acts cover the generation, transmission, distribution and sale of electricity.
- Botswana National Energy Policy,2021: Three key points stand out relating to the electricity subsector. Electricity will be generated optimally from locally available resources to meet local demand to ensure self-sufficiency; Transmission and Distribution infrastructure will be enhanced to facilitate growth and universal access to electricity; and electricity tariffs will be cost-reflective to balance the interests of the investors, consumers, and the environment.
- National Energy Efficiency Strategy for Botswana, 2018: Lays emphasis on the introduction of Minimum Energy Performance Standards (MEPS) that will drive the country to achieving energy saving goals.
- Electricity Supply Act; enacted in 1973 (Electricity Supply Act, 1973), with a provision which necessitated the Minister to consult the Botswana Power Corporation before issuing a generation license above 25 kW. The Act did not specify the energy source, and it established BPC as an integrated monopoly, operating generation, transmission, distribution and retail.
- Botswana Power Corporation Act, 1970: Formed in 1970 by an Act of Parliament and is responsible for the generation, transmission, and distribution of electricity within Botswana.
- Botswana Energy Regulatory Authority Act: The Authority is responsible for providing an efficient energy regulatory framework for electricity, gas, coal, petroleum products, solar, and all forms of renewable energy with the primary mandate of providing the economic regulation of the sectors.

4.4.2. ENVIRONMENTAL REGULATIONS FOR OIL-FILLED TRANSFORMERS AND CURRENT PROGRAM STATUS (PCB CONTENT, DISPOSAL ETC.)

Environmental Assessment Act, 2011[18]: This is an Act to provide for environmental impact assessment to be used to assess the potential effects of planned developmental activities; to determine and to provide mitigation measures for effects of such activities as may have a significant

[18] https://www.gov.bw/sites/default/files/2020-02/Environmental%20Assessment%20Act%202011.pdf

adverse impact on the environment; to put in place a monitoring process and evaluation of the environmental impacts of implemented activities.

Environmental Assessment Regulations of 2012[19]: The regulations guide how exercises such as scoping should be presented and which activities for which an environmental statement is necessary.

Atmospheric Pollution Prevention and Control (Chapter 65:03): Empowers Director of Environment to deny environment permits to undertakings that do not conform to national laws and regulations, as well as global protocols.

4.4.3. STAKEHOLDER PERSPECTIVE ON OPPORTUNITIES AND BARRIERS TO TRANSFORM THE MARKET TOWARD MORE ENERGY-EFFICIENT DISTRIBUTION

To be populated

4.5. UTILITY'S PROCUREMENT SPECIFICATIONS

The BPC is responsible for the distribution of electricity in Botswana. To aid in this endeavor, the BPC developed the Standards Requirements for Distribution Systems (SRDS)[20] guidelines. These guidelines have eased the pressure of designing the systems that BPC needs to implement and aided with improvement of electricity distribution in Botswana. The main components of the SRDS are the design parameters, the standard designs, the standards specifications for equipment and materials and the standards specifications for construction.

4.6. FINANCIAL ENVIRONMENT AND GOVERNMENT PROCUREMENT FOR BOTH REPLACEMENTS AND NETWORK EXPANSION

The National Development Bank has a loan facility that caters to Energy Projects for Farmers, particularly Renewable Energy Technologies. NDB and other Banks will likely have an interest in this project. BPC also offers a Transformer Scheme where the customer can gradually pay for the installation of a distribution transformer. Several retail shops sell the domestic appliances either on layby purchase or hire- purchase model.

