Green Climate Fund Readiness Project

Market Assessment Report on Residential Refrigerators and Distribution Transformers

Namibia

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By

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

For

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

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List of Abbreviations

AFD	Agence Française de Développement
AU	African Union
BUR	Biennial Update Reports
CC	Contestable Customers
CTCN	Climate Technology Centre & Network
DFI	Development Finance Institutions
DIF	Development Investment Fund
DSM	Demand Side Management
DT	Distribution Transformer
ECB	Electricity Control Board
EE	Eligible Seller
EELA	Energy Efficient Lighting and Appliance
EIF	Environmental Investment Fund
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse gases
GoN	Government of Namibia
GWh	Gigawatt hour
GWP	Global Warming Potential
HC	Hydrocarbon
HFC	HydroFluorocarbons
HPP	Harambee Prosperity Plan
INDC	Intended Nationally Determined Contributions
IPP	Independent Power Producer
MEA	Multilateral Environmental Agreements
MEFT	Ministry of Environment, Forestry and Tourism
MEPS	Minimum Energy Performance Standards

MIT	Ministry of Industrialisation and Trade
MME	Ministry of Mines and Energy
MW	Megawatt
NA	Non-Annex
NAMPOWER	Namibia Power Corporation
NAMRA	Namibia Revenue Agency
NCCI	Namibia Chamber of Commerce and Industry
NDC	National Determined Contributions
NDP	National Development Plans
NEF	National Energy Fund
NEI	Namibia Energy Institute
NENA	Namibia Electricity Network Asset
NEP	National Energy Policy
NIRP	National Integrated Resource Plan
NMA	Namibia Manufacturer Association
NPC	National Planning Commission
NPV	Net Present Value
NQA	Namibia Qualifications Authority
NREP	National Renewable Energy Policy
NSA	Namibia Statistics Agency
NSC	Namibian Standards Council
NSI	Namibian Standards Institution
NTA	Namibia Training Authority
NUST	Namibia University of Science and Technology
OGEMP	Off-Grid Energisation Master Plan
ONAN	Oil Natural Air Natural
OPE	Oshakati Premier Electric
PCB	Polychlorinated Biphenyl
POD	Persistent Organic Pollutants
PPA	Power Purchase Agreements

PPS	Probability Proportional to Size
PSU	Primary Sampling Units
RAC	Refrigeration and Air conditioning
REDMAP	Rural Electrification Master Plan
REDs	Regional Electricity Distributors
REFIT	Renewable Energy Feed- in Tariff
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAPP	Southern Africa Power Pool
SOLTRAIN	Southern Africa Solar Thermal Training and Demonstration Initiative
SRF	Solar Revolving Fund
TOU	Time of Use
UN	United Nations
UNEP	United Nations Environment Programmes
UNFCCC	United Nations Framework Convention on Climate Change
ZPC	Zimbabwe Power Company

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1. Executive Summary

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

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

This will transform the market to energy-efficient refrigerators and distribution transformers and ultimately reduce the strain on the electricity grid, increase disposable income for householders and potentially reduce greenhouse gases (GHG) emissions. The activities are being coordinated with similar GCF readiness projects in 7 additional Southern African countries (Botswana, Eswatini, Lesotho, Malawi, Tanzania, Zambia, Zimbabwe) and also regional harmonisation efforts, which are being coordinated by UNEP's United for Efficiency (U4E) initiative. (Readiness and Preparatory Support, 2019).

The readiness project, which has been titled *"National framework for leapfrogging to Energy Efficient Appliances and Equipment in Namibia (Refrigerators and Distribution Transformers), through regulatory and financing mechanism",* is being implemented by the government of Namibia through Ministry of Environment, Forestry and Tourism (MEFT) and Ministry of Mines and Energy (MME).

As part of the local market assessment, a comprehensive data collection exercise aimed at helping to inform the policy recommendations and the development of financing mechanisms that will be implemented jointly in Namibia, was conducted. The exercise included a middle-income household survey conducted in the country's five[1] electricity distribution zones (CENORED, Central zone, ERONGO RED, NORED and Southern zone), suppliers, retailers, importers and wholesalers of refrigerators in Namibia; utilities including NamPower, Regional Electricity Distributors (REDs) and local municipalities (for distribution transformers only); Government ministries, energy efficiency

[1] Currently only three Reds are in existence and operational. Central and Southern Reds are in the pipeline.

entities, customs, standards and regulatory bodies, such as the Namibia Statistics Agency (NSA); private sectors, including technology providers, local retailers and local consulting engineers and financial institutions. The field work was supplemented by a comprehensive desktop study on the relevant areas.

This market assessment report outlines the findings of the data collected and analysis on the use and demand of refrigerators and distribution transformers in Namibia.

While Namibia has generally demonstrated its commitment to implement various strategies aimed at promoting energy efficiency, such as time of use tariffs, 2007 Cabinet resolution on solar water heaters and the implementation of the Energy Efficiency on Lighting and Appliances (EELA) as well as a regional project in the Southern and East African region on energy-efficient cooling through United for Efficiency (U4E), this GCF readiness project focuses on refrigerators and distribution transformers. Participation in this GCF project is also a result of the country's request for technical assistance to the CTCN (Readiness and Preparatory Support, 2019).

Namibia currently does not manufacture any refrigerators or distribution transformers, with the bulk of refrigerators (82 %) imported from South Africa, where they are manufactured, 8 % from China and the remainder from different European countries. At least 90 %of distribution transformers are imported from South Africa, where they are manufactured.

This report highlights the common types of residential refrigerators and distribution transformers in use in Namibia, giving an insight into what drives consumer preferences when it comes to acquiring refrigerators for household use and what drives utilities when it comes to acquiring distribution transformers. It further highlights some barriers and identifies opportunities in the transition to energy efficient refrigerators and distribution transformers.

It is estimated that the stock level of residential refrigerators in 2021 was 251 000 units, while the estimated market size and value for residential refrigerator were 28 000 units and USD 12.9 million (NAD 177.1 million) in 2021. Based on projections, the stock level, market size, and market value of residential refrigerators, respectively would be 346 000, 39 000, and USD 17.9 million (NAD 245.8) by 2030 based on replacement of end-of-life appliances and economic growth opportunities. The stock level would grow by 27 % by 2030, while the market size and the market value would grow by 28 % respectively.

There seems to be a lack of clear financial incentives aimed specifically at encouraging the uptake of energy efficient household appliances, such as refrigerators, and neither are there any regulations sanctioning such. Namibia has also seen little or no awareness campaigns encouraging citizens to invest in energy efficient appliances and as a result, consumers are not aware of the technological and environmental benefits of energy efficient refrigerators and hence do not see the need to invest money buying them rather than the cheaper ordinary refrigerators. Furthermore, there are no local standards and labelling schemes available for residential refrigerators.

Regarding the distribution transformers, lack of Namibian uniform standards and technical knowledge on the maintenance of distribution transformers were identified as the main barriers to transforming the distribution transformers market towards energy efficiency, while high cost of distribution transformers also contributed towards the slow transition to energy efficiency.

The report assumed the market size projections of distribution transformers would fall in line with the government strategy to reach full electrification by 2030. It is estimated that the total market for distribution transformers would be 1 900 units in 2021, while subsequent stock level would be at 27 000 units in 2021. This would correspond to a total market value for distribution transformers of USD 18 million (NAD 265million) in 2021. The end of the full electrification drive would bring the projected market size figure to the highest figure of 2 600 units by 2030. Corresponding to a market value of USD 24.7 million (NAD 363 million), while the total stock of distribution transformers would be projected to reach 38 265 units by 2030. Once 100 % electrification would be achieved in 2030, projected market size figures will go down driven by replacement of end-of-life equipment and economic growth opportunities only for the years ahead.

Namibia is one of the countries that have ratified the Kigali Amendment to the Montreal protocol, on substances that deplete the ozone layer, since 2010. The Kigali amendment advocates for energy efficient and low Global Warming Potential (GWP) technology in the cooling sector, including refrigerators. This assessment found out that the Kigali Amendment is being implemented in the country, since most of the refrigerators are equipped with R600a, which is a low GWP refrigerant. In addition, due to Namibia's efforts to phase out ozone depleting substances, most of the residential refrigerators in the survey areas (55.6 %), refrigerator-freezers (65.2 %) and freezers (56 %) are A rated. Refrigerators, freezers and refrigerator-freezers are rated from A+++ to G, with A+++ being the most efficient and G being the least efficient. Refrigerators without a freezer had the least average volume compartment of 262 liters, while refrigerators with a freezer showed the biggest volume compartment of an average of 293 liters. For freezers the average volume compartment was 276 liters.

2. Background and Introduction

Namibia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995 as a Non-Annex I Party and became obligated to prepare and submit National communications (NC), Biennial Updates Reports (BUR) and National Determined Contributions (NDC) (Ministry of Environment, 2015). Namibia also ratified the Paris Agreement in 2016 (Ministry of Environment, Forestry & Tourism, 2015). As a signatory to the convention, the country has prepared and submitted three NCs and three BURs. In addition, Namibia prepared and submitted its updated Nationally Determined Contributions in 2021 (Ministry of Environment, Forestry & Tourism, 2021).

Various measures contributing to the mitigation in climate change in different sectors were identified in the INDC. For the energy sector in the updated NDC, the national sustainable energy strategy of Namibia looks to introduce new emissions-reducing technologies and encouraging healthier practices that are more energy efficient. Furthermore, the updated NDC includes climate-friendly and energy efficient refrigeration and air conditioning (RAC). Low Global Warming Potential technology options, particularly technology with natural refrigerants, exist as an alternative to hydrofluorocarbons (HFCs)for almost any RAC appliance (Ministry of Environment, Forestry & Tourism, 2021). In addition, the Namibia's Renewable Energy Policy aims to drive emerging technologies that reduce emission and support cleaner practices. The policy aims to substitute the existing higher emission technologies with cleaner, more efficient, and lower-cost technologies. The country's efforts in renewables will

contribute to a 30 % reduction equivalent in the quantity (2.668 TWh) of electricity imported in 2018 resulting in 0.8 TWh (800 GWh) in new renewable energy generation of 330 MW of Solar photovoltaic per year until 2030 (Ministry of Environment, Forestry & Tourism, 2021).

In 2020, a review of the potential for implementation of energy efficiency policies and strategies was conducted in Namibia by United for Efficiency (U4E) Country Savings Assessments (CSA). The appliances and equipment that were identified include lighting, residential refrigerators, room air conditioners, transformers and industrial electric motors. Assuming a successful implementation of the various energy efficiency strategies, the targeted cumulative savings from the five appliances and equipment are expected to reduce electricity use by over 2.06 TWh, worth of USD 186 million (NAD 2 604), by 2030, while CO_2 emissions are expected to be reduced by 2.92 million tonnes in the same period (U4E CSA, 2020).

Since 2019, Namibia has been part of the EELA project which is being implemented across Eastern Africa and Southern Africa to develop harmonised cost-effective, mandatory regulations on lighting, which was found to be the largest contributor to the annual electricity savings of 49 % by 2030. Savings from distribution transformers will amount to 18 %, while residential refrigerators are expected to contribute 9 % (CTCN, 2018).

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

As part of the country's commitment to implement various energy efficiency strategies of the identified appliances and equipment, MEFT, through the National Designated Entity (NDE) submitted a request for technical assistance to CTCN. This allows Namibia to be part of the eight countries in Southern Africa[2] embarking on GCF Readiness projects on *"Developing a national framework for leapfrogging to energy efficient appliances and equipment (refrigerators and distribution transformers) through regulatory and financing mechanisms*". The project aims to enhance the country programs regarding refrigerators and distribution transformers and strengthen climate finance strategies. In addition, the project will be a key driver for good policy development and governance to inform the adequate measures. The key components of the project include a national policy roadmap and enabling environments for the implementation of standards and labels, appropriate financing mechanism to increase the uptake of energy efficient refrigerators and

[2] The GCF Readiness Assessment project countries are; Botswana, Eswatini, Lesotho, Malawi, Namibia, Tanzania, Zambia and Zimbabwe

distribution transformers and contribute to capacity building to develop standards and labels for other appliances in future (U4E & UNEP, 2021).

Namibia's national development ambitions are guided by Vision 2030, which was adopted in 2004. Vision 2030 foresees the provision of secure and affordable electricity to the country's developing economy and its people; it provides the overall long-term development goals for the country; and it subscribes to the principle of sustainable development. Specifically, Vision 2030 foresees "a prosperous and industrialised Namibia, developed by her human resources, enjoying peace, harmony and political stability" (NPC, 2004).

Namibia's medium-term goals and strategies are expressed in National Development Plans (NDPs) which are formulated in accordance with Vision 2030. The NDPs are revised every five years. Since 2016 the President released the Harambee Prosperity Plan (HPP), which sets out short term development priorities which includes energy access targets. HPP 2 targets to achieve a secure and cost-effective energy supply through;

- Increasing local electricity generation capacity from 624 MW (2020) to 879 MW by 2025, through renewable energy sources
- Electrifying 6,000 rural and 13,000 peri-urban households by the end of 2025
- Electrifying 213 new schools and health facilities by 2025

Access to electricity plays a crucial role in driving the economic growth and social development of a country. Across the world, emerging technologies, changing customer behaviour and the effect of climate change are reshaping how electricity is generated, supplied, and consumed. Currently, the electrification rate for Namibia is around 50 % (Namibia: Geospatial Least Cost Electrification Plan, 2021) with 59 % of electricity being imported from South Africa (200 MW), Zambia (100 MW) and Zimbabwe (80 MW), through bilateral power purchase agreements (NamPower, 2020). However, with the current financial constraints, high dependency on electricity imports is not sustainable.

Namibia currently has the highest electricity tariffs in the region of 0.15 USD per kWh for residential consumers and 0.16 USD per kWh for industrial consumers (ECB, 2021). Higher efficiency equipment, including refrigerators and distribution transformers, will play a crucial role in the reduction of electricity distribution losses (which average between 5.6 % and 11 %), and pressure on the country's grid and lessen the burden on the governments' budgets hampering the country's electrification potential. Government does not subsidize electricity costs in Namibia, but cross subsidization exists whereby business tariffs are higher than domestic tariffs.

Relevant demand side management initiatives have been undertaken as documented in the report of 2006 and reviewed in 2016. NamPower, together with the regional electricity distributors (REDs) and the Electricity Control Board (ECB), have undertaken consumer awareness campaigns. In 2016, NamPower launched an exercise to distribute one million energy saving bulbs to households in the country. The campaign, known as the "1 Million Light Emitting Diode" (1mLED), focused on replacing incandescent light bulbs used for domestic lighting with LED bulbs, free.

The utility introduced the time of use (TOU) tariffs to all transmission customers, including the distribution licensees taking supply at transmission level and to most of the distribution demand metered customers and select three phase business and institutional customers.

In 2007 cabinet introduced a resolution on the installation of solar water heaters in public buildings, and the Solar Revolving Fund (SRF) was broadened to include such technologies (EMCON Consulting Group, 2016). The resolution is complemented by the regional Southern Africa Solar Thermal Training and Demonstration Initiative Project (SOLTRAIN), implemented by the Namibia Energy Institute (NEI) since 2009, aimed at raising awareness by providing a subsidy for solar water heaters and capacity building.

Namibia has instituted the Energy Efficiency Programme, which included a baseline study on energy efficiency in selected commercial and industrial buildings as well as the establishment of the Green Building Council of Namibia (EMCON Consulting Group, 2016).

However, according to the DSM review of 2016, it was noted that past initiatives seem to have been undertaken with a degree of uncertainty as to who would initiate and implement them. The DSM committee's role, function and mandate were neither adequately clear nor fully accepted amongst the electricity supply industry (ESI) players. Dedicated funding required for the implementation was unavailable, resulting in stakeholder disagreement as to who should pay for them.

The absence of dedicated instruments such as building codes, energy efficiency policy and MEPS hindered the implementation of energy efficiency.

This project is expected to develop a national framework for leapfrogging to energy efficient refrigerators and distribution transformers aiming to put in place MEPS and a labeling scheme, which will create an enabling policy and regulatory environment for refrigerators and distribution transformers in Namibia. This regional initiative will increase investment and acceleration of the deployment of energy efficient products, reduce the strain on the electricity grid, increase income for householders and potentially reduce greenhouse gases (GHG) emissions in Namibia.

This market assessment report outlines the findings of the data collected and analysis on the use and demand of refrigerators and distribution transformers in Namibia. The findings of this report are based on the actual assessment conducted in Namibia.

3. Methodology and Approach

This chapter presents the data collection methodology and approach used in the development of this market assessment report.

3.1 Objective and scope

The objective of this market assessment is to provide detailed information to inform the development and subsequent adoption of national policy roadmaps for the promotion of higher efficiency refrigerators and distribution transformers, including MEPS-HEPS, labelling scheme, consumer awareness, end-users' education, capacity building for custom officials and procurement officers, and a MV&E framework, as well as financing mechanisms and strategies, adopted by the government in Namibia[3].

[3] A Guidance Note from CTCN/UNEP-U4E was used in conducting the Market Assessment for energy efficient refrigerators and distribution transformers

The scope of this assessment was limited to the below stakeholders:

- Middle income consumers (for easier accessibility) who have access to electricity (for residential refrigerators only);
- Suppliers, retailers, importers and wholesalers of refrigerators in Namibia;
- NamPower, REDs and local municipalities, suppliers and importers (for distribution transformers only);
- Government ministries, energy efficiency entities, customs, standards and regulatory bodies and Namibia Statistics Agency (NSA);
- Private sector, including technology providers, local retailers and local consulting engineers and
- Banks and other financial institutions.

3.2 Existing information, sources and gaps

Available macroeconomic data is of high quality, while detailed information on the supply side of residential refrigerators was rather challenging to collect. The reason for this was that the response rate from the private sector on the questionnaire was low, due to the reluctance to answer questions in the questionnaire that were deemed market competitive. Furthermore, some companies indicated that they didn't have time to complete such long questionnaires due to their busy schedules.

With regards to distribution transformers, there is limited technical knowledge related to operations and maintenance, which leads to distribution transformers being in operation without maintenance until they fail.

Additionally, some of the information on distribution transformers seemed contradictory as it came from different sources. Some of the contradictory information included the lifetime of the distribution transformers. Wherever possible, several sources were consulted for the same type of information to validate the data.

3.3 Information gathering methodology

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

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

Three surveys were conducted to assist in data collection for the market assessment. These included surveys for residential refrigerators, supply chain of residential refrigerators and for distribution

transformers. The sample sizes for the three surveys conducted were already predetermined by the local experts in the consultation meetings due to budget limitations, as indicated in Table 1 below.

Table 1: Sample sizes of survey target groups

Target Group	Method of Data collection	Purpose of Sampling	Sample Size
Residential Households	Door to door survey	Household Refrigerators	200
Supply Chain (suppliers, retailers, importers, wholesalers)	Telephone calls, door to door visits, questionnaires, and interviews	Market landscape of Refrigerators	20
NamPower, REDs, suppliers, importers, retailers, engineering consulting firms	Telephone calls, door to door visits, questionnaires, and interviews	Distribution Transformers	10
Government ministries, energy efficiency entities, customs, standards and regulatory bodies, and financial institutions	Emailed questionnaires, telephone calls and interviews	Household refrigerators and transformers	21

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

Primary data collection for residential refrigerators

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

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

[4] A Guidance Note from CTCN/UNEP-U4E was used in conducting the Market Assessment for energy efficient refrigerators and distribution transformers

- Total stock of refrigerators in use, and typical annual sales, market size, markets segments, and projections for the upcoming years. Disposal of old refrigerators.

The team of enumerators collected residential refrigerators data based on the geographical locations of the country. The project team kicked off by grouping households with access to electricity as per the regional clusters based on the regional electricity distributor (RED) zones. The existing three and envisaged two regional electricity distributor zones are depicted in Figure 1 below.

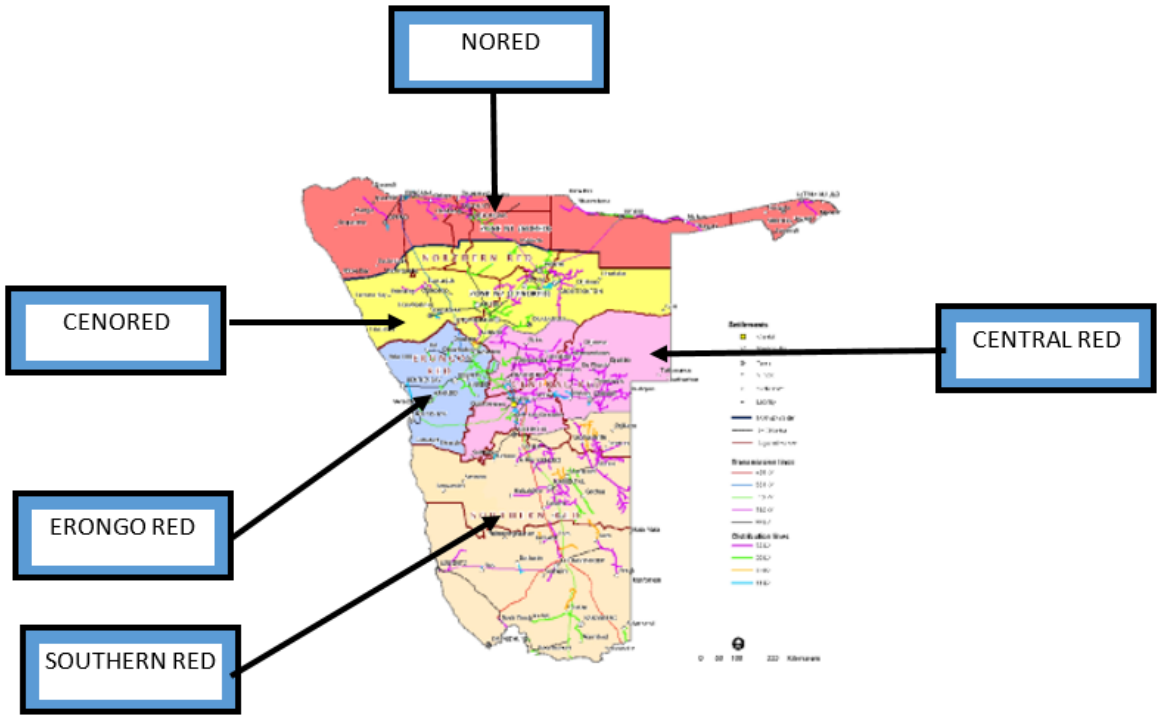

Figure 1: Five regional electricity distributor in Namibia. Image Source: ECB

The sampling methodology for the survey was a random quantitative research approach. The sampling frame included the entire households. Firstly, a unit or cluster primary sampling unit was selected, which contains a number of households (dwelling units) and then we took a sample from those households (dwelling units) in that cluster. The number of such clusters and the number of sampled households within each cluster was predetermined (ideally 20) in such a way that the total number of sample households (sample size) was achieved. In this design only one member per household (the Head of Household) was interviewed.