4.7. EMBEDDING AND DEPENDENCIES OF THE NATIONAL DISTRIBUTION TRANSFORMERS MARKET IN THE CONTEXT OF THE REGION

To be populated

[19] https://www.gov.bw/sites/default/files/2019-12/Environmental%20Assessment%20Regulations%202012%20%28002%29.pdf
[20] https://www.bpc.bw/procurement/srds-document

CONCLUSION

4.8. CONCLUSION

This *Botswana Refrigerator Market Study and Policy Analysis* provides the technical evidence to support establishment of MEPS. Government agencies can use this information to define their efficiency baseline for refrigerators, quantify potential energy and GHG emissions reductions in support of national energy efficiency targets or NDC commitments, and estimate other potential benefits from revising the drafted energy efficiency policy requirements.
The analysis presented in this report was based on product data for almost 357 models found in retail and 359 models provided by households, in addition to information provided by the distributors and government stakeholders. Stock was based UN Comtrade data, distributor's data and governments interviews.
Refrigerators are an important household appliance in Botswana, and the demand for these appliances are increasing due to the increasing economic power of consumers, energy access levels and climate change. The increase in the demand will contribute significantly to the nation's electricity use due to their high unit energy consumption and high penetration by 2030

KEY RESULT ON REFRIGERATORS TECHNOLOGY TRENDS

The project team observed the following in the current market.

- R-134a refrigerants are phased out in the market.
- Bottom Freezer and Chest Freezer are more consistently popular in the market
- French door and side-by-side available in the current market have auto-defrost technology.
- Automatic ice makers were very scarce in the current domestic market in Botswana.
- The refrigerators come in varied capacity with very few models with gross volume of above 500L
- Side-by-side-door refrigerators are usually available in bigger capacity ranges i.e., beyond 300L

KEY RESULT ON THE TYPICAL REFRIGERATOR MARKET CHARACTERISTICS

FIGURE 53: REFRIGERATOR MARKET

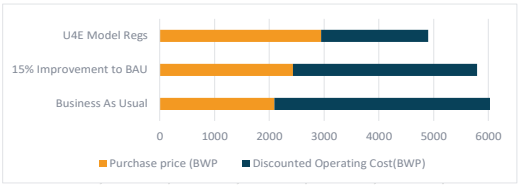
Type	Defrosting Technology	Typical Total Volume (liters)	Energy consumption at typical volume (kWh/year)	Average price of models meeting both criteria (BWP)
Single door (w/frozen compartment)	Manual	90	281.5	1,816
Single door (w/frozen compartment)	Auto	93	199	2,351
Bottom Freezer	Manual	286	313.5	5,099
Top Freezer	Manual	161	193	2,721
Bottom Freezer	Auto	269	332	4,676
Top Freezer	Auto	161	254	2,850
French Door	Auto	418	329.5	12,999
Side by Side	Auto	514	411	13,299
Chest Freezer	Manual	210	387	2,993
Chest Freezer	Auto	95	220	2,385

KEY IMPACTS TO CONSUMERS UNDER THE 15% IMPROVEMENT SCENARIO AND THE U4E MODEL FOR REFRIGERATORS

FIGURE 54: COST SCENARIOS

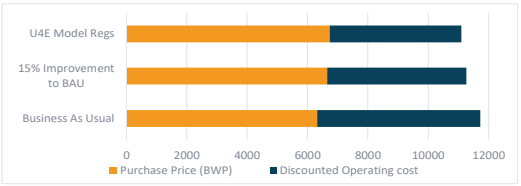
REFRIGERATOR

	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	2095	2434	2945
Unit Energy Consumption (kWh	238	203	118
Annual Operating Cost (BWP/y	267	227	132
Lifetime Operating Cost (BWP)	3944	3364	1956
Life Cycle Cost (BWP)	6039	5798	4901
Life Cycle Cost Savings (BWP)	0	241	1139
Payback Time (Years)	0	9	6



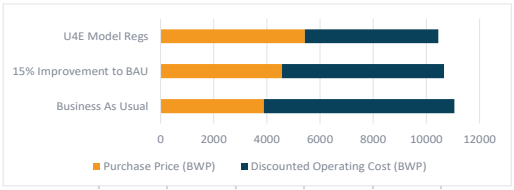
Refrigerator -Freezer

	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	6321	6654	6739
Unit Energy Consumption (kWh	326	278	263
Annual Operating Cost (BWP/y	365	311	295
Lifetime Operating Cost (BWP)	5403	4607	4359
Life Cycle Cost (BWP)	11724	11261	11098
Life Cycle Cost Savings (BWP)	0	463	626
Payback Time (Years)	0	6	6