The Primary Sampling Units (PSUs) were selected with the probability proportional to size sampling (PPS), together with households that were selected with systematic sampling procedure. The PSU maps were provided by Namibia Statistics Agency (NSA) based on their middle-income sampling. Sample size was determined under the PPS design to distribute the sample size across all the 14 regions of Namibia taking the five zones into consideration. In determining the sample per regional grouping, the following formula represented by equation 2 was used.

$$n= (k^2\ pq)e\ ^2 \quad \text{where n is the sample size and } q=1-p \qquad (2)$$

n= (1.96(0.93)(1-0.93))/(0.5(0.5))=100 (per regional grouping)

n = first estimate of sample size (minimum sample size for large population)

e = Margin of error is fixed at 5 % (always less than 10 %)

k = Desired confidence level 95 % where the critical value k = 1.96 ~ 2

p = estimated prevalence (proportion) in target population is 93 % (0.93)

q = 1-p = (0.07)

To counteract for the loss in precision, the sample size was raised by a factor of 0.5. Non response was assumed to be about 5 %. The replacement for refusals was used adding another 5 % to the total. Table 2 below indicates the red zones, towns in the red zones, the PSU number with the number of households in that sampling unit, the PPS representing the number of questionnaires for that zone, proportional allocation per town in the red zones, proportional allocation (observed and expected) in the red zones.

RED ZONE	Towns	PSU Number representing HH	HH Connected to Grid	Probability Proportional to Size (PPS) Sample Allocation of HH	Probability Proportional to Size (PPS) Sample Allocation of HH	Proportional allocation	Proportional allocation (Total observed)	Proportional allocation (Total expected
CENORED	Otjiwarongo	130601027	34293	23	**23**	12	12	12
CENTRAL ZONE	Windhoek	061001019	78287	53	**27**	13		
	Windhoek	060101035			**26**	13	26	27
ERONGO RED	Swakopmund	020501208	42784	29	**15**	8		
	Walvis Bay	020701074			**14**	7	15	14
NORED	Katima Mulilo	140501082	104365	71	**18**	9		
	Rundu	040601121			**18**	9		
	Oshakati	110901024			**18**	9		
	Ondangwa	110601065			**18**	9	36	35
SOUTHERN ZONE	Keetmanshoop	010601023	35483	**24**	**24**	12	12	12
Total			**295212**	200	**200**	**100**	**100**	**100**

Table 2 indicating the red zones, towns in the red zones, the PSU number with the number of households in that sampling unit, the PPS representing the number of questionnaires for that zone, proportional allocation per town in the red zones, proportional allocation (observed and expected) in the red zones.

Ten enumerators collected data for residential refrigerators from the towns based on the PPS allocated questionnaires, as indicated in Table 2, after an intensive training on data collection. The list of enumerators with their field of expertise and PSU maps from NSA are attached in Annex 1 and 2 respectively.

Administering a set of questionnaires per region was not absolutely necessary for this type of survey, although it would have provided regional data necessary for regional planning and development. However, grouping regions based on the RED zone similarity will provide useful data for planning and development and is less expensive. This sample is based on administering 550 interviews spread across five regional grouping as per the Table 3 and Table 4 below.

Table 2: Regional groupings (clusters)

Southern Zone	**Erongo Red (Coastal)**	**Central Zone**	**NoRed**	**OPE**	**CenoRed**
● Hardap Region ● !Karas Region	Erongo Region	● Khomas Region ● Includes some towns & Settlement in Otjozondjupa Region (such as Okondjatu, Okahandja, Ovitoto & Kalkfeld) ● Omaheke Region except some Towns and Settlements in Omaheke Region (Such as Ben-Hur, Onderoumbapa, Corridor 13, Aminius & Leonardville)	● Zambezi Region ● Kavango East Region ● Kavango West ● Oshikoto except Towns and Settlements downwards Oshivelo such as Tsumeb ● Oshana except Oshakati, and Southern Towns and Settlements within the Region which are	● Oshakati	● This zone is formed by towns and Settlements from Otjozondjupa, Oshikoto, Omusati and Kunene Regions. They are Kamanjab, Outjo, Fransfontein, Khorixas, Tsumeb, Okakarara, Otavi, Otjiwarongo, Tsumkwe, Gam etc.

			part of CenoRed ● Kunene Region except Kamanjab, Outjo, Fransfontein, Khorixas which are part of CenoRed		

Table 3: Sample Allocation

RED ZONE	Total Households	HH Connected to Grid	Percent distribution	PPS Sample Allocation
CENORED	61657	34293	11.6	64
CENTRAL ZONE	126979	78287	26.5	146
ERONGO RED (COASTAL)	48836	42784	14.5	80
NORED	321708	104365	35.4	194
SOUTHERN ZONE	43279	35483	12.0	66
TOTAL	**602459**	**295212**	**100.0**	**550**

NSA advised the team to consider a sample of at least 550 households in order to gather adequate countrywide data that could be used in formulating policy and governance to inform the adequate measures. However, due to budgetary constraints to fund additional enumerators to conduct the survey covering the required sample size, a decision was made to interview 200 households. The 200 households sample size covered the "five REDs zones" shown in Table 5.

Table 4: Sample allocation for 200 households

RED ZONE	Total Households	HH Connected to Grid	Percent distribution	PPS Sample Allocation
CENORED	61657	34293	11.6	23
CENTRAL ZONE	126979	78287	26.5	53
ERONGO RED (COASTAL)	48836	42784	14.5	29
NORED	321708	104365	35.4	71
SOUTHERN ZONE	43279	35483	12.0	24
TOTAL	**602459**	**295212**	**100.0**	**200**

Out of a total number of 200 questionnaires, 200 responses were received back, though it must be noted that a small number of the questionnaires were partly incomplete. The questionnaire template is attached in Annex 3. Table 6 displays the questionnaire response data and the level of completeness of each questionnaire. The level of completeness refers to the extent to which the questions in the questionnaire were answered.

Table 5: Questionnaire response data and level of completeness of each questionnaire

ZONE	Town	PSU Number	Number of Questionnaires sent (Zone)	Number of Questionnaires received (Zone)	Number of Questionnaires sent (Town)	Number of Questionnaires received (Town)	Level of completeness of questionnaire (%)
CENORED	Otjiwarongo	130601027	23	23	**23**	23	98
CENTRAL ZONE	Windhoek-Khomasdal	061001019	53	53	**27**	27	98
	Windhoek-Luxury Hill	060101035			**26**	26	95
ERONGO RED	Swakopmund	020501208	29	29	**15**	15	95
	Walvis Bay	020701074			**14**	14	95
NORED	Katima Mulilo	140501082	72	72	**18**	18	98
	Rundu	040601121			**18**	18	98

	Ondangwa	110601065			**18**	18	95
SOUTHERN ZONE	Keetmanshoop	010601023	**24**	24	**24**	24	80
OPE	Oshakati	110901024			**18**	18	95
Total			201	201	**201**	201	98

The project did not have an awareness campaign prior to commencement of the household survey. The Namibia Media Expert proposed that SACREEE conduct newspaper, radio and television interviews to introduce the exercise to the public, but due to budget limitations this was not done. Only a brochure was made available.

Due to inadequate national awareness on the project and the data collection exercise, and COVID-19 fears, some enumerators experienced resistance from some homeowners in providing the information required in the questionnaire, despite the enumerators having been provided with NEI/SACREEE name tags, T-Shirts, introduction letters and a flyer introducing the project. Some enumerators were refused entry into some homes, while some struggled to extract detailed information from households. In some instances, the homeowners viewed some questions as personal and intrusive, particularly those pertaining to finance/loan issues. This forced the enumerators to move to next house or simply take pictures of the refrigerator information tags to extract information from the internet later.

Furthermore, some enumerators faced challenges of missing information on the refrigerators. In some cases, only the name of the refrigerator was obtainable with no serial number or model number, which made it very difficult to retrieve key parameters of the questionnaire, such as the volume and annual energy consumption. This resulted in enumerators using manufacturer catalogues and internet searches to extrapolate the missing information.

Primary data collection for supply chain of residential refrigerators

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

- Supply chains, including interaction with markets from the countries where the other GCF projects are implemented;
- Brands and characteristics, including prices of products on the market with a specific focus on energy efficiency;
- Identification of manufacturers, distributors and retailers in the market;
- Market appetite for new and used (second-hand) equipment as well as repairing facilities for both products;
- Information on service technicians (skillset evaluation, training and certification, etc.);
- Stock and sales data (related to at least three to five years), market size and market segments, barriers and opportunities;
- Demand forecast and trends in sales, market projections for the upcoming years;
- For refrigerators: Identification and evaluation of the knowledge of refrigerators technicians in relation to refrigerants;

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

- For distribution transformers: The use of distribution transformers in the mining industry as well as the compliance with standards and consideration of energy efficiency in the specification of transformers to clients.please clarify

Out of a total number of 20 questionnaires for the supply chain, five responses were received, though it must be noted that the questionnaires had been partly complete. The questionnaire template is attached in Annex 3. Table 7 displays the various stakeholders identified and contacted for data collection on the supply chain of residential refrigerators indicating those that responded and non-response and the level of completeness of each questionnaire.

Table 6: Suppliers/retailers/importers/wholesalers of residential refrigerators

Suppliers/retailers/importers/wholesalers	**Responded**	**Non-response**	**Level of completeness of questionnaire (%)**	**Brand**
Manrico International (importer)	Responded		40	Defy, Hisense, AEG, Bosch & Fridgestar,
FurnTech (wholesaler)	Responded		50	Samsung, KIC, Whirlpool, Snowmaster, Univa, Sinotech & Skyworth
Atlantic Distributors (distributor/wholesaler)	Responded		60	Defy
Game Discount World (retailer)	Responded		40	Hisense, Defy, Whirlpool, LG, AEG, Logik, KIC& Samsung
Plusminus Electrical Repairs (distributor)	Responded		40	AEG & Bosch
Lewis Stores Namibia (PTY) LTD (retailer)		No response		
Nictus EDMS BPK (retailer)		No response		
Ohlthaver & List Group of Companies (retailer)		No response		
House & Home (retailer)		No response		
Furnmart (retailer)		No response		

Homecorp (retailer)		No response		
Hi-Fi Corporation (retailer)		No response		
Atlantic Refrigeration CC (distributor)		No response		
Pam Refrigeration Pty Ltd. (distributor)		No response		
Kovco Namibia Pty Ltd (distributor)		No response		
Millennium Refrigeration & electrical (distributor)		No response		
Trinity Import & Export Pty Ltd (distributor)		No response		
Starke Manufacturing and Air conditioning (distributor)		No response		
Metraclark (distributor)		No response		
Conversion Refrigeration & Air conditioning (distributor)		No response		
JB Cooling & Refrigeration(distributor)		No response		

From Table 7 above, it can be observed that only five suppliers/retailers/wholesalers/importers responded to the questionnaire sent to them and agreed to be interviewed. Their concern was that some of the questions in the questionnaire were requesting sensitive information that they were not willing to divulge due to market competitiveness. Samsung and Bosch don't display their energy consumption on the name plate. They are only displayed in their catalogues, which they use for their marketing purposes.

Primary data collection on distribution transformers

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

- Total stock of distribution transformer (by type) in use (i.e. single/three-phase liquid-filled, three-phase dry-type) and any other stock data;

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

- Characteristics of the distribution transformers used, rated power, technologies used(please clarify), typical losses, typical lifetime;
- Purchasing behavior, procedures and rules, as well as the financing of transformers, including technical specifications for purchases (with the objective to map the adoption of LLCC (TOC) based procurement practices and preferences, loss specifications and to check the MV&E process). Moreover, including purchase preferences from local industry versus imports, local value addition (and technical and tariff barriers, if any);
- Refurbishment practices and end of life;
- Procurement of distribution transformers in relation to energy efficiency;
- Disposal practice of old transformers;
- PCB content (ppm) in liquid filled transformers;
- Load demand (per household income, per region), as well as the demand and supply side barriers;
- Financial reports, existing subsidies, electricity bill payment systems and processes, metering systems and processes, etc. and;
- General electricity situation of the country.
- For distribution transformers: Use of distribution transformers in the mining industry/compliance with standards and consideration of energy efficiency in the specification of transformers to clients.

Table 8 displays the various stakeholders identified and contacted for data collection on the distribution transformers, indicating those that responded and those that did not, as well as the level of completeness of each questionnaire.

Table 7: Distribution transformers stakeholders

Utility, regional electricity distributors, suppliers, importers, retailers, engineering consulting firms	**Responded**	**Non-response**	**Level of completeness of questionnaire (%)**
NamPower (utility)	Responded		80
NORED (regional electricity distributor)	Responded		90
CENORED (regional electricity distributor)	Responded		70

Erongo RED (regional electricity distributor)	Responded		90
OPE (local authority electricity distributor)	Responded		60
Keetmanshoop Municipality (local authority electricity distributor	Responded		60
City of Windhoek (local authority electricity distributor	Responded		95
ACTOM Energy Namibia (distributor)	Responded		90
Megatron Namibia (importers/retailer)	Responded		10
Pupkewitz MegaTech (importer/retailer)	Responded		5
Swanib Cables (importer)		No response	0
Emcon Consulting Group (engineering consulting firm)	Responded		10
Lithon Project Consultants (engineering consulting firm)	Responded		10
G S Fainsinger and Associates (engineering consulting firm)	Responded		10

Additional stakeholders that were consulted for additional information on residential refrigerators and distribution transformers are depicted in Table 9 below.

Table 8: Government ministries, energy efficiency entities, customs, standards and regulatory bodies and financial institutions

Government ministries, energy efficiency entities, customs, standards and regulatory bodies
Ministry of Mines and Energy
Ministry of Industrialization and Trade (National Ozone Unit)
Ministry of Environment, Forestry and Tourism (Nationally Designated Authority)
Namibia Statistics Agency
Namibia Standards Institutions
Electricity Control Board
Namibia Revenue Authority (Customs and Excise division)
Namibia Chamber of Commerce and Industry (NCCI)
Financial Institutions
Bank of Namibia
Namibia Financial Institutions Supervisory Authority (NAMFISA)
Development Bank of Namibia
First National Bank of Namibia (FNB)
Standard Bank
Environment Investment Fund (EIF)
Solar Revolving Fund (SRF)
Bank Windhoek
AgriBank of Namibia
NEDBANK

EOS Capital
Letshego Bank
Government Institution Pension Fund (GIPF)

Secondary data collection through a desk study

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

- Official reports from organizations;
- Information from online stores;
- Books and academic reports (thesis, etc.);
- Online databanks;
- Policy documents and legal instruments and
- International and regional reports.

Data analysis, validation and interpretation

The data collected was entered into the Statistical Package for the Social Sciences software (SPSS) for data cleaning and validation. The data was cross-checked through various sources to ensure consistency and data quality. An SPSS file was created for analysis of the data. SPSS requires variables from the questionnaires which was used in the interpretation of the data at point of analysis.

Data from the household refrigerator survey was the only data entered in SPSS for analysis while the other two surveys were more informative and not investigative. Graphs, charts and tables were used in the interpretation of the data.

3.4 Key Assumptions

The survey was guided by the following assumptions:

- All households with access to electricity in selected areas own a refrigerator, refrigerator – freezer or freezer;
- The middle-income group is easily accessible and willing to provide data;
- Household samples collected from all the electrification zones would give us a true indication of the geographical representation of the country and
- The utility, regional electricity distributors and local authorities are the key players in the distribution transformer sector.

4. Overview of the Country

4.1 Socio-economic situation

The Republic of Namibia, is a country located on the west coast of Southern Africa. It borders the Atlantic Ocean to the west, while its land borders are shared with Zambia and Angola to the north, Botswana to the east and South Africa to the south and east, as shown in Figure 2. Although it does not have a land border with Zimbabwe, less than 200 meters of the Zambezi River separates the two countries. Zimbabwe and Namibia are thus considered neighbouring countries.

Namibia gained independence from South Africa on 21 March 1990, and its capital and largest city is Windhoek. The country is a member state of the Southern African Development Community (SADC), the African Union (AU), the Commonwealth of Nations and the United Nations (UN).

Figure 2: Map of Namibia. Image source: CTCN 2018

Namibia's population is estimated at 2, 5 million according to a World Bank country overview updated in March, 2021. The country's population density is 3 per km^2 (8 people per mi2), with 55.2 % of the

population living in urban areas (1,403,099 people in 2020). The median age in Namibia is 21.8 years. The country's total land area is 823,290 km^2 (317,874 sq. miles)[7].

Namibia is classified as a higher-middle-income country with an estimated annual gross domestic product (GDP) of USD 11 billion and per capita GDP of USD5,828[8] as of 2021 but has extreme inequalities in income distribution and standard of living. Namibia's GDP has grown by an average of 3.68 % annually between 1990 and 2019 (World Bank, 2021). The country leads the list of countries with income inequality with a Gini coefficient 74.3 (UN 2020). According to the National Household Income and Expenditure Survey (2016), the Gini coefficient for Namibia over a three-year period is represented in Figure 3 below.

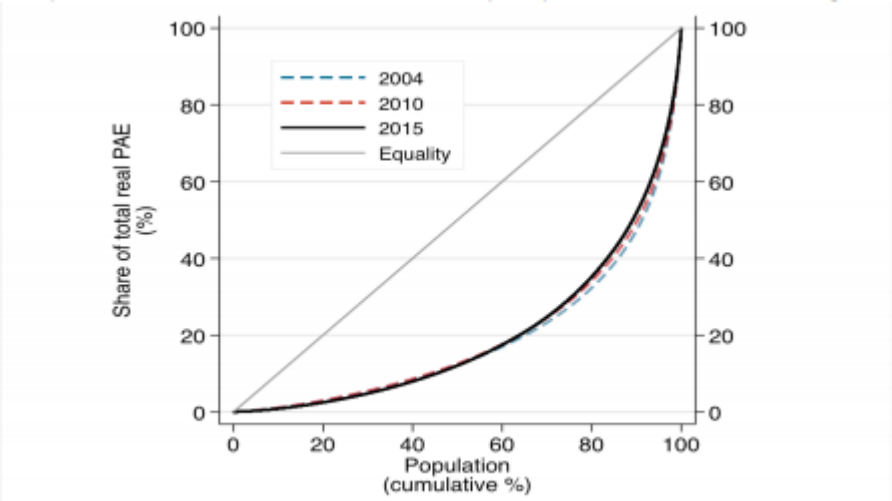

Figure 3: Lorenz diagram for income distribution among the population in Namibia: Image source: Namibia Household Income& Expenditure Survey (2016)

Since independence, the Namibian Government has pursued free-market economic principles designed to promote commercial development and job creation to bring disadvantaged Namibians into the economic mainstream. To facilitate this goal, the government has actively courted donor assistance and foreign investment. The liberal Foreign Investment Act of 1990 provides guarantees against nationalisation, freedom to remit capital and profits, currency convertibility, and a process for settling disputes equitably.

The country's formal economy is based on capital-intensive industry and farming. However, Namibia's economy is heavily dependent on the earnings generated from primary commodity exports in a few vital sectors, including mining especially diamonds, livestock, and fish. Furthermore, the Namibian

[7] https://www.worldbank.org/en/country/namibia/overview

[8] https://tradingeconomics.com/namibia/gdp#:~:text=GDP%20in%20Namibia%20is%20expected,according%20to%20our%20econometric%20models.

economy remains integrated with the economy of South Africa, as the bulk of Namibia's imports originate there.

The COVID-19 pandemic adversely affected Namibia's economy, shrinking it by 7.8 % in 2020 (BoN 2021), due to declines in tourism, retail, trade and investments, health, and education. However, the economy is projected to grow by 2.6 % in 2021 and 3.3 % in 2022[9], on the back of a steady recovery in financial services, tourism, retail and wholesale trade, and the mining industries—combined with an improvement in the regional and global economic environment

4.2 Energy (electricity) context

Electricity access/connectivity

The Government of the Republic of Namibia has been committed to supporting and actively promoting rural electrification. The Ministry of Mines and Energy's electrification programme focuses mainly on the provision of grid electricity infrastructure to connect Government assets in rural areas to the national grid and renewable energy solutions in remote rural areas, while urban electrification has largely been the domain of REDs or local authority entities. Policy, planning and strategic coordination for scaling up connectivity to electricity in rural areas has been the primary remit of the MME; informed by Rural Electricity Distribution Master Plans (REDMPs) and the Off-grid Electrification Master Plan (OGEMP). The original REDMP was adopted by the MME in 2000, with updates in 2005 and 2010 [REDMP, 2010].

The Namibia: Geospatial Least Cost Electrification Plan (2021) indicated that Namibia currently has an electricity access rate estimated at 50 %, with a rate of 72 % in urban areas and 21 % in rural areas, leaving over 300,000 households without a connection in 2020. Figure 4 below, details the electrification rates in Namibia in 2020.