Freezer

	Business As Usual	15% Improvement to BAU	U4E Model Regs
Purchase Price (BWP)	3885	4574	5437
Unit Energy Consumption (kWh	433	368	303
Annual Operating Cost (BWP/y	485	412	340
Lifetime Operating Cost (BWP)	7176	6099	5022
Life Cycle Cost (BWP)	11061	10673	10459
Life Cycle Cost Savings (BWP)	0	388	603
Payback Time (Years)	0	9	11



KEY IMPACTS AT NATIONAL LEVEL ON ENERGY AND CO2 EMISSIONS UNDER THE 15% IMPROVEMENT AND U4E MODEL SCENARIO

FIGURE 55: ENERGY SAVING SCENARIOS

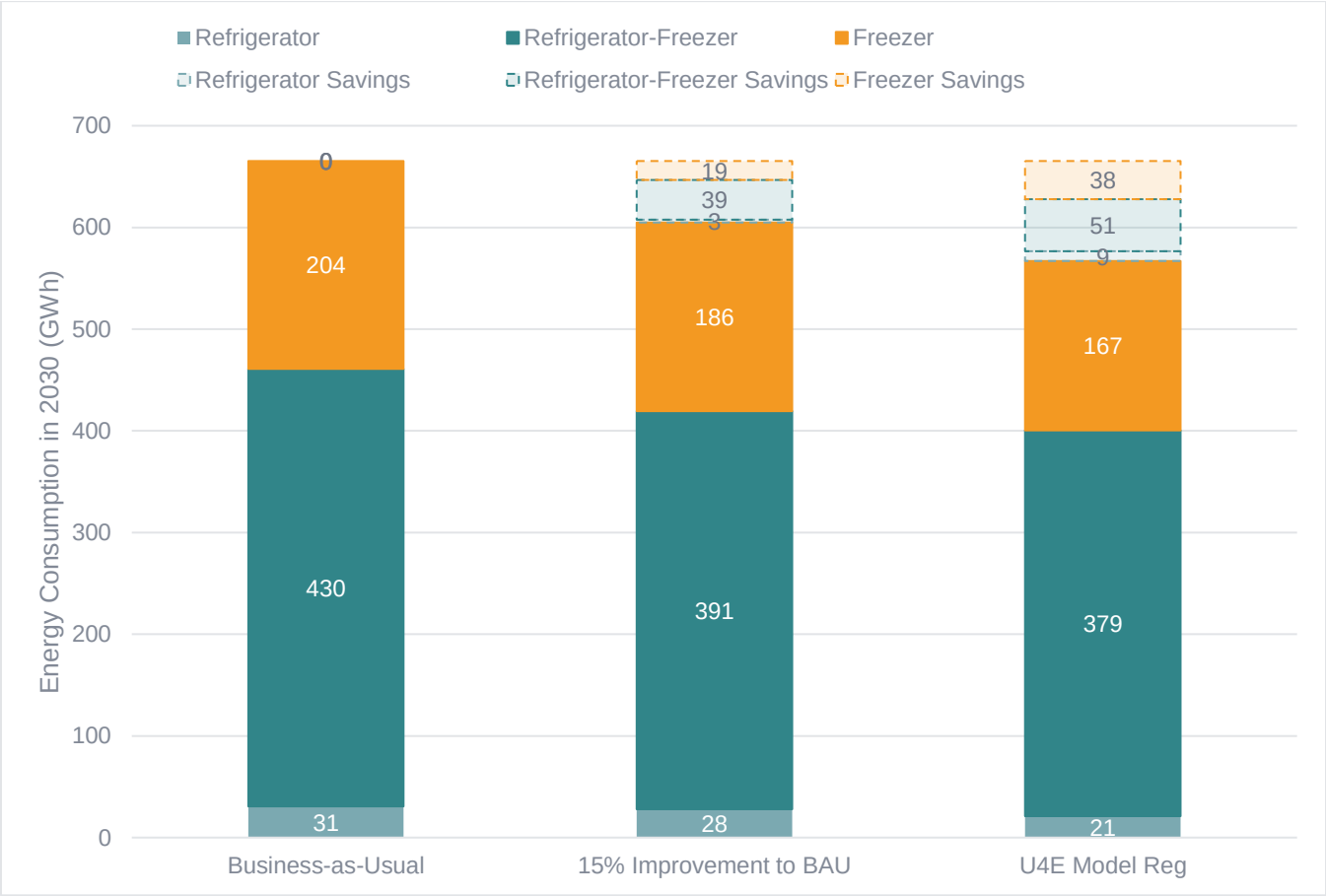
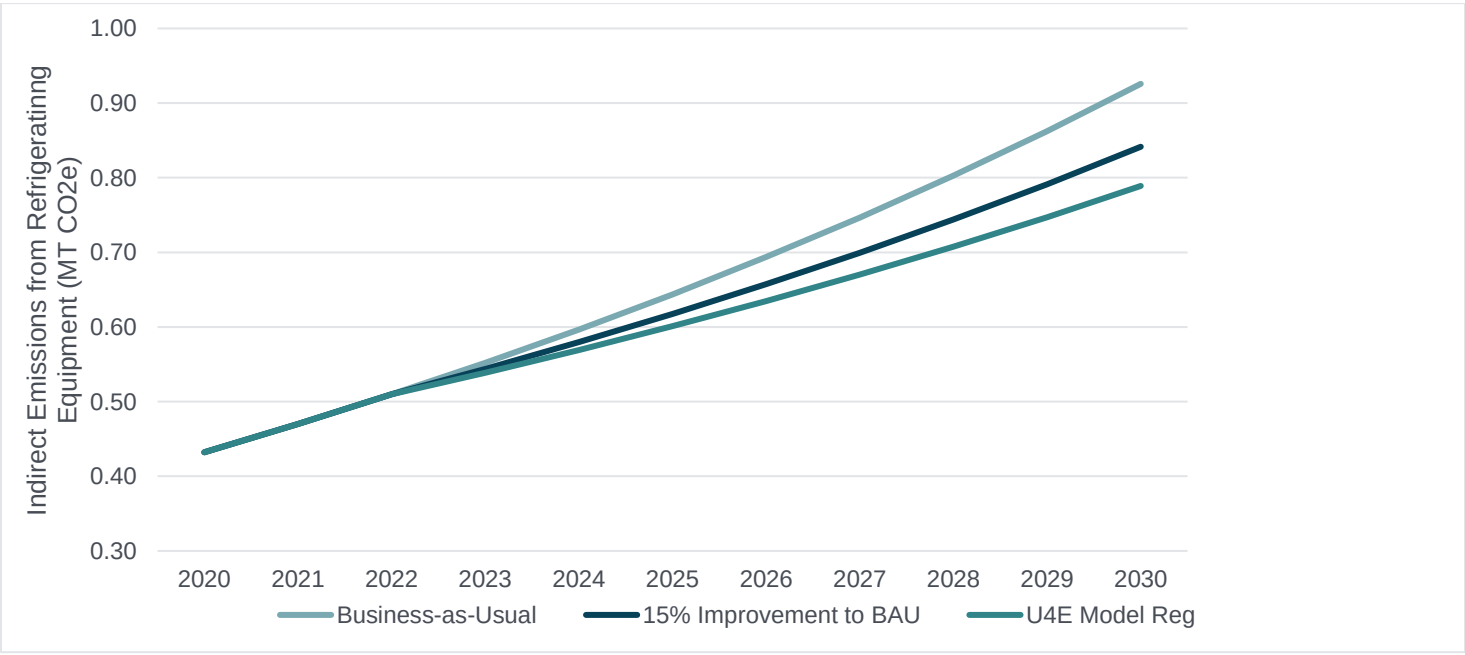


FIGURE 56: CO2 REDUCTION SCENARIOS



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Endnotes