[9] https://www.afdb.org/en/countries/southern-africa/namibia/namibia-economic-outlook

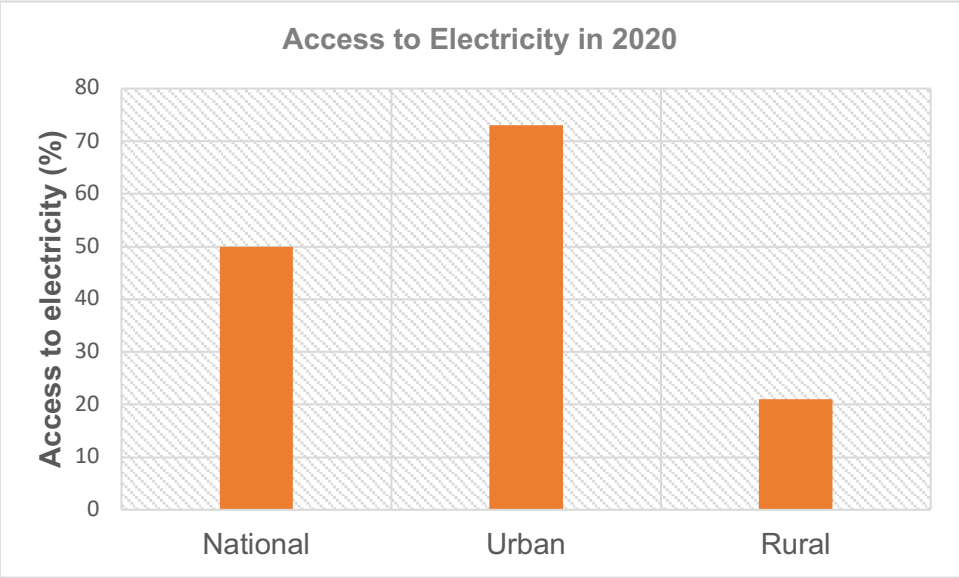

Figure 4: Electrification rates in Namibia in 2020. Image source: Namibia: Geospatial Least Cost Electrification Plan, 2021

With an annual population increase of 1.9 % (Namibia Population - Worldometers 2021), this number is projected to grow to 430,000 needing connections by 2030 to achieve universal connectivity by grid and off-grid options.

About 87 % of new connections are situated within 5 km of existing distribution network infrastructure and 77 % are within 2 km (Namibia: Geospatial Least Cost Electrification Plan, 2021). For the overwhelming majority of these proposed connections, grid intensification and densification represent the lowest cost modality to provide connectivity; with off grid solutions being more cost effective potentially to reach smaller and dispersed settlements situated further off from the existing grid network infrastructure across all the REDs.

The 430,000 new connections projected over 2020-2030 nationwide are distributed across the service areas of the REDs as follows: NORED (64 %); followed by Central RED (18 %). The spatial settlement patterns in CENORED (10 %), Southern RED and Erongo RED (4 %) and South RED (4 %) point to the potential for off-grid connectivity implementation (Namibia: Geospatial Least Cost Electrification Plan, 2021).

National electrification initiatives and roles of key Institutions

Over the past two decades, Namibia's electricity sector has undergone numerous important developments and changes, including improvements in the institutional and regulatory framework, electricity generating capacity addition, network expansion, and cross-border power interconnection (with South Africa and Zambia).

The sector has a well-developed regulatory framework with mandate for oversight of the responsibility with the regulator, the ECB. The MME has a key role in the electrification process as the policy maker and in leading rural electrification planning.

Electricity distribution is the responsibility of three REDs, OPE – presently these licensees are NORED, CENORED, ERONGO RED in their respective service areas. NamPower is the distributor for most of the Central and Southern region of Namibia geospatially. In addition, there are several local authorities and municipality distributors responsible for distribution and supply to certain end-consumers. In recent years, several Independent Power Producers (IPPs) have come on board as generators of renewable energy (NamPower, 2020).

NamPower is responsible for electricity generation, transmission, trading, and importing and exporting of electricity in the country. The utility owns and operates the major power stations in the country as well as the transmission grid. NamPower's distribution arm is responsible for rural electrification and also acts as the distributor of last resort where no other licensed distributor is present (NamPower, 2019)

MME leads the development of the Rural Electrification Master Planning process. At the project level, for rural areas and public institutions that benefit from subsidized electrification projects, as well development of mini-grids, MME conducts annual planning processes in consultation with regional councils, other local stakeholders and NamPower in order to determine priority projects to receive funds from Development Finance Institutions (DFIs), Government or NamPower's rural electrification budget. NamPower is responsible for executing some projects before handover to a distributor (or NamPower Distribution) for operation, while MME implements the bulk of rural electrification before handover to the REDs for operation for grid electrification only. However, the containerized solar systems and mini-grids are handed over to the Ministry of Works and Transport for operation.

REDs, local and regional authorities and NamPower may also propose new non-subsidized electrification projects based on local strategies, private requests (farms, etc.) and Net present value (NPV) costs; most grid densification and urban/per-urban electrification is handled in this manner.

Namibia's installed power capacity is about 639 MW (hydro 54 %, coal 14 %, diesel 3.5 % and solar and wind 28 %). This includes NamPower power stations and IPPs, while peak demand is 632 MW (excl. Skorpion Zinc mine which is connected to the NamPower grid but gets supplied power directly from Eskom, with a peak demand of 52 MW) (ECB, 2019). Table 10 indicates the existing grid connected power plants in Namibia in 2019 (ECB, 2019).

Table 9: Existing grid connected power plants in Namibia (ECB, 2019)

Name & Type of Power Plant	**Installed Capacity (MW)**
Ruacana Hydro Power Station	347
Van Eck Coal Power Station	120 (90)
Anixas HFO Power Station	22.5
IPPs (Solar and Wind)	180
Total	**639.5**

Figure 5 below shows the annual peak demand for electricity in Namibia (excluding Skorpion Mine) and the installed local generation capacity (licensed on-grid generators). The Figure clearly indicates

that the demand was equivalent to the generating capacity in Namibia. The demand increased by 5% from 602.39 MW in 2018 to 632.92 MW in 2019 (without Skorpion), while the generation capacity increased by 7.7 % from 593.71 MW in 2018 to 639.32 MW in 2019.

According to NamPower Strategic plan of 2019, the demand for power is expected to increase further over the next five years, up to 755 MW in 2022.

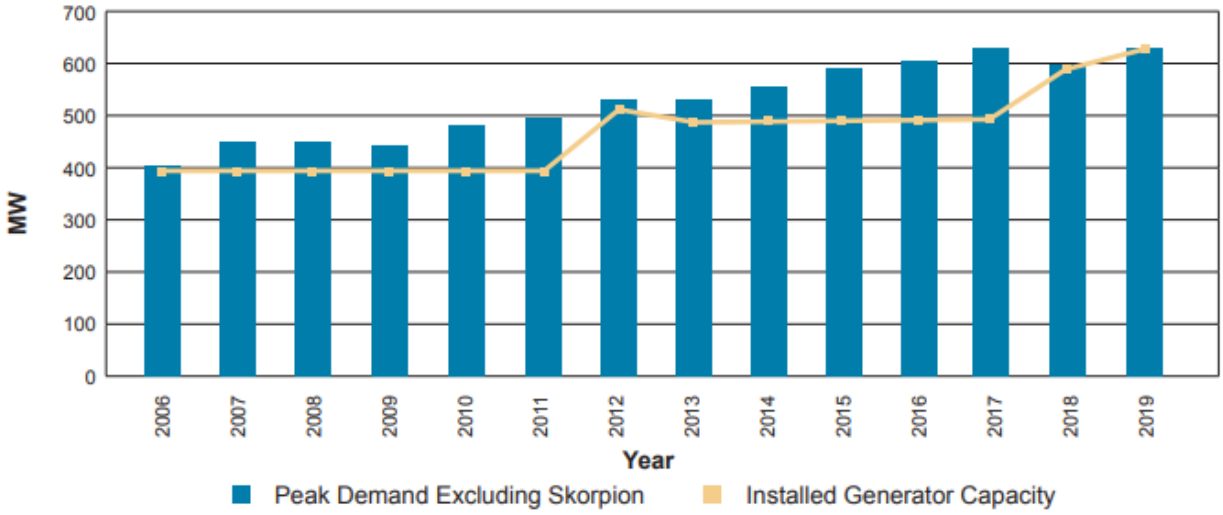

Figure 5: Namibia Electricity Generation versus demand. Image Source: ECB, 2019

NamPower anticipates that future growth demand of customers will be driven by REDs and Mines. Figure 6 below shows the consumption by customer groups (MWh) per financial year (NamPower, 2019).

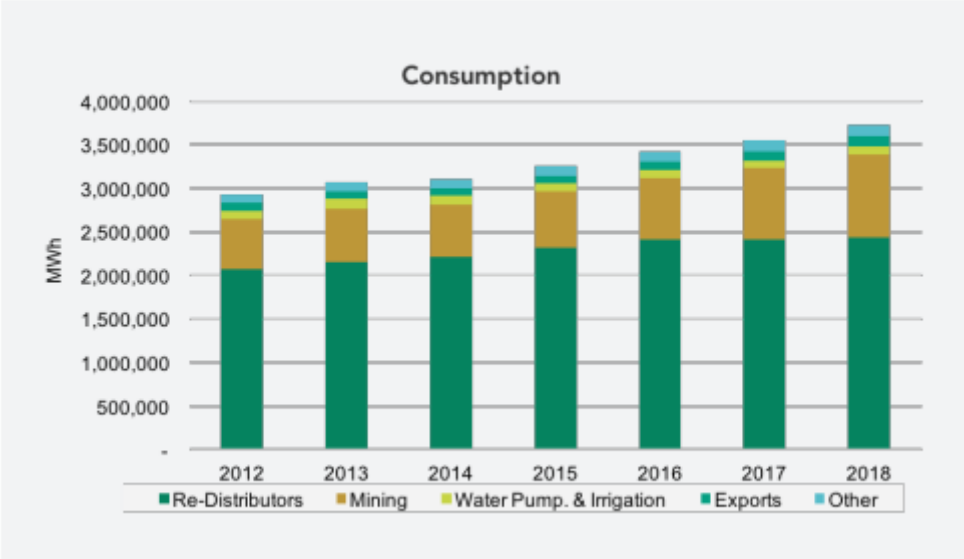

Figure 6: Consumption by customers groups (MWh). Image Source: NamPower, 2019

Namibia is a net importer in order to meet the electricity demand at all times, NamPower supplements its energy requirements with power from the region through Southern African Power Pool (SAPP) long term bilateral power purchase agreements (PPAs) and short-term trade markets. According to the NamPower annual report (2020), 59 % of electricity was imported into the country. NamPower currently has three bilateral agreements (PPAs).

- 200 MW with ESKOM (South Africa)
- 100 MW with ZESCO (Zambia)
- 80 MW with ZPC (Zimbabwe)

With one of the highest solar radiation levels in the world, Namibia stands to benefit as the worldwide boom in the solar market results in reduced costs and improved efficiency of solar PV panels and related equipment. Additionally, Namibia has potential sites for the development of large-scale wind power projects that have the potential to provide the country with sustainable power. NamPower is therefore developing, in alignment with the National Integrated Resource Plan (NIRP), multiple renewable energy projects that will provide Namibia with low-cost, green energy in the future. Table 11 indicates the planned new generation capacity to be installed with estimated commissioning dates.

Table 10: Planned Generation Projects with estimated commissioning dates (NamPower, 2019)

Project Name	Location	Technology	Capacity (MW)	Commissioning Date
Diaz Wind	Lüderitz	Wind	44	2023
IPP	Usakos	Solar PV	20	2022
NamPower	Omaruru	PV	20	2022
NamPower	Rosh Pinah	Wind	40	2024
IPP	Lüderitz	Wind	50	2024
NamPower	Tsumeb	Biomass	40	2025
NamPower Baseload	Walvis Bay	HFO	50	2023
Total capacity (MW)			264	

Transmission and distribution networks

Namibia's transmission network is composed of 66-400 kV and 350KVDC of overhead lines spanning more than 11 704 km, connecting generation sites and major demand centres, as shown in Figure 7 below. Some 400 kV lines are planned to extend the transmission grid into north-eastern and north-western Namibia, as well as additional transmission infrastructure associated with regional interconnection projects with South Africa to the south, Angola to the north and Botswana to the east.

Multiple line strengthening projects are planned, the largest of which include the Auas-Gerus 400 kV line, the Auas-Kokerboom 2nd 400 kV line and the Obib to South Africa (Oranjemund) 400 kV line (NamPower, 2019).

Figure 7: Generation and transmission network in Namibia. Image Source: Namibia: Geospatial Least Cost Electrification Plan, 2021

The distribution network covers most of the densely populated areas in Namibia, as well as many rural areas. In total, the 11- 33 kV medium-voltage network extends more than 45, 000 kilometres across the country, with approximately 306 distribution and transmission substations as shown in Figure 8 below.

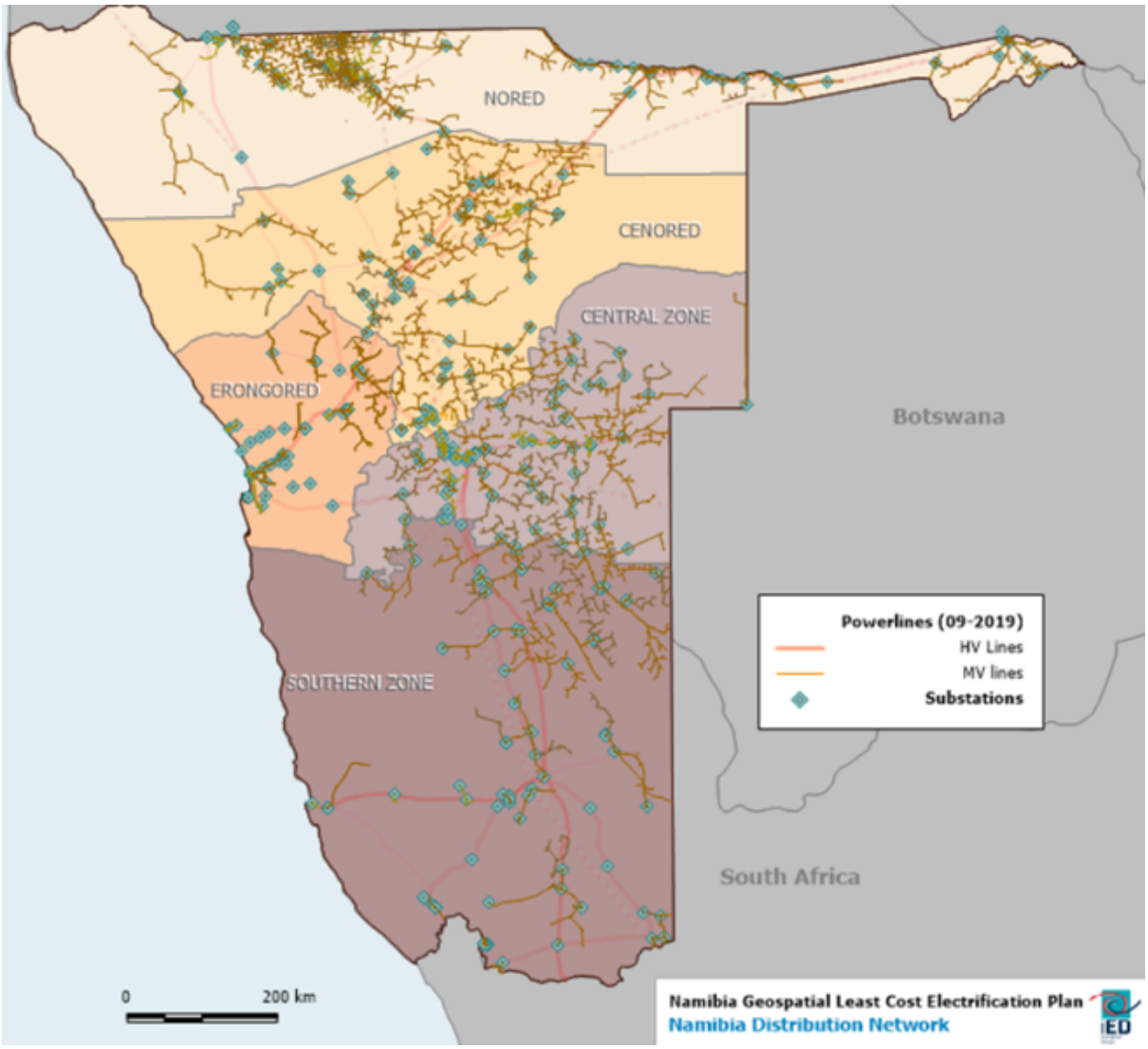

Figure 8: Distribution Network in Namibia. Image Source: Namibia: Geospatial Least Cost Electrification Plan, 2021

The transmission grid is a highway for electricity delivery across the country and also forms part of the regional grid used for power exchange with other countries. NamPower transmission grid comprises transmission lines at voltage levels of 400 kV, 350 kV DC, 330 kV, 220 kV, 132 kV and 66 kV voltage levels, while the REDs are operating at distribution voltage levels of 11 kV, 19 kV (SWER), 22 kV and 33 kV. Table 12 below indicates the system voltage for single and three phases.

Table 11: Voltage levels (NamPower, 2020)

Type	**Voltage Range**	**Application**
Single Phase	220 V – 240 V	Domestic
Three Phase	380 V – 400 V	Large users /Commercial

Other	11 kV – 33 kV	Industrial

Legal framework and key institutions

Energy sector activities in Namibia are guided by the following Policies and Legislation:

i. National Energy Policy (NEP,2017)

In 2017, Cabinet approved an updated National Energy Policy, replacing the White Paper on Energy Policy of 1998, the revised Policy is the Government's new aspirational energy framework, and it is to guide our energy sector into the future. The main goals of the Policy are to,

- ensure the security of all relevant energy supplies to the country
- create cost-effective, affordable, reliable and equitable access to energy for all Namibians
- promote the efficient use of all forms of energy
- incentivise the discovery, development and productive use of the country's diverse energy resources.

ii. National Renewable Energy Policy (NREP,2017)

In 2017, a National Renewable Energy Policy for Namibia was developed, signalling the intent of the Government on how to develop the Renewable Energy sector and scale-up the contribution of power from renewable sources in the country's electricity mix. The Policy will address major barriers that stand in the way or constrain the development of renewable energy, and create an enabling environment that reduces or eliminates such barriers, and fosters accelerated development of renewable energy.

Policy Statement 16 in the National Renewable Energy Policy (2017) states that:

- "Government shall develop a detailed Energy Efficiency (EE) and Demand Side Management (DSM) Policy for all sectors of the economy that continues to build on existing energy efficiency efforts including research on energy end-use data and public education campaigns promoting the efficient use of energy." and
- "The Energy Efficiency and DSM Policy shall examine the need for Regulatory reform to eliminate perverse incentives that utilities have to promote consumption rather than conservation. The Policy would also set energy efficiency goals for which utilities shall be held accountable."

Table 13 indicates the priority areas for energy efficiency in the National Renewable Energy Policy (2017).

Table 12: Priority areas for energy efficiency policy (NREP, 2017)

Energy Efficiency Priority Areas	Examples of international policies and measures
Building and homes	Building codes and performance ratings for existing and new buildings
Appliances and Equipment	Minimum energy performance standards (MEPS) and labelling
Lighting	Efficient lighting requirements for retail sales and street light installations
Transport	Vehicle fuel-efficiency standards, support for electric vehicles, transport system efficiency
Industry and mining	Energy management protocols such as ISO 50001 and MEPS for energy intensive equipment (e.g. motors)
Other sectors and cross-cutting areas	Utility efficiency requirements and targets, price signals, data collection, monitoring and verification, enforcement, public awareness and education

Although the Government is committed to develop an Energy Efficiency and Demand Side Management policy that supports the development of MEPS, relevant government officials interviewed indicated that there are currently no regulations promoting the uptake of energy efficient refrigerators and distribution transformers. Furthermore, there are no local standards and labelling available for residential refrigerators currently.

iii. National Integrated Resource Plan (NIRP)

The National Integrated Resource Plan is the electricity supply sector's development plan for the next 20 years. The Plan spells out what electricity generation projects we need to be able to meet the growing demand for electrical energy. It projects significant growth in the country's electricity demand and estimates that an investment in the range of NAD 90-97 billion (USD 6-7 billion) will be needed over the next 20 years (NIRP, 2016). NIRP outlines the development of the plans for new power generation and transmission additions taking into account the increase in demand, the aging of the existing generation fleet, the possibility of curtailment of imports from other networks and the implementation of the security of supply aspects outlined in the National Energy Policy (2017). NIRP is currently under review, and is expected to be available in the third quarter of 2021.

The projected supply and demand for the planning horizon indicates that the committed projects are not sufficient to diminish Namibia's dependence on imports from Eskom, ZPC and ZESCO. In 2020, a gap of 450 MW existed between national capacity and peak demand excluding imports (NIRP, 2021). Figure 9 below shows the power capacity supply and demand balance projected, excluding Skorpion Zinc Mine, from 2020 – 2040 (NIRP, 2021).

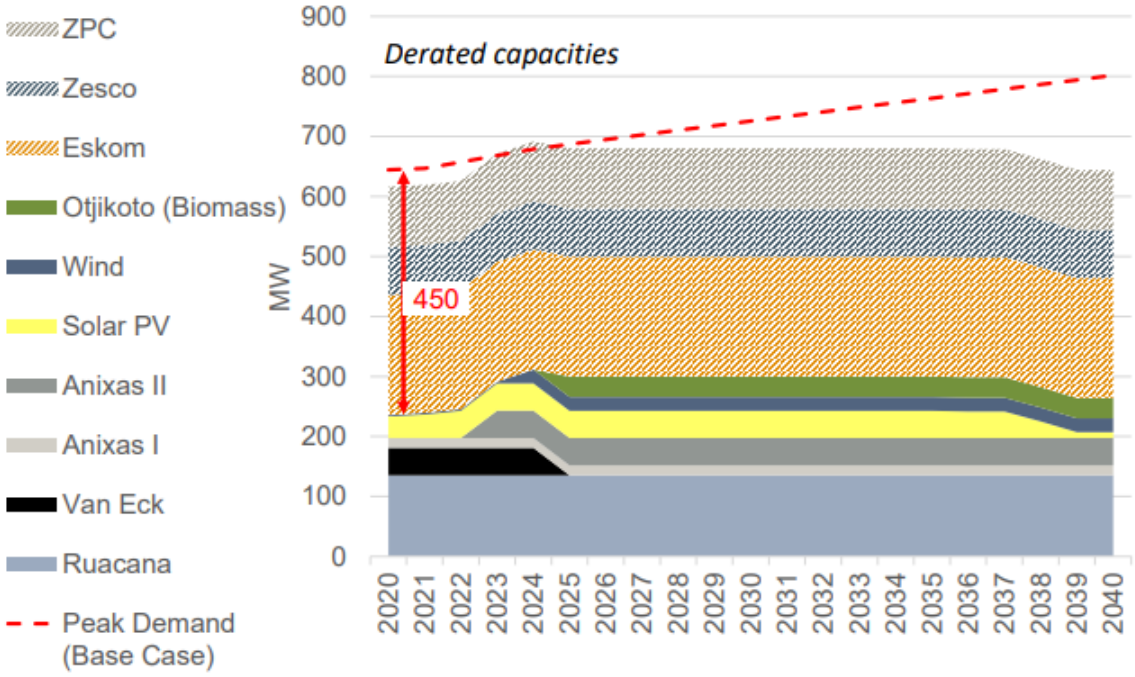

Figure 9: Power capacity supply and demand balance. Image Source: NIRP, 2021

iv. National Independent Power Producer Policy

The National Policy for Independent Power Producers (IPPs) in Namibia is currently under development. The IPP Policy outlines the key provisions of the Government's commitment to encourage private investment in Namibia's power sector and outlines the power market model, pricing regime, procurement approach, and the requirements for the IPPs to develop power generation projects and seek licenses for implementing the projects. To date, several Independent Power Producers (IPPs) have commenced operations, and more are due to commence operations in the very near future (MME, 2018).

v. Electricity Act of 2007

This is the main law regulating electricity in Namibia. It establishes the ECB as the sector's regulator and introduces licensing of all electricity supply side activities and regulation of electricity tariffs. This will be replaced by the Energy Regulatory Bill and Electricity Bill currently under development (MME, 2018).

vi. Energy Regulatory Authority Bill

The Namibia Energy Regulatory Authority Bill focuses on provisions regarding the establishment and operation of the to-be-established Namibian Energy Regulatory Authority (NERA). The Bill describes NERA's roles and responsibilities, which include the regulation of the electricity sector, downstream gas including gas pipelines and storage facilities, renewable energy and energy efficiency activities (MME, 2018).

vii. Electricity Bill

The Electricity Bill aims to create a more formalised foundation for the electricity sector's market reform and market structure initiatives, to pave the way for the systematic modernisation of the country's ESI. The Bill also provides for the establishment of a market operator and a system operator, which are currently exercised by the state-owned utility NamPower.

The Bill also deals with IPPs through the introduction of regulatory oversight of Power Purchase Agreements (PPAs). In addition, and in order to accommodate local government, the Bill makes specific provisions regarding local authority and regional council royalties, as well as levies payable by customers.

Currently, there are no electricity subsidies in Namibia but electricity tariffs are fixed at cost-recovery levels, with businesses on time of use and peak demand tariffs which cross-subsidize the non-commercial tariff. In Namibia end customers are billed either through pre-paid or post-paid meters. Distribution companies prefer pre-paid electricity meters. For example, the City of Windhoek has already installed more than 50 000 pre-paid meters and all new housing developments come with pre-paid electricity meters. However, there are still 17 000 post-paid meters in Windhoek which the city authorities aim to convert to pre-paid in the next five years.

viii. Modified Single Buyers Model

The Modified Single Buyer (MSB) model is a new market framework which is an incremental modification of the older Single Buyer (SB) model which allowed only NamPower to procure electricity supply from SAPP utilities or IPPs. The new MSB model allows identified Contestable Customers (CC) and Eligible Sellers (ES) to transact with each other directly for the supply of electricity of up to 30 % of the customer's energy requirement as identified and licensed by the ECB. The MSB model also aims to allow for private generators to build new generation capacity in Namibia for export purposes. The MSB is a step further towards greater competition and choice in the electricity industry (NamPower, 2020).

The key institutions that play a major role in promoting energy efficiency in Namibia are summarised in Table 14 below.

Table 13: Key Institutions in Namibia

Main Organisation	Description /Role
Directorate of Energy, Ministry of Mines and Energy	MME is the custodian of the country's mineral and energy resources. The Ministry provides policy direction and through the Energy Directorate in the Ministry all the activities in the electricity sector is being coordinated. Furthermore, the ministry is the custodian of the National Energy Policy (2017), National Renewable Energy Policy (2017) and Rural Electrification Master Plan of 2010 (MME, 2021)

Electricity Control Board (ECB)	ECB is a statutory regulatory authority established in 2000 under the Electricity Act 2 of 2000, which has subsequently been repealed by the Electricity Act, 4 of 2007 that provided for the private sector participation and Independent Power Producer (IPP) framework. The core mandate of the ECB is to exercise control over the electricity supply industry with the main responsibility of regulating electricity generation, transmission, distribution, supply, import and export in Namibia through setting tariffs and issuance of generation and transmission licenses (ECB, 2020). The Namibia Energy Regulatory Authority (NERA) Bill is currently being drafted. Under the NERA Bill, the ECB will be transformed into the Namibia Energy Regulatory Authority (NERA). The new Electricity Bill will introduce the required changes to give effect to the establishment of the NERA. ECB is also a custodian of the Namibia Electricity Network Asset (NENA) (ECB,2020)
Namibia Power Corporation (NamPower)	NamPower is a state-owned national utility responsible for electricity generation, transmission, trading, and importing and exporting of electricity in the country. The utility owns and operates the major power stations in the country as well as the transmission grid, and it is involved in the distribution of electricity where other suitable suppliers are unavailable (NamPower, 2020)
Regional Electricity Distributors (REDs)	REDs are responsible for transmission and distribution of electricity in their areas of jurisdiction. There are three REDs currently fully operational in Namibia; NORED (accounting for 35.3 % of the market share), CENORED (11.6 %) and ERONGO RED (14.4 %)
Local, Regional and Traditional Authorities	Local and regional authorities are second-tier government structures whose mandate includes the provision of services and planning of land within their areas of responsibility.
Namibia Energy Institute	NEI is a joint venture initiative between the Namibia University of Science and Technology (NUST), formerly known as the Polytechnic of Namibia, and the Ministry of Mines and Energy. Its mandate is to research and disseminate information on conventional energy, renewable energy and energy efficiency technologies and practices. Furthermore, NEI aims to build to capacity across the field of energy, and to contribute to Namibia's industrialisation by linking energy research, technology, policy, and education to the needs of all stakeholders. The institute is working closely with the Ministry of Mines and Energy (NEI, 2021)

National Planning Commission (NPC)	The overarching mandate of the NPC is to "plan and spearhead the course of national development", and its main functions include (NPC, 2021). • Identifying Namibia's socio-economic development priorities • Formulating short-, medium- and long-term development plans in consultation with stakeholders • Developing monitoring and evaluation mechanisms to ensure effective implementation of plans • Evaluating the effectiveness of the Government's socio-economic policies • Coordinating the development of Government socio-economic policies to ensure consistency • Mobilising, managing, and coordinating international development cooperation
Ministry of Environment, Forestry and Tourism (MEFT)	MEFT responsibilities relate to ensuring that electrification activities meet environmental standards, issuing environmental clearances where relevant, and monitoring compliance with environmental regulations (MEFT, 2021)
Namibian Standards Institution (NSI)	The Namibian Standards Institution (NSI) was established in terms of the Standards Act, 2005 (Act No. 18 of 2005) and is governed by the Namibian Standards Council (NSC). In relation to electrification, the NSI's roles and responsibilities include (NSI, 2021). • Managing and coordinating the implementation of the National Quality Policy • Developing, adopting, and publishing standards that meet World Trade Organisation requirements • Certifying products and management systems through the Marks of Conformity

5. Market assessment on residential refrigerators

5.1 Supply Chain

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

A number of institutions and entities were identified as key stakeholders that play a fundamental role in the supply chain of refrigerators in Namibia. The Namibian market is dominated by refrigeration appliances manufactured and imported from South Africa. The main leading importers of the refrigerators active in the Namibian market include Furntech (distributor for KIC, Whirlpool, Snomaster, Univa, Sinotech, Skyworth and Samsung), Atlantic distributors (Defy Namibia distributor) and Namibia Audio Mecca, distributor for HiSense and LG, as well as Manrico International (AEG and Liebherr distributor). Most distributors offer a warranty from the factory of two years on a unit, and up to 10-year warranty on the inverter compressors.

The survey of the supply chain also identified some of the large retailers, such as Game Stores, Bears Furnishers, House & Home, Furnmart, Hi-Fi Corporation, Homecorp, Lewis stores, Nictus, amongst others. These retailers also import directly from their head offices in South Africa. The retailers are responsible for selling to the end users and have their own funding schemes which enable consumers to apply for in-store credit to purchase the appliances. The retailers also take risk insurance on the appliances bought by consumers for the duration of the repayment period of the loan they extend to the consumers. This also extends the two-year warranty period to the repayment period, so the consumer can be able to return or repair the appliance within the repayment period, using the risk insurance.

The Namibia Revenue Agency (NAMRA) is responsible for tax collection in the country was identified as a key stakeholder, as customs and excise play a major role in the enforcement of the Montreal Protocol.

Other key stakeholders included the National Ozone Unit and the Namibian Standards Institution. The National Ozone Unit together with NSI recently established a Technical Committee responsible for developing refrigerators and air conditioning safety standards. This is likely to be merged with the Technical Committee on refrigerators (TC-REF) that is about to be formed as part of this project.

5.1.2 Manufacturing of refrigerating appliances

Namibia does not manufacture any refrigeration appliances, which was confirmed by the Namibia Manufacturers Association (NMA) and the Namibia Chamber of Commerce and Industry (NCCI). Some of the reasons given for this are:

- lack of manufacturing machinery;
- lack of access to affordable energy and;
- unaffordable labour force in the country.

Although the Government of Namibia offers highly competitive incentives and fiscal regime, such as the Special Incentives for Manufactures and Exporters, there are no special incentives targeted at manufacturing of cooling appliances. The NCCI and the NMA are of the opinion that the incentives for

manufacturers are not clearly articulated and the procedures of acquiring such incentives are not clear. Both institutions cited lengthy and bureaucratic processes as reasons why local manufacturers had not pursued manufacture of cooling appliances.

Some of the incentives for manufacturers promoted by the Ministry of Industrialisation and Trade include the following;

a) Corporate Tax at a rate of 18 % for a period of 10 years, where after it will revert to the general prevailing rate.

b) Value Added Tax (15 %) exemption on purchase and import of manufacturing machinery and equipment.

c) A special building allowance where factory buildings are written off at 20 % in first year and balance at 8 % for 10 years and;

d) Transport allowance for land-based transportation by road or rail translating to a 25 % deduction from total cost.

According to 2020 Annual International Trade Statistics by Country, published by TrendEconomy, Namibia's imports of "Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines", were mostly from neighbouring South Africa, with a market share of 82 % (USD 16 million in value)[10]. Other imports came from China (7.78 %, with USD 1.51 million in value) and the remaining 10 % from European countries (TrendEconomy, 2020).

5.1.3 Overview of the supply chain

Residential refrigerators used in Namibia are imported, mainly from South Africa. The market is supplied with various types of refrigerators, refrigerators with freezers and freezers. The most used refrigerator technology in Namibia includes the refrigerator-non-inverter, refrigerators-freezers-non-inverter and refrigerator inverter. These include chest freezer, single door refrigerator, double door refrigerators and bar fridges as shown in Figure 10 below. No information could be obtained with regards to frost free or direct cool refrigerator types.

[10] https://trendeconomy.com/data/h2/Namibia/8418#:~:text=million%20in%202019)-,Imports%20of%20commodity%20group%208418%20%22Refrigerators%2C%20freezers%20and%20other%20refrigerating,amounted%20to%20%24%206.82%20billion).

Figure 10: Types of refrigerators and freezers supplied in Namibia.
Image Source: Suppliers of Refrigerators in Namibia

The overview of the supply chain of residential refrigerators is summarised in Figure 11 below. All refrigeration products entering Namibia must be examined to ascertain the energy efficiency of the product, mainly for Value Added Tax (VAT) exemption purposes. The main leading importers of the refrigerators active in the Namibian market include Furntech, Atlantic distributors, Namibia Audio Mecca and Manrico International. Game Stores, Bears Furnishers, House & Home, Furnmart, Hi-Fi Corporation, Homecorp, Lewis stores and Nictus are some of the large retailers in the country.

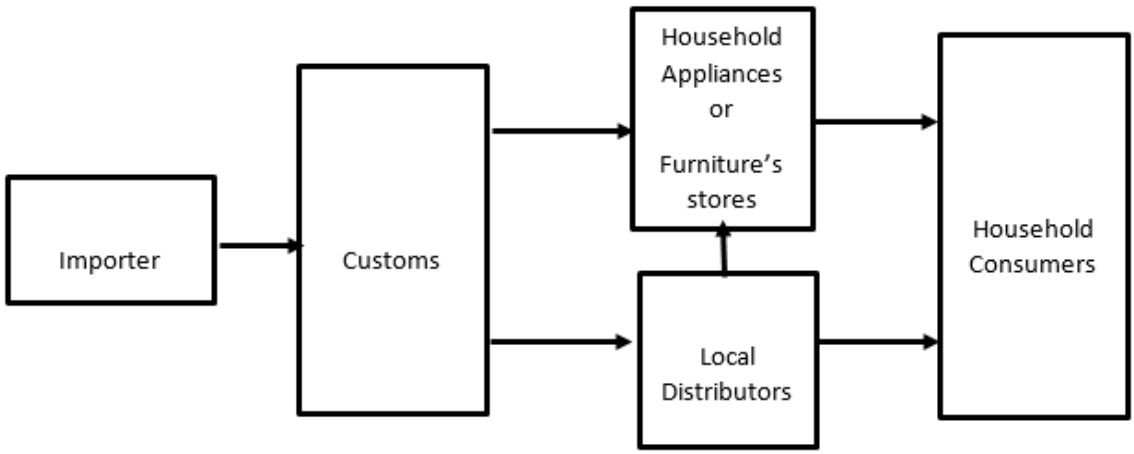

Figure 11: Supply chain of refrigerators in Namibia (UNEP-U4E, 2021)

The survey found that the most common refrigerant used in most refrigerators, refrigerator-freezers and freezers is R600a with 93.3 %, 84 % and 77 % respectively as indicated in Figures 12, 13 and 14. R134a was the second highest refrigerant equipped in most refrigerators, refrigerator-freezers and freezers. R134a is a hydrofluorocarbons (HFC) refrigerant, with a highest percent of 13.9 % in refrigerator-freezers, which are mostly used by middle income consumers, whereas R600a is a

hydrocarbon (HC) refrigerant with a relatively low Global Warming Potential (GWP) and recommended as the standard refrigerant for European domestic refrigerators and freezers (UNEP-U4E, 2021).

Namibia is one of the countries that have ratified the Kigali Amendment to the Montreal Protocol on substances that deplete the Ozone layer. Adopted in 1987, the Montreal Protocol is the sole protocol to the 1985 Vienna Convention for the Protection of the Ozone Layer, which protects life on earth from the harmful UVB radiation. A Government Gazette was amended and published following Namibia's ratification to the Kigali Amendment. The Kigali amendment advocates for energy efficient and low GWP technology in the cooling sector, including refrigerators. The gazette set control measures on the importation and consumption of low energy efficient and high GWP refrigerants used in the cooling appliances such as refrigerators, with an aim to phase out and have a much greener and energy efficient industry by 2045.

Hence, the survey found a high number of refrigerators using R600a which is low GWP refrigerant. Furthermore, the amended Gazette No.148 of 2020 prohibits the importation of harmful refrigerant gases including R134a, R500a, R12, F502, NH3 as from January 2021 (MIT, 2020). Some of these refrigerants have been outlawed in Namibia but still exist in the market at a small scale as they are in the process of being phased out.

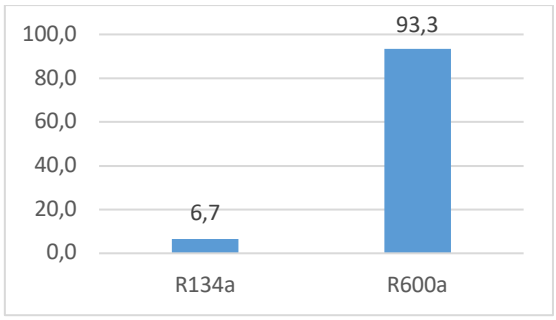

Figure 12: Respondents by refrigerator refrigerant type

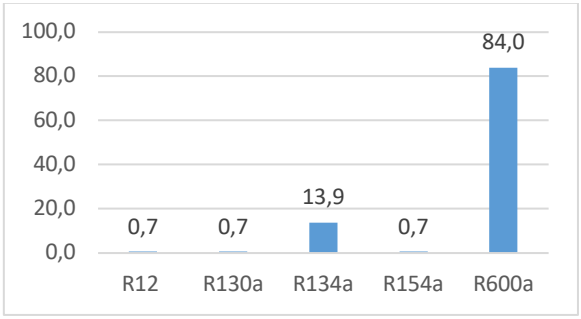

Figure 13: Respondents by refrigerator-freezer refrigerant type

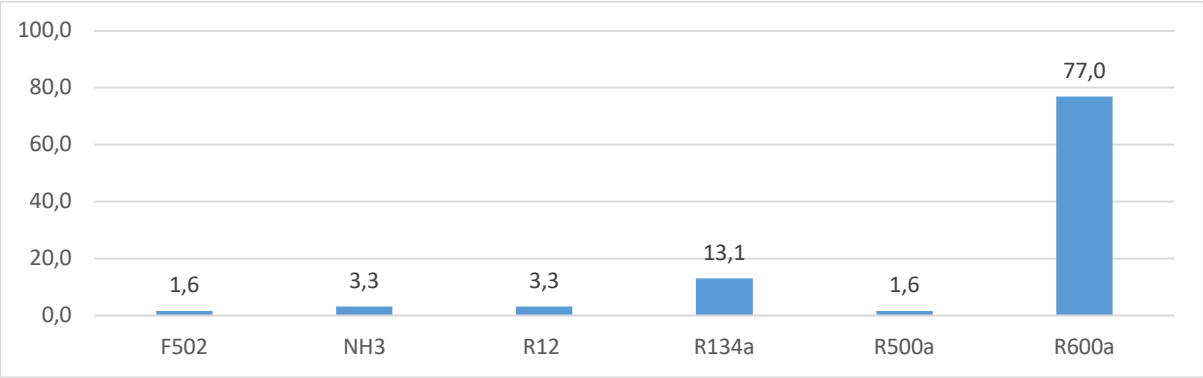

Figure 14: Respondents by freezer refrigerant type

5.1.4 Best-selling equipment

Despite the difficulties that the supply chain survey had in acquiring information on best-selling equipment, the household survey indicated that the most common refrigerator brand amongst respondents was Defy (36.7 %), followed by KIC brand with 26.7 %. For the freezers, the most common brand amongst respondents was Defy (44.6 %), followed by KIC brand with 32.3 %. The most common refrigerator-freezer brand amongst respondents was KIC (30.6 %), followed by Defy brand with 25.7 %. Figures 15, 16 and 17 depict the respondents by brand of refrigerator, refrigerator-freezer and freezer respectively.

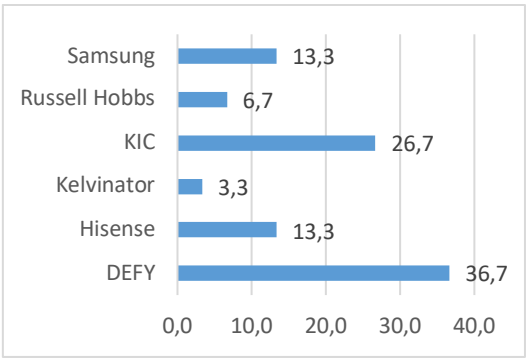

Figure 15: Respondents by brand type of refrigerator

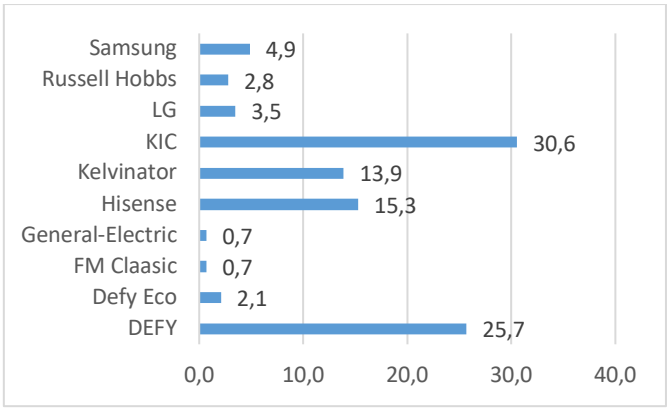

Figure 16: Respondents by brand type of refrigerator-freezer

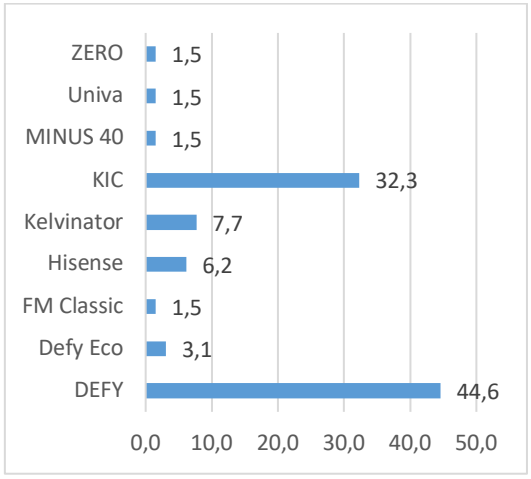

Figure 17: Respondents by brand type of freezer

The lowest purchasing price for a refrigerator appliance was found to be USD 117.98 (Oanda currency converter, 2021) and this was a KIC brand refrigerator, with an exchange rate of 1USD equivalent to NAD 14.04. The highest purchase price for a refrigerator was USD 783 a Russell Hobbs factory brand refrigerator. The lowest purchasing price for a refrigerator-freezer appliance was found to be USD 106.7 and this was a KIC brand refrigerator-freezer. The highest purchase price for a refrigerator-freezer was USD 1 281, a KIC factory brand refrigerator-freezer. The lowest purchasing price for a freezer appliance was found to be USD 71 and this was a General-Electric brand freezer. The highest purchase price for a freezer was USD 1 067.8 for a Kelvinator factory brand freezer.

The most-costly among the fridge types are the refrigerator-freezers and less costly are the freezers.

The survey indicated that the most used refrigerator technology were refrigerator-non-inverter and refrigerator-freezers-non inverter, at 25 %, followed by the refrigerator–inverter at 20 %. Figure 18 indicates the type of technology used.

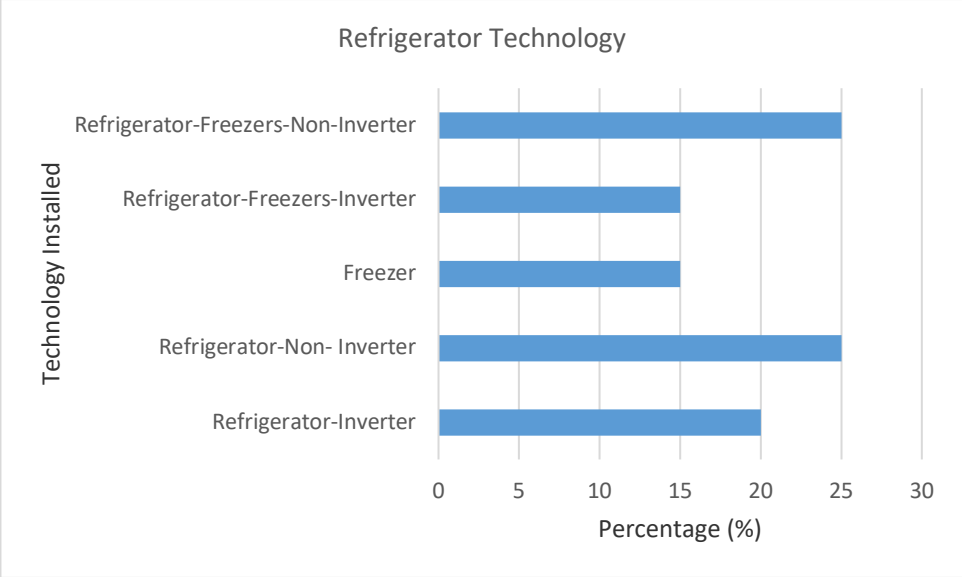

Figure 18: Refrigerator Technology in the market

Table 15 below indicates the typical prices for the residential refrigerators in Namibia.

Table 14: Typical Prices of residential refrigerators in Namibia based on supply survey (Exchange rate of 1USD ~ NAD14.0)

Type of Refrigerator	Volume	New product price range USD
Freezer only	100 L - 590L	150 - 393
Refrigerator only	100 L - 590L	71- 571
Refrigerator- Bottom-Freezer	100 L - 590L	165 – 670
Top Freezer	100 L -590 L	178

5.1.5 Barriers to the sale of efficient residential refrigerators

Supply chain is a price-driven market where the items that they stock are driven by the consumers' affordability to buy them. And since energy efficient refrigerators are more expensive than the energy inefficient appliances which the majority of consumers can afford, suppliers are forced to stock the cheaper appliances for the sake of business. For example, an energy efficient Samsung refrigerator (model number RR39M71407F), with an annual energy consumption of 146 kWh, costs NAD 16 200 (USD 1 160), compared to a Defy refrigerator (model number DFD430), with a similar capacity and an annual energy consumption of 316 kWh, costs NAD 8 600 (USD 615). A Samsung refrigerator freezer (model number RB29HWR3DS), with a volume of 360 liters, costs NAD 10 700 (USD 765), while a KIC model with almost the same capacity (model number 6220564), costs NAD 7 000 (USD 500).

There are also no financial incentives aimed specifically at encouraging the uptake of energy efficient household appliances, such as refrigerators, leading to low consumer demand for energy efficient appliances. This is compounded by the fact that the Namibian market is very small and up to 47 % of the total population do not have access to electricity.

The survey could not find specific national policies governing the use of energy-efficient appliances, although there was general policy encouraging energy efficiency. Namibia has ratified the Kigali Amendment to the Montreal protocol, on substances that deplete the Ozone layer. Adopted in 1987, the Montreal Protocol is the sole protocol to the 1985 Vienna Convention for the Protection of the Ozone Layer, which protects life on earth from the harmful UVB radiation. A Government Gazette was amended and published following Namibia's ratification to the Kigali Amendment. The Kigali amendment advocates for energy efficient and low GWP technology in the Refrigerator and Air Conditioning (RAC) sector. The gazette set control measures on the importation and consumption of low energy efficient and high GWP refrigerants used in the RAC appliances such as air conditioners and refrigerators, with an aim to phase out and have a much greener and energy efficient industry by 2045 with effect from January 2021.

5.2 Demand

5.2.1 General consumer information

Namibia is divided into five electricity distribution zones, CENORED, Central zone, ERONGO RED, NORED, Southern zone. These five zones contain all the country's 14 geographical regions, where CENORED includes the eastern regions, central zone includes the central regions, ERONGO RED includes the western regions, NORED includes the northern regions and southern zone includes the Southern regions. The majority, 35.6 % of the respondents were from NORED zone, 26.7 % from the Central Zone, 14.4 % from the ERONGO RED, while 11.4 % and 11.9 % of the respondents were from CENORED and Southern zones respectively. Figure 19, depicts the respondents by electricity distribution zones.

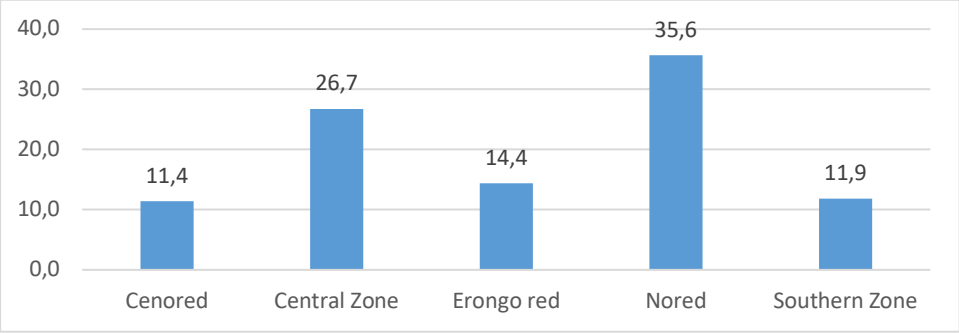

Figure 19: Respondents by electricity distribution zones

Respondents were asked to state their average monthly income and 24.3 % of the respondents reported that they earn between NAD 5 000 (USD 357) and NAD 10 000 (USD 714) monthly (at the prevailing exchange rate of 1 USD to 14 NAD). About 22.3 % earn less than NAD 5 000 (USD 357), 20.8 % earn between NAD 15 000 (USD 1 071) and NAD 20 000 (USD 1 429). Another 18.3 % earn between

NAD 10 000 (USD 714) and NAD 15 000 (USD 1 071), while 12.9 % earn above NAD 20 000 (USD 1 429). The remaining 1.5 % declined to reveal their income.

Figure 20 below, represents the sex composition and age distribution of the respondents that participated in the survey. More than half, 53.5 % of the respondents, were males, while 45.5 % were females. The majority of the male respondents were between the ages of 40 and 49 (31.3 %), while the majority of the female respondents (31.7 %) were in the 30-39 age bracket.

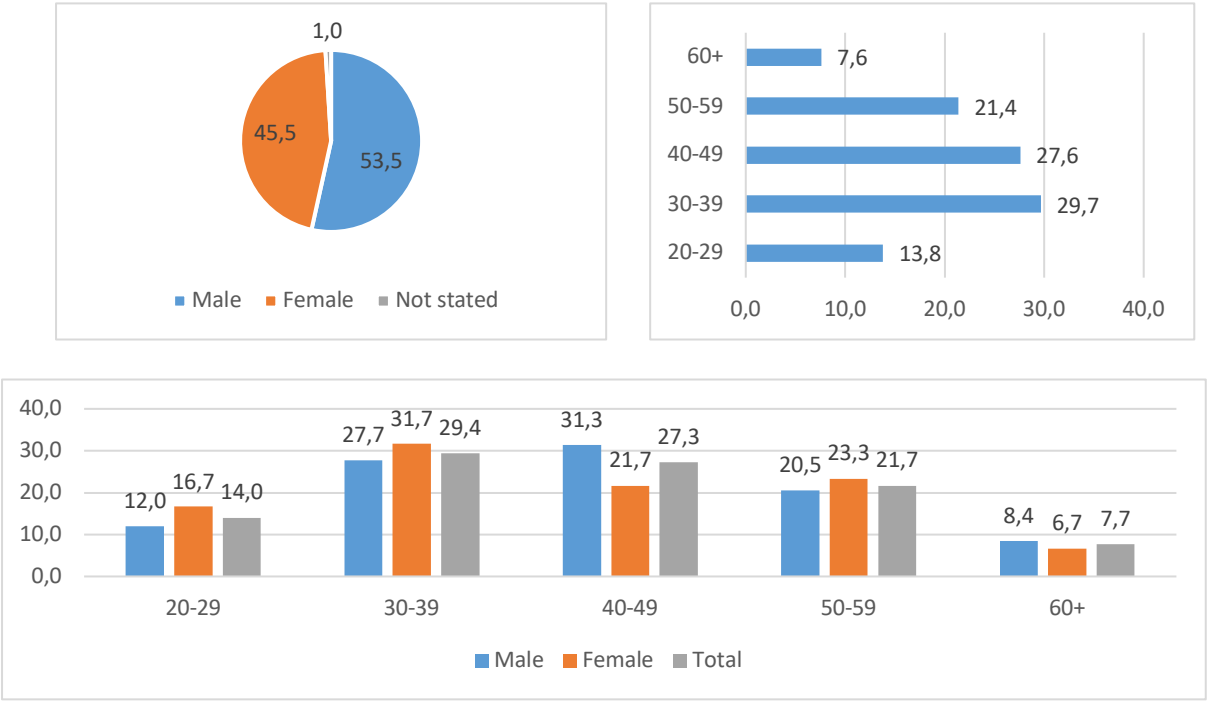

Figure 20: Respondents by sex, Respondents by age, and Respondents by age and sex

The survey indicated that 40.6 % of the respondents are employed in the public sector, 27.2 % in private sector, while 24.3 % are self-employed. While 7.9 % of the respondents did not state their type of employment. Figure 21 depicts the type of employment sector.

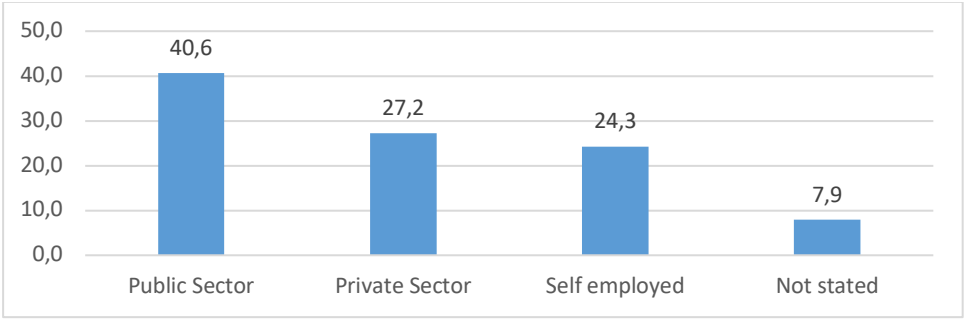

Figure 21: Respondents by employment sector

The survey indicated that about 45 % of the respondents' houses had three bedrooms, a hall area and a kitchen (3BHK), while 6.9 % of the respondents' houses had 1 bedroom, a hall and a kitchen, as indicated in Figure 22 below.

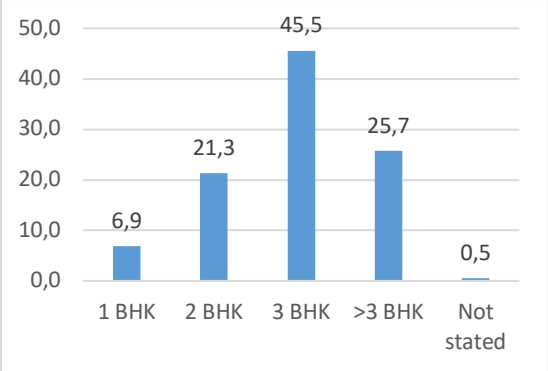

Figure 22: Respondents by size of house in BHK

It can be observed from Figure 23 that 38.1 % of the respondents were fathers, while the majority (56.9 %) of the respondents indicated that they owned the house they are currently living in. However, this is not representative of the home ownership rate in Namibia because the survey targeted a small number of middle-income households.

Table 16 below indicates the household size using mean and standard deviation. The results show that the average household size of respondents was between 4 and 5 persons per household, with an average of adult members between 3 and 4 and children, 12 years and below, between 1 and 2 members per household.

Table 15: Household size

Descriptive Statistics		
	Mean	**Std. Deviation**
Total adults	3.46	1.768
Total male adults	1.68	1.169
Total female adults	1.99	1.068
Total number of children 12 years and below	1.70	1.378
Total number of male children 12 years and below	0.86	0.931
Total number of female children 12 years and below	1.01	0.937
Total number of family members	4.81	2.499

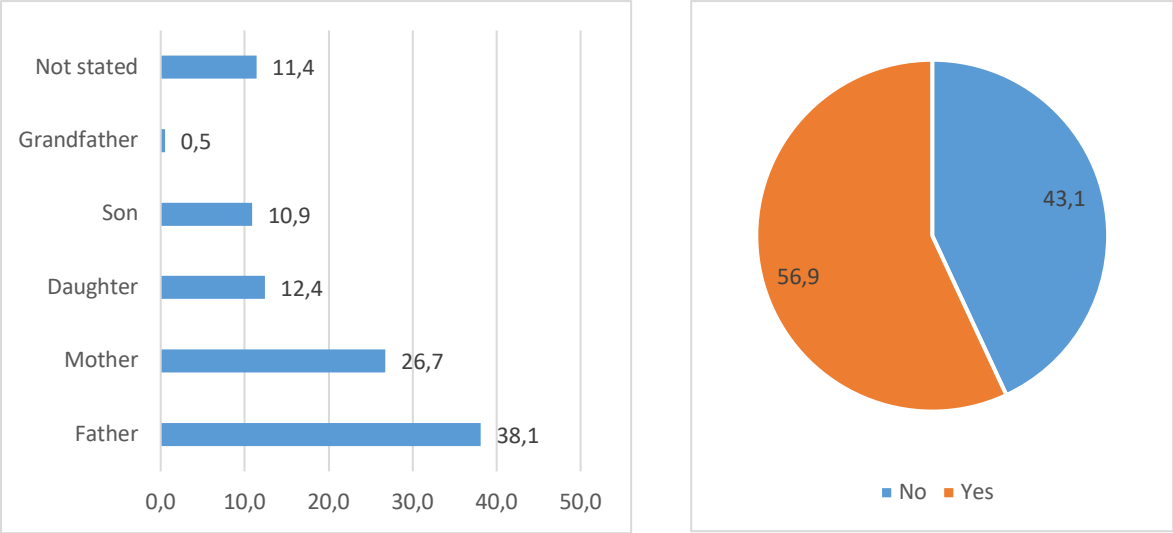

Figure 23: Respondents by family position and Respondents by ownership of house

5.2.2 Level of Financial inclusion

Respondents were asked whether they hold a bank account and the majority, 94.6 %, responded in the affirmative. About 35 % of the respondents indicated that they had taken a loan from the institution where they hold a bank account. The majority of responded declined to disclose information on whether they had taken loans from the bank or from micro lenders.

A large percentage, 61.4 %, didn't seem to know a lot about their loan conditions. Figure 24 below illustrates.

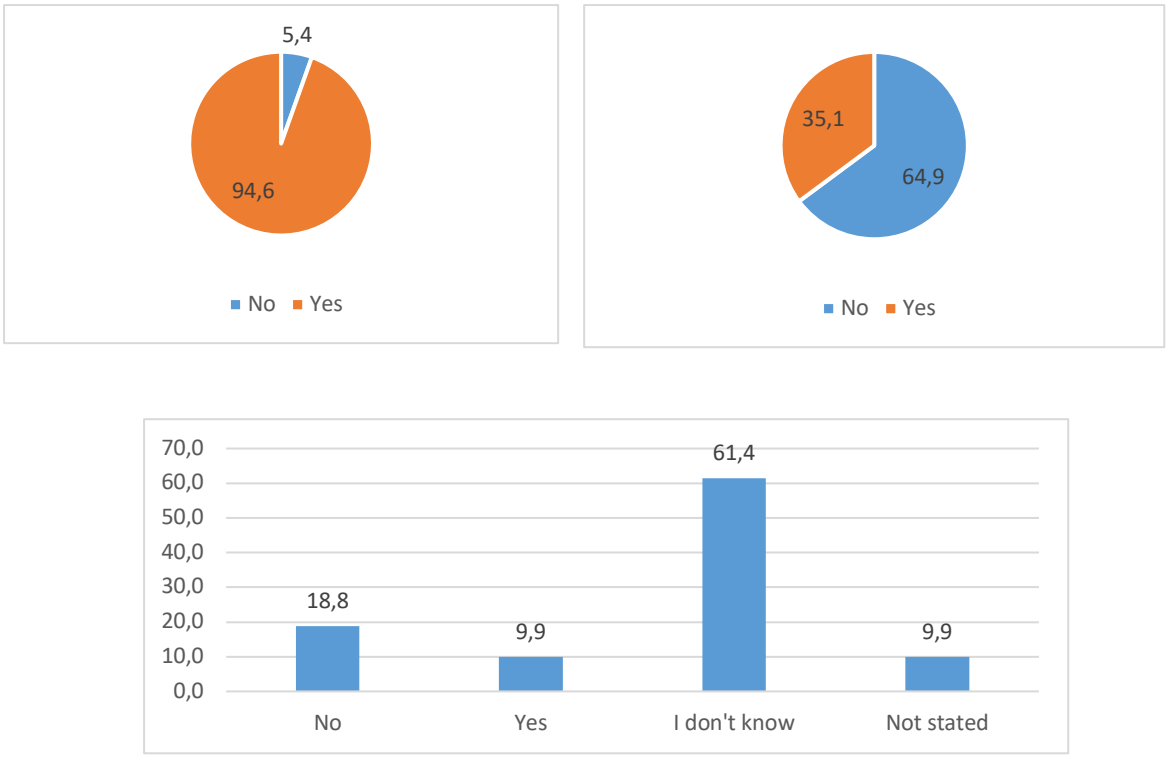

Figure 24: Respondents by bank account holder, Respondents by taken a loan from the institution and, Respondents by attractiveness of loan conditions respectively

Over 65 % of the respondents indicated that they purchased their refrigerator, refrigerator-freezer or freezer using their own funds. Slightly more than 18 % reported that they purchased their refrigerator, refrigerator-freezer or freezer using in-store credit. More than 93 % of the respondents signify that they prefer to own a refrigerator, refrigerator-freezer or freezer, rather than lease it, as shown in Figure 25 and 26.

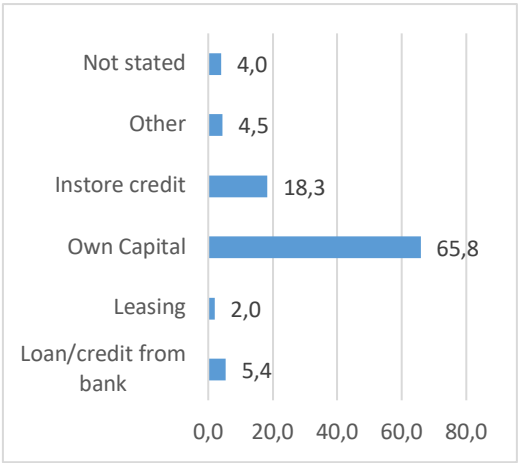

Figure 25: Respondents by mode of purchase of refrigerator, refrigerator-freezer or freezer

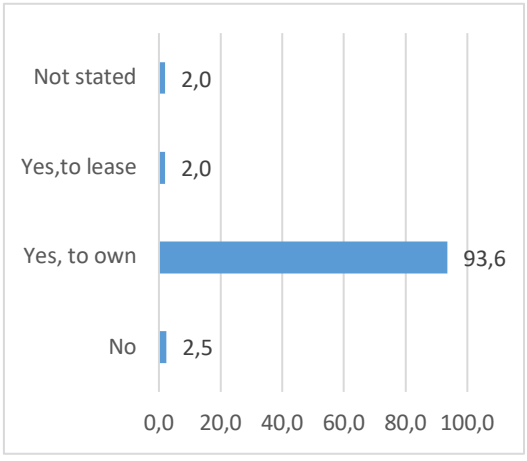

Figure 26: Respondents by preference to own or lease refrigerator, refrigerator-freezer or freezer

5.2.3 Current expenditure on electricity

Eighty-five percent (85 %) of the people surveyed use prepaid electricity and 15 % use post-paid electricity. Those using post-paid electricity meters are billed monthly. The majority of the respondents (48 %) spend between NAD 500 and NAD 1 000 (USD 36 and USD 72) on electricity per month, while 19.3 % spend between NAD 1 000 and NAD 1 500 (USD 72 and USD 107). Less than 9 % spend above NAD 1 500 monthly (over USD 107). Just under 24 % of the respondents spend between NAD 100 and NAD 500 per month (USD 7 and USD 35) on electricity (Figure 27 below).

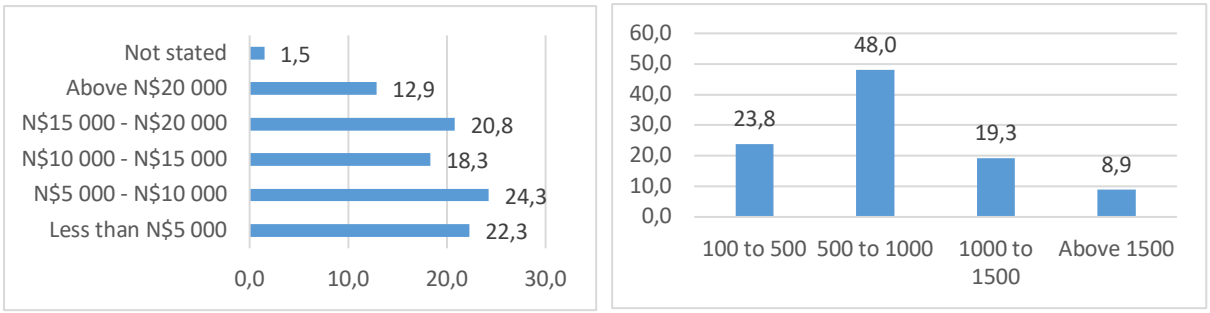

Figure 27: Respondents by average monthly income and Respondents by average monthly electricity payment

5.2.4 Ownership of refrigerating equipment

Table 17 below presents the number of appliances owned by respondents and it shows that the majority of the appliance owned is refrigerator-freezer (61.7 %), followed by freezer with 26.3 %. The lowest appliance owned is a refrigerator (12 %).

From the 200 households sampled, 66.8 % respondents own a single refrigerator-freezer type, 5.4 % own two and 0.5 % own three, while 27.3 % do not own a refrigerator-freezer. 30.7 % own a single freezer, 1 % own two freezers and 68.3 % do not own a freezer. Only 14.9 % own a refrigerator, while 85.1 % do not own a refrigerator only.

All respondents who own refrigerators revealed that the appliances were brand new when they bought them. Furthermore, 13 % and 9.2 % of the respondents who own refrigerator-freezers and freezers, respectively, reported that they bought them second-hand.

Table 16: Number of Appliances owned

Type of Appliances	**Number of appliances**	**%**
Refrigerator	60	12
Refrigerator-freezer	307	61.7
Freezer	131	26.3
Total	**498**	

About 66 % of the respondents indicated that their refrigerators were less than three years old, while less than 5 % of the respondents reported that their refrigerators were between 3-7 years of age. The majority (41.3 %) of the respondents who own refrigerator-freezers signify that their refrigerator-freezers are aged less than 3 years, while 36.9 % reported that their freezers are aged less than 3 years. Nearly 14 % of the respondents indicated that their freezers are over 10 years old. This is depicted in Figure 28 below.

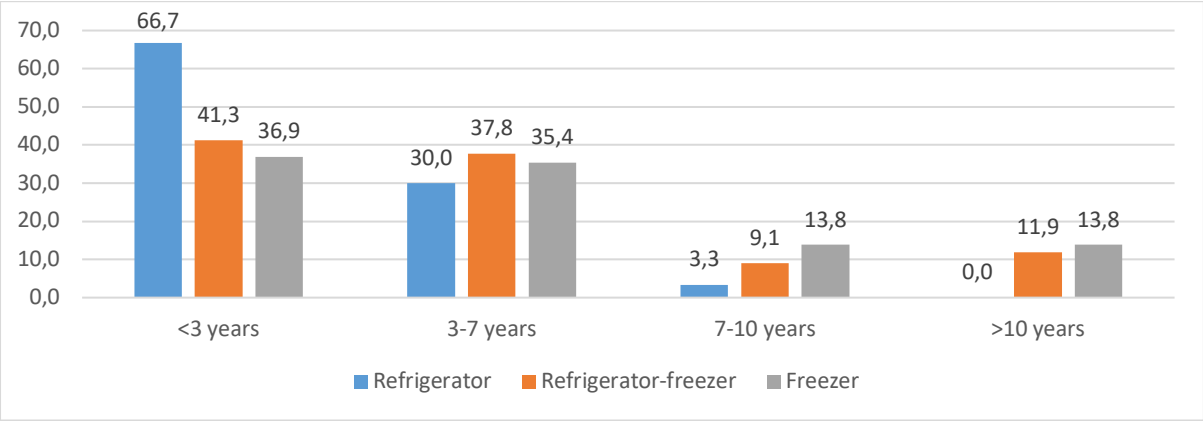

Figure 27: Respondents by type of appliances and age of appliances

From the household survey, it can be observed that the most common refrigerator brand amongst respondents was Defy 36.7 %, followed by KIC brand with 26.7 %. For the freezers, the most common freezer brand amongst respondents was also Defy 44.6 %, followed by KIC brand with 32.3 %. The most common refrigerator-freezer brand amongst respondents was KIC with 30.6 %, followed by Defy brand with 25.7 %. See Figures 29, 30 & 31. From the supplier data the top two selling brands were also Defy and KIC.

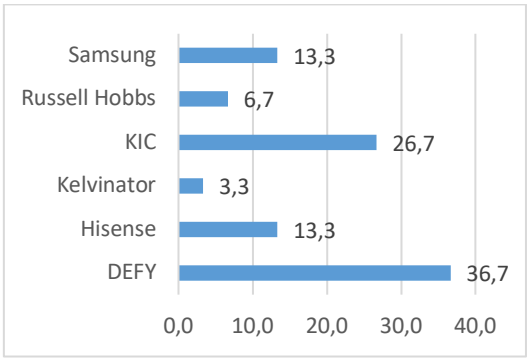

Figure 28: Respondents by brand type of refrigerator

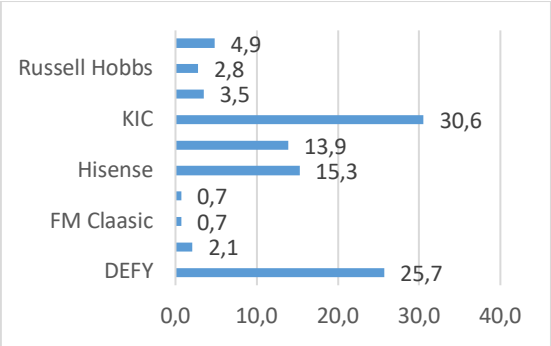

Figure 29: Respondents by brand type of refrigerator-freezer

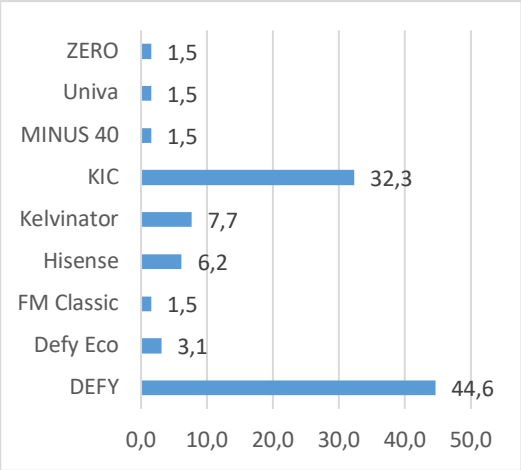

Figure 30: Respondents by brand type of freezer

Figures 32, 33 & 34 presents the type of refrigerant observed for refrigerators, refrigerators -freezers and freezers in respondent households. It shows that R600a refrigerant was the most common refrigerant amongst refrigerators, refrigerators-freezers and freezers, with 93.3 %, 84 % and 77 %, respectively, similar to the supply chain.

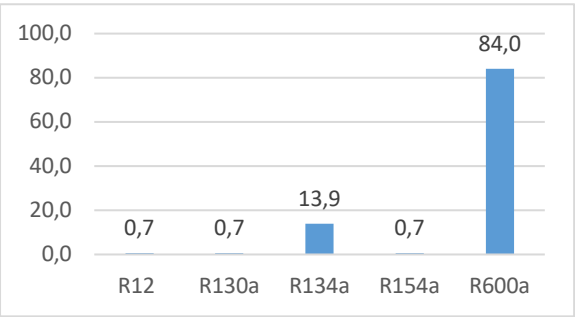

Figure 31: Respondents by refrigerator-freezer refrigerant type

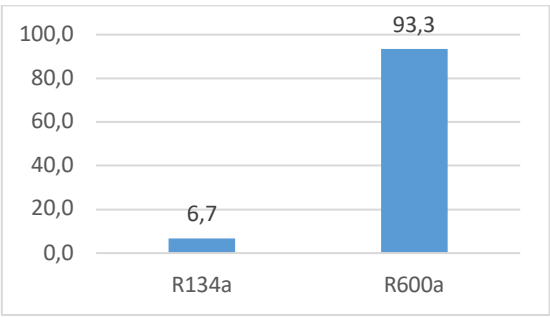

Figure 32: Respondents by refrigerator refrigerant type

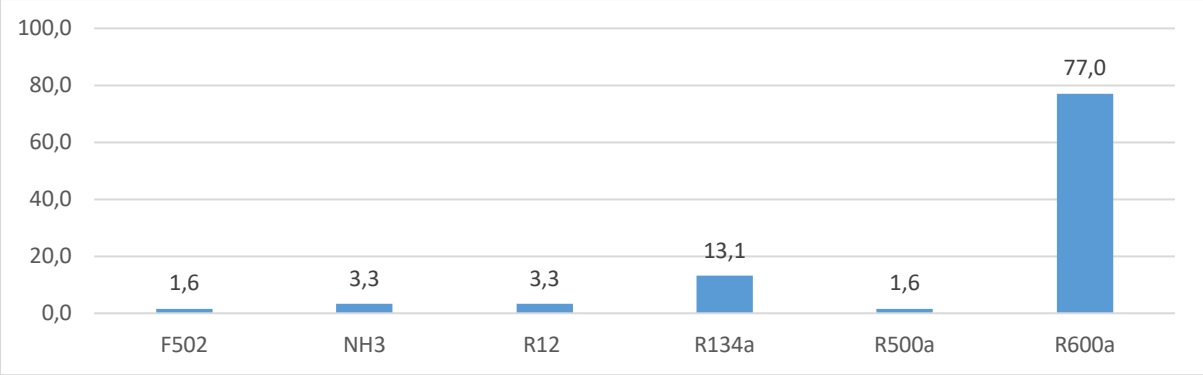

Figure 33: Respondents by freezer refrigerant type

A large majority of the respondents (93.1 %) reported that their refrigerators are frost free, while 60 % of those surveyed indicated that their refrigerator-freezers were also frost free. Nearly 60 % revealed that their freezers were direct cool. Figure 35 below illustrates.

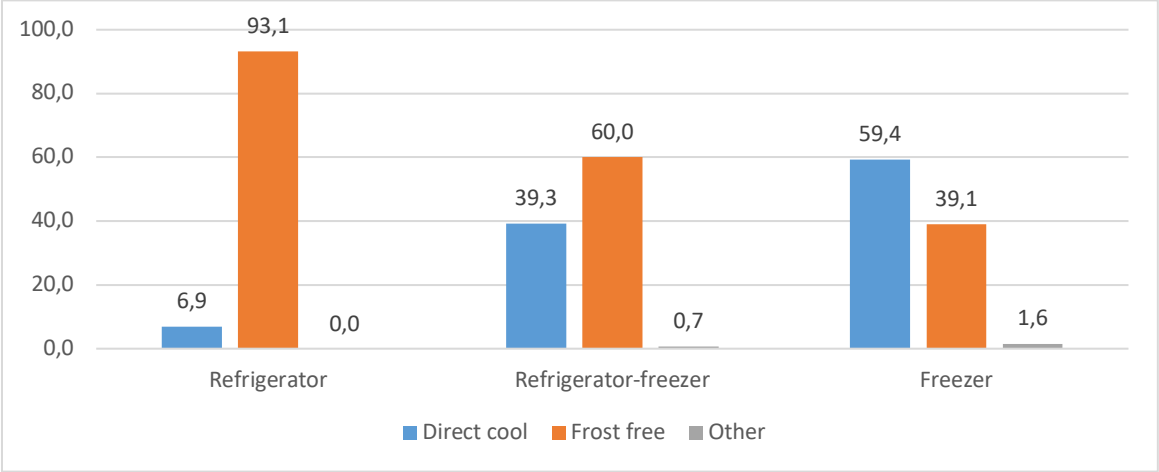

Figure 34: Respondents by technology type of appliances

Most of the appliances, comprised of 55.6 % of refrigerators, 65.2 % of refrigerator-freezers and of freezers were “A” rated. Figures 36, 37 & 38.

Refrigerators, freezers and refrigerator-freezers are rated from A+++ to G, with A+++ being the most efficient and G being the least efficient. N (Normal) appliances are suitable for use under ambient temperature range of 16 °C, SN (Subnormal) are suitable for use under ambient temperature range of 10 °C, ST and T (Subtropical/Tropical) suitable for use under ambient temperature range of 18 °C (Procool 2021).

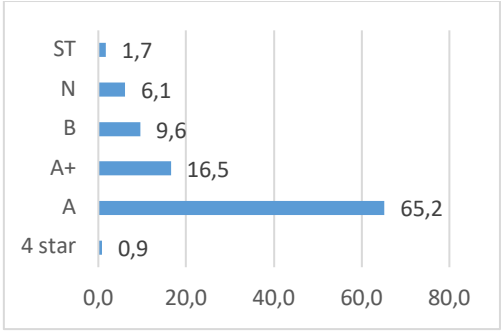

Figure 35: Respondents by energy efficient rating of refrigerator-freezers

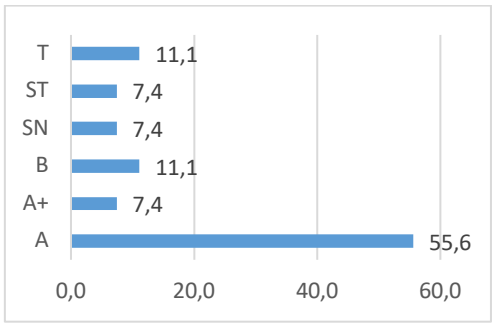

Figure 36: Respondents by energy efficient rating of refrigerators

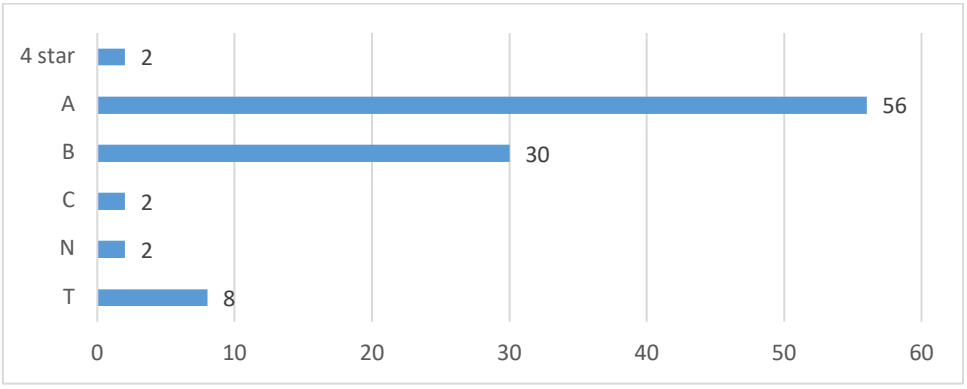

Figure 37: Respondents by energy efficient rating of freezers

5.2.5 Desired features of equipment

Consumers were asked to list which features they considered most when deciding which cooling appliance to purchase. These included the purchase price of the equipment, warranty, look/design/color, functionality, energy consumption, noise level, capacity/size and brand, among others. More than 76 % reported that quality and functionality/practicality were key factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer. Over 68 % of the respondents indicated that the price of the equipment and warranty were highly important factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer. Slightly above 50 % of the respondents considered access to financing, energy consumption, availability of transport, installation and maintenance services, capacity/size and look/design/color as important factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer.

It is worth noting that noise level is considered by 35.6 % of respondents as a low factor when purchasing a refrigerator, refrigerator-freezer or freezer. Furthermore, 44.1 % of the respondents reported that brand of appliances is of medium importance when purchasing a refrigerator, refrigerator-freezer or freezer. See Table 18 below.

Table 17: Importance factors on decision to purchase a refrigerator, refrigerator-freezer or freezer

Factors	Importance				
	None	Low	Medium	High	Total
	%	%	%	%	%
Price of the equipment	0.5	10.0	20.5	69.0	100.0
Warranty	2.0	4.5	24.8	68.8	100.0
Look/Design/color	1.5	10.9	28.4	59.2	100.0
Functional/Practical	0.5	0.5	22.3	76.7	100.0
Energy consumption	10.4	15.9	21.9	51.7	100.0
Noise Level	17.8	35.6	21.3	25.2	100.0
Access to financing	8.4	12.4	28.2	51.0	100.0
Capacity / size	0.0	8.7	32.7	58.7	100.0
Brand	5.4	12.9	44.1	37.6	100.0
Quality	0.6	2.4	20.6	76.5	100.0
Recommendation from people you know	14.4	26.2	29.2	30.2	100.0
Availability of transport, installation and maintenance services	3.5	14.0	28.5	54.0	100.0
Other factors	93.8	0.0	0.0	6.3	100.0

5.2.6 Consumer preference on purchase of a refrigerator

All respondents who own refrigerators revealed that they purchased their refrigerators brand new. Furthermore, 13 % and 9.2 % of the respondents who own refrigerator-freezers and freezers, respectively, reported that they bought them second-hand. See Figure 39.

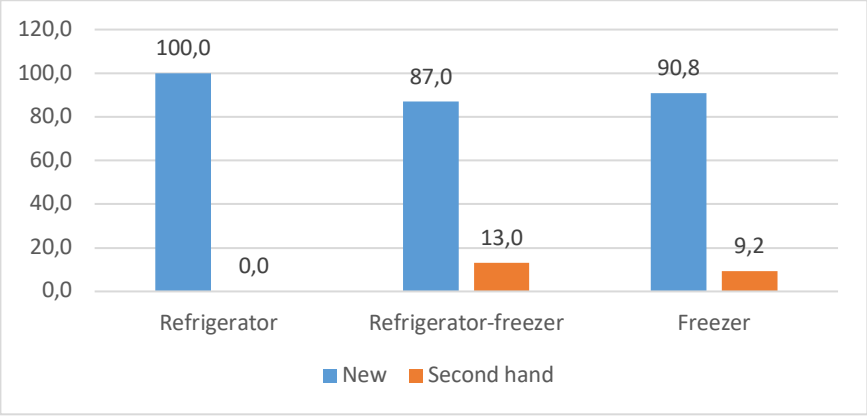

Figure 38: Respondents by new and second-hand purchases of appliances and type of appliances

About 94.72 % of the consumers would prefer to purchase an energy efficient refrigerator, while 2.03 % of the consumers would prefer to lease the energy efficient refrigerator. On the other hand, 3.25 % of the consumers did not indicate their preference.

5.2.7 Barriers to the purchase of efficient refrigerators

Energy efficient refrigerators are more expensive than the normal refrigerators which are not energy efficient. Most consumers look at the price tag of the refrigerator rather than its energy usage.

While most of household appliance retailers offer hire purchase terms to customers (which give the buyer conditional full ownership rights as soon as the contract is signed with the seller), with commercial banks also offering financing for household appliances through their already existing financial channels that cover other items like vehicles, there's no financing directed specifically at energy efficient appliances, neither are there preferential interest rates offered to consumers willing to invest in efficient household appliances.

Financial institutions interviewed cited the lack of "cheap" funding, green credit lines or lack of guarantees, current economic downturn, which forced consumers to change spending patterns and focus on essential commodities, and the fact that most consumers view energy efficient appliances as "luxury goods", as some of the barriers to the uptake of energy efficient refrigerators in Namibia.

Namibia has seen little or no awareness campaigns encouraging citizens to invest in energy efficient appliances. As a result, consumers are not aware of the technological and environmental benefits of energy efficient refrigerators and hence do not see the need to invest money buying them rather than the ordinary refrigerators.

The lack of energy efficiency standards and labelling policies came out prominently during the household survey. Respondents were asked whether they were aware of any energy efficiency standard and labelling policies or schemes in Namibia and 92.6 % indicated that they were not aware of any.

About 54 % of the respondents reported that they would consider buying an energy efficient refrigerator, refrigerator-freezer or freezer. However, from the analysis it was observed that affordability remained a deciding factor since cheaper energy inefficient appliances are still dominant in the market. See Figures 40 & 41 below.

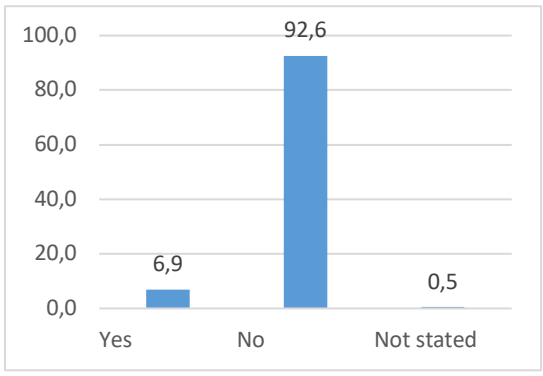

Figure 39: Respondents by awareness of any energy efficiency standard & labelling policies/schemes

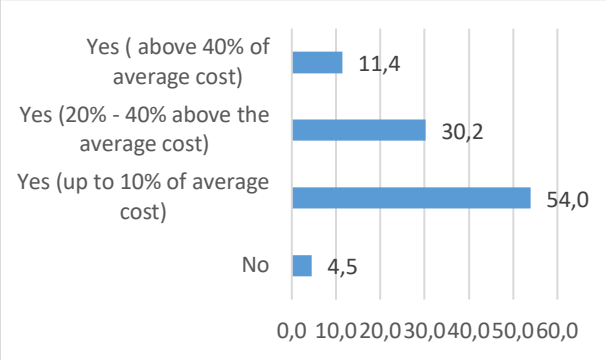

Figure 40: Respondents by willingness to pay an extra cost for an energy efficient refrigerator, refrigerator-freezer or freezer

5.3 Equipment stock and projections

The market size of residential refrigerators specified in Figure 42 was derived from the household population estimate of 549’283 in 2020 and the percentage (43 %) of households with residential refrigerators (Global Data Lab, 2016). The estimate and predictions assumed that a number of residential refrigerators were replaced each year due to end of lifetime of the appliances and that an additional number of residential refrigerators were acquired each year because of higher disposable income for households thanks to economic growth in the country, Assuming a replacement rate of 8 % per annum based on an average lifetime of 12.5 years for residential refrigerators in Namibia) and a market growth rate of 3.68 % per annum (World Bank, 2019), our estimated market size for residential refrigerators in 2021 was 28’147 units and the total stock of residential refrigerators for the same year would be 249’857 units. This was calculated based on the estimated stock level of residential refrigerators of 240’989 units in 2020 and the estimated lifespan of a refrigerator-freezer in Namibia of between 10 and 15 years. With an average price of USD 459 per appliance, the estimated total market value for residential refrigerators was USD 12’919’696 in 2021 in Namibia.

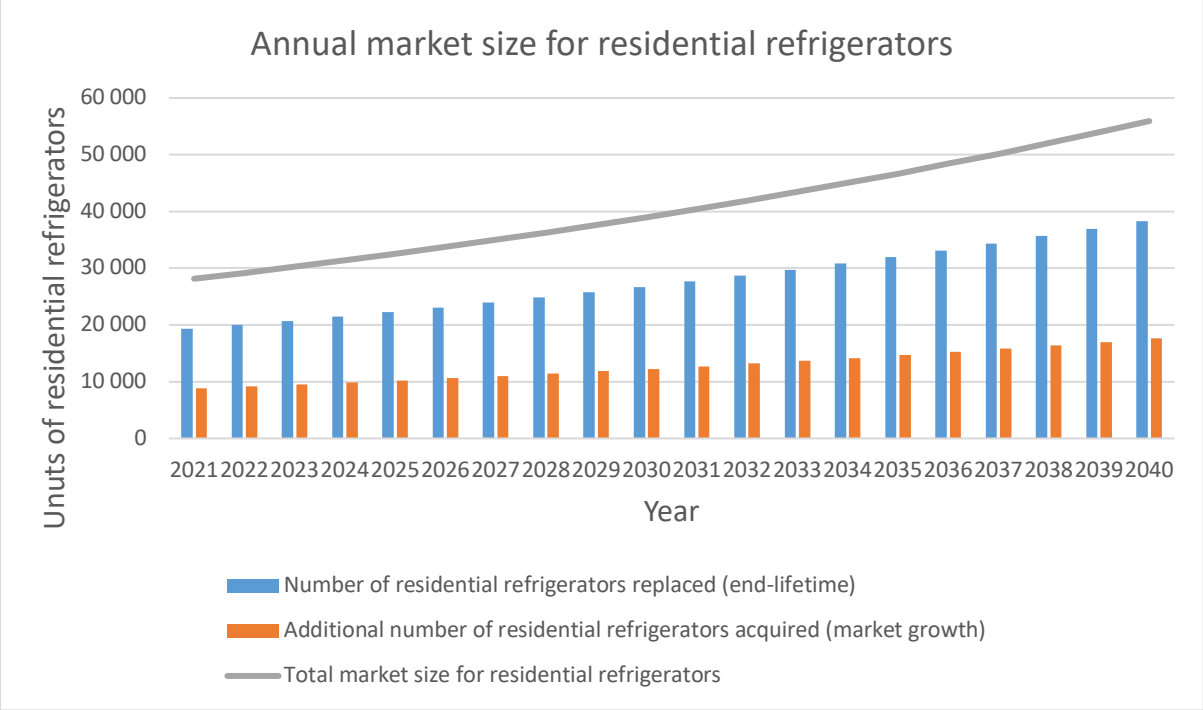

Figure 41: Projected number of residential refrigerator-freezers acquired and replaced in Namibia (Eco Fin Analysis, CTCN Namibia Refrigerators, 2021)

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

The survey concluded that the majority (93.1 %) of the respondents reported that their refrigerators are frost free and 60 % of the respondents reported that their refrigerator-freezers are also frost free. On the other hand, 59.4 % revealed that their freezers are direct cool. Furthermore, the survey indicated that the most common refrigerator brand amongst respondents were Defy 36.7 %, followed by KIC brand with 26.7 %. For the freezers, the most common freezer brand amongst respondents were Defy 44.6 %, followed by KIC brand with 32.3%. On the other hand, the most common refrigerator-freezer brand amongst respondents were KIC 30.6 %, followed by Defy brand with 25.7 %.

Regarding the features, more than 76 % reported that quality and functionality/practicality were high important factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer. More than 68 % of the respondents indicated that the price of the equipment and warranty were important factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer. More than 51 % of the respondents revealed that access to financing, energy consumption, availability of transport, installation and maintenance services, capacity/size and look/design/color are high important factors to consider when purchasing a refrigerator, refrigerator-freezer or freezer. It is worth noting that noise level is considered by 35.6 % of respondents as low important when purchasing a refrigerator, refrigerator-freezer or freezer. Furthermore, 44.1 % of the respondents reported that brand of appliances is medium important when purchasing a refrigerator, refrigerator-freezer or freezer.

According to the household survey, a freezer consumes the most energy on average with the annual energy consumption of about 505 kWh, while a refrigerator with a freezer has an average energy

consumption of 354 kWh per year. The refrigerator without a freezer consumes the least energy on average, with an annual energy consumption of about 285 kWh.

A refrigerator-freezer rates the least in power rating with an average of about 210 W followed by the freezer with an average slightly higher rating than that of a refrigerator with a freezer (about 212 W). A refrigerator without a freezer has the highest power rating with an average of about 250 W.

Refrigerators without a freezer have the least average volume compartment of 262 litres, while refrigerators with a freezer showed the biggest volume compartment on average of 293 litres. The freezer has an average volume compartment of 276 litres. Table 19 summarised the prices, annual energy consumption, power rating and volume compartments of various refrigerators.

Table 18: Prices, annual energy consumption, power rating and volume compartments (Household Refrigerator Survey)

Types of residential refrigerators				
	Refrigerator mean	**Refrigerator -freezer mean**	**Freezer mean**	**Total mean**
Price (USD) (1USD~NAD14)	484	459	349	434
Annual energy consumption (kWh)	285.148	345.393	505.493	371.380
Power rating (W)	249.9	210.4	211.8	215.9
Volume compartment (litre)	262	293	276	285

The survey shows that R600a refrigerant was the most common refrigerant amongst refrigerators, refrigerators-freezers and freezers, with 93.3 %, 84 % and 21.8 %, respectively.

5.3.2 Technology trends and market projections

According to the Namibia Statistics Agency, around 576 383 units were imported into the country in 2020 of which 35 % of the units were a combination of refrigerator and freezer as indicated in Figure 43. However, this figure was not indicative of the total number of households cooling appliances.

In addition, based on aforementioned assumptions (section 5.3) and predictions, the stock level, market size, and market value of residential refrigerators, respectively will be 346 000, 39 000, and USD 17.9 million by 2030. Technologies expected to get to the market in the near future are inverter type refrigerators and refrigerator freezers.

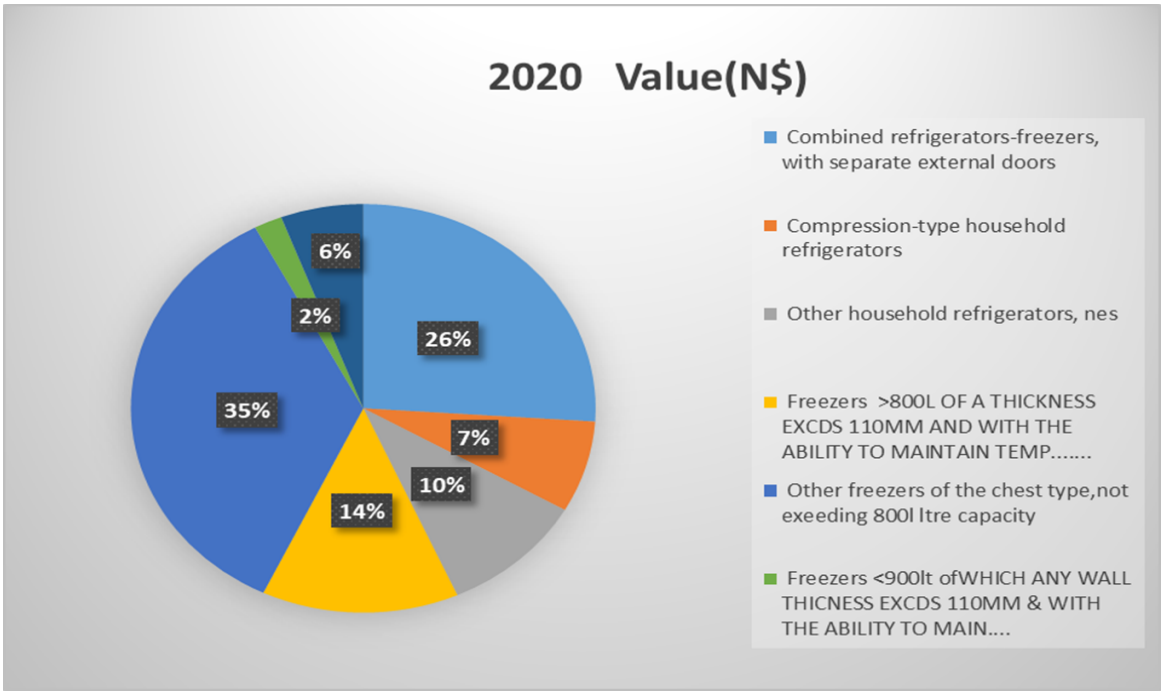

Figure 42: Imports of refrigerators in Namibia in 2020 (NSA, 2020)

5.4 Policies and programme landscape

5.4.1 Current and planned refrigerator policies and program

In 2015, Namibia signed the Paris Climate Agreement, codifying its Intended Nationally Determined Contributions (INDCs) to the UNFCCC. Namibia's INDCs commit the country to increase the share of renewables in electricity production to 70 %, to increase energy efficiency and demand side management measures, to implement mass transport, and to introduce car and freight pooling.

The country updated its NDCs and it was submitted in July 2021.. The energy sector is expected to contribute to the National Sustainable Energy Strategy of Namibia in introducing new emissions-reducing technologies and encourage healthier practices that are more energy efficient. The updated NDC includes climate-friendly refrigeration and air conditioning. Currently, low GWP technology options exist as an alternative to HFCs for almost any RAC appliance.

In the updated NDC, a progressive shift above the 2015 pledge was made to reduce emissions from 89 % to 91 % by 2030 by which Industrial Processes and Product Use (IPPU) and Refrigeration and Refrigeration and Air Conditioning (RAC) should contribute to reduce the emissions by 0.165 %. RAC was not included in the 2015 NDC pledge. Namibia's mitigation commitment is in the form of a decrease in GHG emissions compared to the Business as Usual (BAU) baseline over the 2015-2030 period.

The Kigali amendment advocates for energy efficient and low Global Warming Potential (GWP) technology in the RAC sector. The gazette set control measures on the importation and consumption of low energy efficient and high GWP refrigerants used in the RAC appliances such as air conditioners

and refrigerators, with an aim to phase out and have a much greener and energy efficient industry by 2045 with effect from January 2021.

5.4.2 Status of electronic-waste management in the country

There is a National Solid Waste Management Strategy that was developed by the Ministry of Environment and Tourism (MET) in 2017, aimed at ensuring that the future directions, regulations, funding and action plans to improve solid waste management including electronic waste are properly co-ordinated and consistent with national policy, and to facilitate co-operation between stakeholders.

There are few e-waste management companies and e-waste collection points in Namibia. NamiGreen, recycles electronic waste such as broken/old computers, mobile phones, laptops, and basically any other electronics one can think of. Currently the company has over 400 large companies, organizations and institutions in Namibia on its reference list. NamiGreen also recycles e-waste from private individuals.

Rent-A-Drum is the leading organisation in waste management and recycling in Namibia, and offers the most comprehensive services to Namibian corporations, mines and smaller companies, including citizens of the capital city Windhoek, other large cities of Swakopmund, Walvis Bay, Oshakati, Oranjemund and Rundu.

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

While all the stakeholders interviewed were supportive of the transformation to energy-efficient and climate-friendly refrigerators, they expressed frustration with what seemed to be a lack of policy direction and awareness being raised on why consumers must consider shifting to more energy-efficient appliances. The Namibia Manufacturers Association (NMA), which plays an important role in influencing the formulation of Government policies directly affecting manufacturers, expressed frustration over a lack of support for local manufacturers wishing to venture into refrigeration and as a result said it did not have a single member from this sector.

The Namibia Chamber of Commerce and Industry saw a huge opportunity for investment and growth in the refrigeration sector but said there were still no local manufacturers for household cooling appliances thus far in the country due to a variety of reasons, among them a lack of clear incentives for businesses wishing to venture into this sector. The Namibian Standards Institute (NSI) currently also has no infrastructure for testing for energy efficient appliances and “has no plans for setting up such a facility in Namibia in the near future”.

The Environmental Investment Fund of Namibia (EIF) is of the opinion that barriers are more aligned to limited investment in the energy efficiency sector. There is also limited space and synergy between the private and public sectors towards investing in energy efficient capital projects. It says the Ministry of Mines and Energy has tried to design and develop enabling policies including the Energy White Paper and other small scale energy efficient projects being implemented through the Namibia Energy

Institute (NEI). However, much is still needed on the implementation and monitoring modalities for energy efficient intervention, taking stock of the current investment and understanding the gap funding.

Research and development on energy efficient technology is one of the untapped areas to develop the sector.

Some financial institutions cited a lack of financial incentives, such as zero interest loans, economic downturn and the fact that most consumers view energy efficient appliances as "luxury goods" and as a result prefer to direct their spending towards the best value for money. But they acknowledge that improving energy efficiency is a key tool for reducing carbon dioxide emissions over the long run, and therefore it is evident that there still exist many untapped opportunities to use energy efficiency to save money, cut harmful pollution and meet the country's climate goals. For instance, Letshego Africa already offers green friendly consumer financing options for residential refrigerators and air conditioners (ECOFRIDGES GO, 2020). The bank has put in place measurable performance and success indicators to ensure they are meeting and achieving tangible and collective milestones towards achieving green friendly climate change targets.

As the Green Bond of 2019, Bank Windhoek recently launched the Sustainability Bond issued on 2 June 2020, aimed at supporting socially and environmentally responsible projects, such as those focused on renewable energy, energy efficiency, green buildings, sustainable waste management and a focus on sustainable agriculture and tourism, and investments into quality, accessible and innovative healthcare and education facilities.

While energy efficient technologies are considered to be a valuable opportunity for financial institutions and public sector partners to collaborate in the interest of reducing harmful carbon emissions and excess energy consumption, thereby promoting and supporting a more green friendly society, they note that in financing and providing green friendly appliances, it is important that only accredited/approved appliances that meet global standards in quality and energy consumption, are considered.

The Development Bank of Namibia (DBN) identified the lack of information in the market about energy efficient technology solutions that are available in the market and being able to know that there are financiers who are able to finance these solutions, as a major barrier in impeding access to green finance in Namibia.

5.5 Existing Financial Institutions and financing instruments for appliances

The Bank of Namibia (BoN), which is the country's central bank, is supportive of green technology and energy efficient appliances as prioritized in the Harambee Prosperity Plan II (HPPII) and therefore since it is a national undertaking, it expects the financial sector to play its role. BoN welcomes current initiatives within the industry targeting this growing demand.

The central bank says although it would like to see more projects related to energy efficiency and green technology being financed by commercial banks at an industry and household level, it notes that credit extension is guided by credit policies of individual commercial banks.

BoN expects the commercial banks do not only consider their financial and economic positions, but also the environment in which they operate. Therefore, it says, boards of commercial banks should no -longer make decisions purely based on the needs of the institutions they serve but are also expected to make deliberate decisions to promote sustainability of the environment.

Namibia has a number of institutions that provide funding for a variety of energy efficient appliances, including solar technologies. These include the state-owned Development Bank of Namibia (DBN), which focuses mainly on large scale funding. DBN offers green finance that could be structured to support investments in energy efficiency. The DBN's loan size starts at NAD 150 000 (USD 10 700). DBN has obtained a Climate Finance line of credit from the KfW and is in the process of applying to the GCF for accreditation as part of its commitment to fund Green Projects.

Commercial institutions that offer funding for green and energy efficient technologies include all the five leading commercial banks in the country: First National Bank, Standard Bank, Bank Windhoek, Letshego Bank and Nedbank.

Bank Windhoek offers financing for household appliances through its Vehicle & Asset Finance, across all retail branches country wide. The financing is classified as "Asset Financing - Electrical/Household Appliances". The bank evaluates each loan application on a case-by-case basis. Thus, depending on the risk profile and repayment ability of the project and finance applicant, the repayment period and interest rate is calculated, which in turn might be more beneficial compared to a normal finance application, given the favourable funding facility, the nature of the project/Green loan and initiative behind supporting sustainability in the country.

Together with two other major commercial banks, First National Bank and Nedbank, Bank Windhoek is also part of the Sustainable Utilization of Natural Resources and Energy Finance (SUNREF) programme, the global green finance label of the Agence Française de Développement (AFD). In the context of energy and environmental transition, SUNREF helps private actors in southern hemisphere countries seize the opportunities of this transition via an innovative approach and encourages local banks to finance it. Since 2006, 42 SUNREF projects have been successfully implemented, in partnership with 70 local banks in some 30 countries of operation, for a total commitment of over EUR 2.5 billion of loans allocated by AFD, of which EUR 1.2 billion has been disbursed.

In Namibia, the SUNREF three-year programme developed by the AFD mobilizes commercial Namibian banks to finance private sector investments in green technologies in the energy efficiency market segment, sustainable agriculture, sustainable tourism and renewable energy.

Financing to enterprises under this programme will be made available through the three participating commercial banks, namely, Bank Windhoek, FNB Namibia and Nedbank that will each disburse a total investment of EUR 15 million for green investments, while the Environmental Investment Fund of Namibia (EIF) will provide technical assistance to the three participating banks.

The aim of the SUNREF Namibia is to facilitate access to affordable green technologies, thereby guaranteeing the development of a low carbon environmental footprint and contributing to the reduction of the causes of climate change and other environmental disturbances in Namibia.

Letshego Bank Namibia, which launched green funding for consumers for energy-efficient and climate-friendly cooling appliances through a green on-wage financing scheme in Ghana last year (ECOFRIDGES GO, 2020) in partnership with the United Nations Environment Programme's United for

Energy Efficiency (UNEP U4E), Basel Agency for Sustainable Energy (BASE) and the Ghana Energy Commission, is considering a similar initiative for Namibia.

In Namibia, Letshego currently offers short-term loans that accommodate energy and green friendly products and appliances. Letshego says it considers energy efficient technologies to be a valuable opportunity for financial institutions and public sector partners to collaborate in the interest of reducing harmful carbon emissions and excess energy consumption, thereby promoting and supporting a green friendly society, for the benefit of future generations. The bank says in financing and providing green friendly appliances, it is important that green friendly accredited appliances meet global standards in quality and energy consumption, as well as future biodegradable and recycling guidelines.

The Solar Revolving Fund (SRF), under the Ministry of Mines and Energy, provides financing for renewable energy products, such as Solar Water Heaters, Solar Home Systems packaged with energy efficient lights, energy efficient refrigerators and energy efficient stoves. The loan amount is limited to NAD 35 000 (about USD 2 500), this amount is not enough to include the more costly and best energy efficient fridges. SRF offers a subsidized interest rate which is fixed at 5 % for all products financed. SRF interest rate is half the prime rate offered at most financial institutions in the country.

However, the SRF has faced a number of challenges in its implementation. Consumers have complained that the loan amount is inadequate to cover energy efficient refrigerators. To accommodate refrigerators clients, require bigger and more expensive solar systems, especially in rural areas. The fund can also only be obtained in Windhoek as its disbursement has not been decentralised.

The SRF was started with seed capital of NAD 19 million from the Namibian Government. The fund is replenished by Government every year. So far, between 2010 and 2020, a total of 4325 systems have been financed, including Solar Home Systems, PV pumps and Solar Water Heaters, to the tune of NAD 121 million. There was no data available on the number of energy efficient refrigerators acquired through the fund.

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

Namibia imports 82 % of refrigerators, freezers and other refrigerating or freezing equipment from neighbouring South Africa, according to 2020 Annual International Trade Statistics by Country, published by TrendEconomy. The remainder of the imports come from China (7.78 %) and 10 % from European countries.[11]

A small percentage is exported from Namibia, mainly to neighbouring countries: Angola, Botswana, Zambia and Zimbabwe. The value of Namibia's exports of "Refrigerators, freezers and other

[11] https://trendeconomy.com/data/h2/Namibia/8418#:~:text=million%20in%202019)-,Imports%20of%20commodity%20group%208418%20%22Refrigerators%2C%20freezers%20and%20other%20refrigerating,amounted%20to%20%24%206.82%20billion).

refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines", totalled USD 289 000 in 2020, a decrease of 83 % in value terms compared to 2019.

"Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines" amounted to 0.005 % of total exports from Namibia in 2020. Top export destinations of "Refrigerators, freezers and other refrigerating or freezing equipment, electric or other; heat pumps other than air conditioning machines" from Namibia in 2020 were listed as follows:

- **Angola with a share of 58 % (USD 169 000)**
- **South Africa with a share of 23 % (USD 69 000)**
- Netherlands with a share of 11.5 % (USD 33 000)
- **Botswana with a share of 2.1 % (USD 6 000)**
- France with a share of 1.12 % (USD 3 200)
- **Zambia with a share of 1.05 % (USD 3 040)**
- Spain – USD 2 380
- United Kingdom – USD 582
- Norway – USD 572
- **Zimbabwe – USD 489**

6 Market assessment on distribution transformers

6.1 Supply

6.1.1 Summary of suppliers, government officials and other stakeholders as well as market size based on capacity and voltage

Electricity distributors are licensed to distribute and supply electricity. The prominent distributors are the three existing REDs - NORED, CENORED and ERONGO RED, which distribute electricity in their respective jurisdictions, OPE, City of Windhoek, Local Authorities (such as Keetmanshoop municipality) and Regional Councils, as well as NamPower Distribution which distributes electricity to unserved areas in the regions of Khomas, Omaheke, Hardap and //Karas. Additionally, several farmers, electrical utilities and other privately owned commercial/residential suppliers exist. They are in charge of operating the privately owned distributing networks.

The market size of distribution transformers in various locations in Namibia is not uniform, i.e. distribution transformer sizes in the country vary by location, dictated by the number of customers, distribution voltage and the capacity of the electrical load in the specific location. In terms of distribution network, the largest installed transformer is 20 MVA, which is within one of the largest market locations in the country. In other parts, transformers of smaller capacities 10 kVA -1000 kVA both single and three phases are installed either pole mounted or pad mounted. In urban areas, most installed distribution transformers are pad mounted.

The common voltage levels at distribution in many parts of the country are 11 kV, 19.1 kV, 22 kV and 33 kV. Figure 44 below depicts the 16 kVA - 1000 kVA single and three-phase distribution transformer stock at a local supplier, manufactured by PCB Power Transformer (Pty) Ltd.

Figure 43: 10 kVA -1000 kVA single and three-phase PCB distribution transformer stock at a local supplier

All transformers in Namibia are imported mainly from South Africa through the Public Procurement Act No.15, 2015, by public open tenders or contractual agreements. There is also a small number of transformers imported from India and from other parts of the world, depending on the specifications of the tender.

A number of suppliers were identified as key stakeholders that play a fundamental role in the supply chain of distribution transformers in Namibia. The main leading transformer brands in Namibia are Actom, SGB-Smit Power Matla and PCB Power Transformers manufactured in South Africa. The main leading supplier of the distribution transformers active in the Namibian market is MegaTech Pupkewitz (Pty) Ltd (distributor for PCB Power Transformers) which has six branches across the country with the main office in Windhoek. MegaTech Pupkewitz (Pty) Ltd supplies mainly City of Windhoek, CENORED and NORED.

The survey of the supply chain of the distribution transformers also identified some of the suppliers, such as Actom Namibia (distributor for Actom transformers), Swanib Cables (Pty) Ltd, Megatron Engineering Namibia, Walfish Electric (Pty) Ltd, Swakop Electrical Supplies CC (SGB-Smit Power Matla distributors). Other suppliers are Central Technical Suppliers, Ark Trading and HV Transformers. These companies only supplies and import as per there specifications from the distributors. Only two companies, HV transformer (based in Erongo region) and Megatron Engineering Namibia (based in Windhoek) maintain transformers nationwide.

Below is a list of the distribution transformer suppliers in Namibia;

Table 19: Distribution Transformer Suppliers in Namibia

Name of Supplier	Brand Name	Portfolio of Products			Refurbishment/Repair/Rewinding
		Cooling type	Mounting type	Transformer Capacity range	
Walfish Electric (PTY)LTD	Actom and SGB-Smit Power Matla Transformers	Oil Natural Air Natural (ONAN)	Pole and Ground	16 kVA – 800 kVA	Supply only
Swakop Electrical Supplies CC	Actom, Trans Electron, SGB-Smit Power Matla Transformers	ONAN	Pole and Ground	16 kVA - 800 kVA	Supply only
MegaTech Pupkewitz (PTY) LTD	PCB and Actom Transformers	ONAN	Pole and Ground	16 kVA - 2.5 MVA	Supply only
Swanib Cables (PTY) LTD	PCB , SGB-Smit Power Matla and Actom Transformers	ONAN	Pole and Ground	16 kVA - 2.5 MVA	Supply only
Actom Namibia	Actom and SGB-Smit Power Matla Transformers	ONAN	Pole and Ground	16 kVA – 800 kVA	Supply only
Central Technical Suppliers	PCB, Actom, Free State and SGB-Smit Power Matla Transformers	ONAN	Pole and Ground	16 kVA - 2.5 MVA	Supply only
Ark Trading	PCB, Free State and SGB-Smit Power Matla Transformers	ONAN	Pole and Ground	16 kVA - 2.5 MVA	Supply only
Megatron Engineering Namibia	SGB- Smit Power Matla and Actom, and others	ONAN	Pole and Ground	16 kVA - 800 kVA	refurbishment/ repair
HV Transformers	SGB- Smit Power Matla and Actom, and others	ONAN	Pole and Ground	16 kVA - 800 kVA	refurbishment/ repair

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

In some instances, an electric utility, industrial business or electrical contractor may procure a distribution transformer directly from an overseas manufacturer or supplier through an import/trade customs office. For instance, in its dual approach, NamPower procures its transformers directly from overseas transformer manufacturers or from local importers or wholesalers.

Figure 45 below illustrates an overview of the distribution transformers supply chain in Namibia

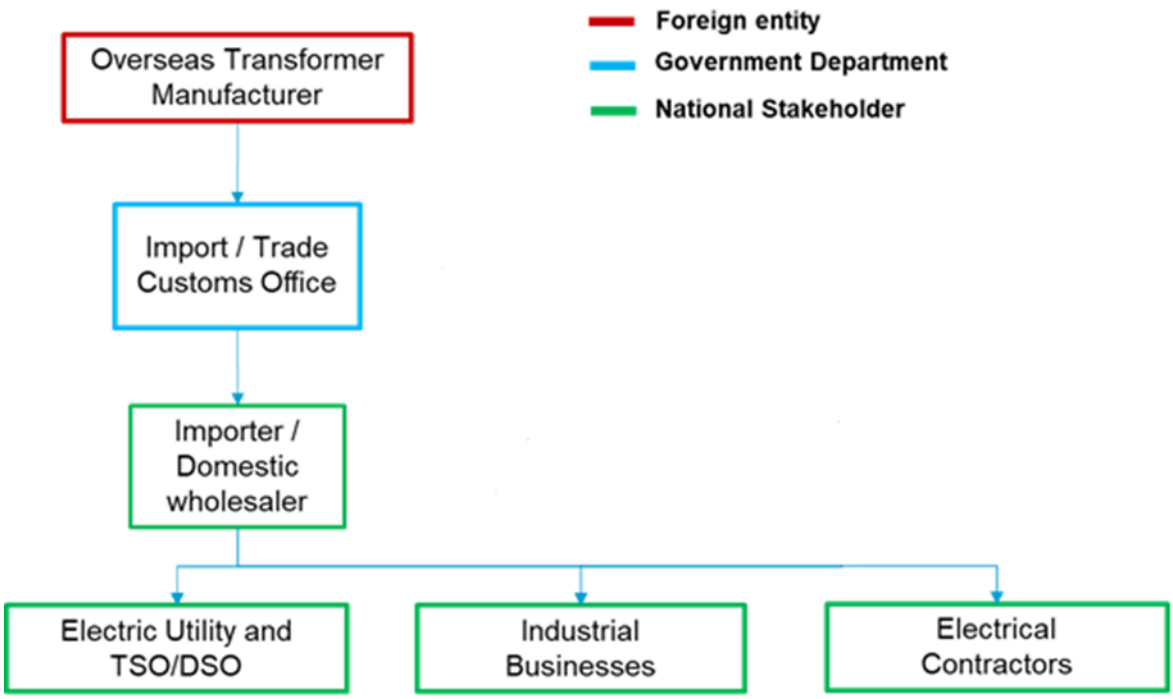

Figure 44: Flow of distribution transformers into Namibia's electricity market.

6.2 Demand

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

The main customers of distribution transformers in Namibia are farmers, small settlements, industrial establishments, commercial establishments, mines, individual households who procure through a utility and electricity distributors, such as ERONGO RED, NORED, CENORED, City of Windhoek, and other municipalities.

The largest buyers of distribution transformers are the two regional distributors with the largest distribution networks – NORED and CENORED, followed by ERONGO RED and the transmission utility

NamPower. The other small distributors include OPE and Keetmanshoop municipality. The types of transformers utilised are single pole mounted transformers, H-pole mount, ground (concrete plinth) mount and can have a dry or liquid filled type of cooling.

The average service life of a transformer can vary with the kVA rating. For example, larger kVA ratings tend to have a longer lifespan because they benefit from greater electrical protection, aggregation of load, maintenance and servicing attention. Smaller transformers can have shorter service lives, due to their vulnerability to changing weather patterns and they are also prone to lightning strikes because they are pole mounted. Peak load in localities that exceeds its rated capacity, or lack of maintenance checks also reduce the smaller transformers service life. Service life can also vary by application, due to environmental conditions (such as rain, heat and humidity) and sustained high levels of load.

Table 21 below indicates the typical service life of distribution transformers, grouped according to their kVA rating from the survey.

Table 20: Transformer Service Life time in Namibia based on kVA rating

kVA rating of Distribution Transformer	**Application sector** **(*e.g.* Utility, Industrial, Commercial)**	**Typical Service Life (in years)**
Small (1-100 kVA)	Utilities, industries, commercial	15 - 20 years
Medium (101-1000 kVA)	Utilities, industries ,mines	15 – 35 years
Large (1001-5000 kVA)	Utilities, industries, mines	35 - 40 years

In general, transformers rated up to 100 kVA are pole mounted used mainly in rural areas, while the ones rated more than 100 kVA are ground mounted via a plinth, mainly used in urban areas and mini-substations.

According to stakeholder interviews, the average initial prices of distribution transformers on the market in Namibia are, respectively approximatively USD 1 400 (NAD 19 200) for 16 kVA distribution transformers (normally used for singe households), USD 3 500 (NAD 48 000) for 50 kVA and USD 13 700 (NAD 200 000) for 315 kVA distribution transformers. Losses associated with the operation of the distribution transformers are usually incorporated in the tariffs charged to customers.

6.2.2 Technical standards and regulations for distribution transformers in public utilities

Namibia does not have its own national standards and regulations for distribution transformers and there is no uniformity in specifications. However, each electricity distributor and large users such as mines have developed their own specifications aligned with SANS 780 for transformers up to 3 150 kVA, while international standards, such as IEC60076-20, are applied for larger transformers.

Table 22 below summarises the standard power ratings and standard component losses of dual-ratio transformers as per SANS 780 including the type of cooling, number of phases, type of mounting and frequency levels.

Table 21: Standard power ratings and standard component losses of dual-ratio transformers: Image Source: ERONGO Red Specifications for Distribution Transformers

Transformer Ratings (kVA)	Primary Voltage (kV)	Secondary Voltage (kV)	No-Load Losses (W)	Load Losses (W)	Type of cooling	Number of Phases	Type of mounting	Frequency (Hz)
16	11	0.242	80	400	Oil Natural Air Natural (ONAN)	Single	Pole	50
16	22	0.242	100	400	ONAN	Single	Pole	50
25	11	0.42	120	570	ONAN	Three	Pole	50
25	22	0.42	150	570	ONAN	Three	Pole	50
50	11	0.42	180	1000	ONAN	Three	Pole	50
50	22	0.42	220	1000	ONAN	Three	Pole	50
100	11	0.42	300	1700	ONAN	Three	Pole	50
100	22	0.42	360	1700	ONAN	Three	Pole	50
315	11	0.42	750	3800	ONAN	Three	Ground	50
315	22	0.42	840	3800	ONAN	Three	Ground	50
630	11	0.42	1300	6400	ONAN	Three	Ground	50
630	22	0.42	1400	6400	ONAN	Three	Ground	50
800	11	0.42	1600	8000	ONAN	Three	Ground	50
800	22	0.42	1650	8000	ONAN	Three	Ground	50

Validation testing is only conducted at a factory for distribution transformers of over 315 kVA, while distribution transformers with lower capacities are provided with test certificates upon delivery. Routine tests are done on all distribution transformers. The engineer reserves the right to witness the tests. The results of these tests are made available to the engineer for evaluation before delivery of the distribution transformers.

Type tests and special tests are conducted on one transformer of each size supplied or the manufacturer may also provide certificates of previous tests done on identical transformers.

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

Large users such as mines (B2 Gold, Husab, Namdeb, Skorpion), green schemes and commercial customers use the same transformers as those used by the distributors. They have developed their own specifications for tendering. All connections made by the larger users feeding at medium-voltage (MV) to or from the grid must comply with the distribution grid code promulgated under the Electricity Act, 2007 (Act No. 4 of 2007). The distribution grid code seeks for compliance to its provisions by all users of the distribution system such as entities, embedded generators, distributors and end-users with appliances/equipment connected to the national distribution system.

6.3 Equipment stock and projections

6.3.1 Data on available distribution transformers in the market

The survey found that the procurement of distribution transformers was guided by quantities required for maintenance and new customers in Namibia. Currently, over 1 000 distribution transformers (DT) are procured each year, with NORED procuring about 90 % of the total, based on stakeholder interviews.

Taking into consideration the estimated stock of 24 000 units in 2018 and the annual procurement of 1 000 units per year in 2019 and 2020 (as per survey information), we reached an estimated stock of 26 000 units for 2020. Assuming the market size projections of DT would fall in line with the government strategy to reach full electrification by 2030 and an average GDP growth rate of 3.68 % (World Bank, 2021) as proxy for market growth, as well as a 30-year lifetime for DT (U4E, 2019), the estimated total market size for DT would be 1 900 units in 2021. This figure includes about 870 units procured to replace end-of-life equipment only. Subsequently, the estimated stock level would go up to 27 000 units in 2021. This large increase reflects the aspiration from the Government to increase the electrification rate from 50 % in 2020 to 100 % by 2030 in Namibia. Progress on that goal this year onwards would impact significantly the market projections.

Finally, assuming the average price of DT was USD 9 300 or NAD 137 000, based on feedback from the local supply chain stakeholders, the total market value for distribution transformers would be USD 18 million (NAD 265 million) in 2021. Again, this is assuming the Government would be right on target to increase the electrification rate between 2021 and 2030.

6.3.2 Technology trends and market projections

Most of the distributors indicated that there is no data or information relating to the technology trends and projected demand for distribution transformers in Namibia. However, from the

procurement data obtained from the distributors, the survey was able to estimate the market size for the distribution transformers in 2021 and projections by 2030.

Our report assumed the market size projections of the distribution transformers would fall in line with the government strategy to reach full electrification by 2030. Also there exists a projection of the country's electrical load demand, which is imperative at estimating the number of distribution transformers required over time; refer to Figure 46 below.

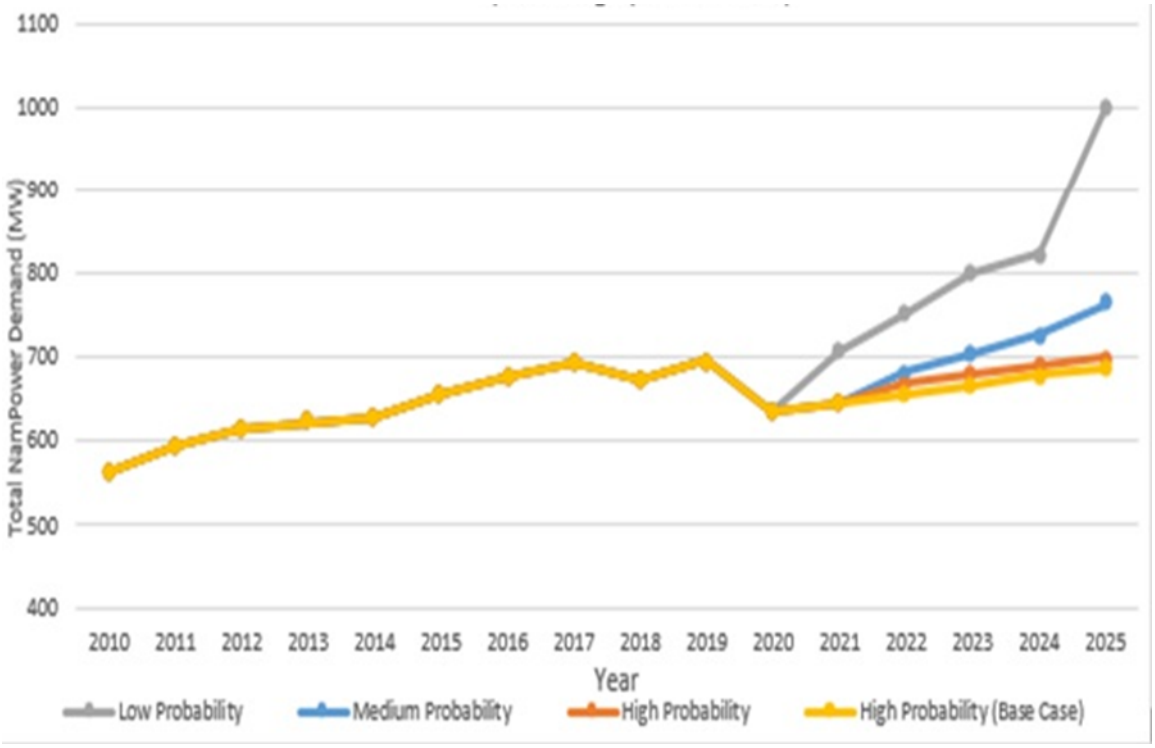

Figure 45: Namibia's electrical load forecast (including system losses). Image Source: NamPower

According to the strategy, in order to achieve 100 % electrification by 2030, 430 000 new household connections to the grid would need to be made to reach the whole population. Without taking into account the different distribution transformers rated power values, considering the average household connection per distribution transformers to be 43, then we reach to the conclusion that subsequently about 1 000 new distribution transformers units would need to be procured each year between 2020 and 2030, in order to reach the full country electrification goal by 2030.

Moreover, assuming the estimated economic growth of 3.68 % (World Bank, 2019) would potentially add new equipment for commercial and industrial end-users and that the total stock would be replaced at a yearly rate of 3.3 % (based on a 30-year lifetime for distribution transformers (U4E, 2019) this would bring the projected market size figure to 2 600 units by 2030. This would correspond to a market value of USD 24.7 million (NAD 363 million). Accordingly, as seen in figure 47, the total stock of distribution transformers would be projected to reach 38 265 units by 2030 in Namibia. Beyond 2030, a significant drop in demand for DTs would be expected following the completion of the full electrification goal. Market demand would then be mainly driven by economic growth for commercial and industrial customers, population growth in the residential sector, as well as replacement of end-of-life equipment, which would not compensate for the end of large-scale electrification investment by the Government. This would justify both the sudden drop in market size and value in 2031 onwards.

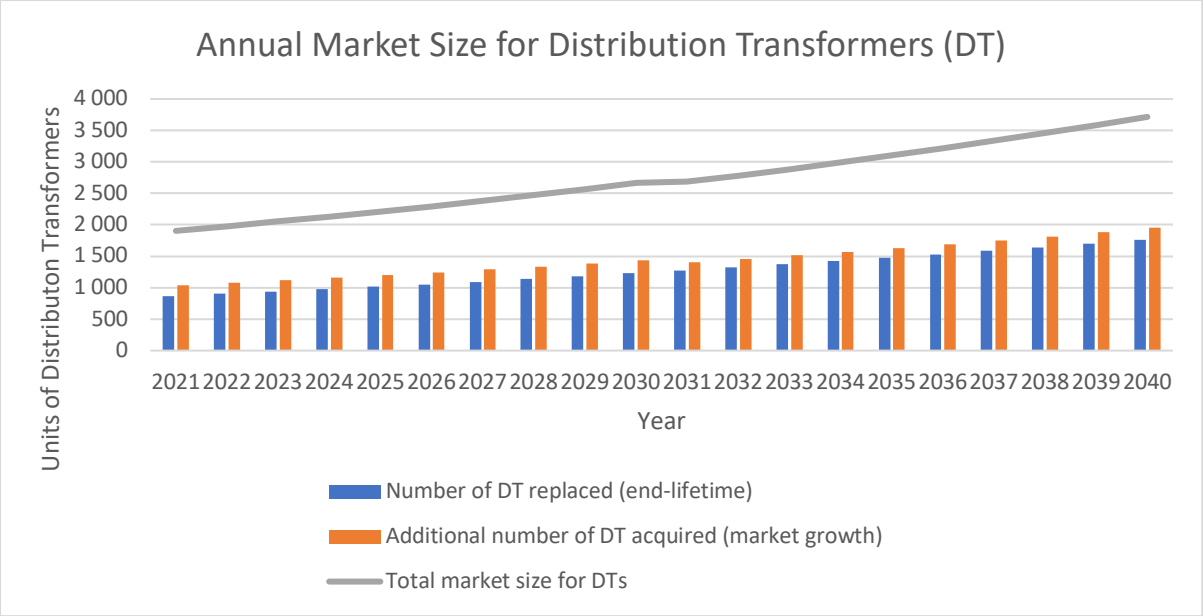

Figure 46: Annual Market Size for Distribution Transformers (Eco Fin Analysis, CTCN Namibia Distribution Transformers, 2021)

Nevertheless, our market projections are highly sensitive to the achievement of the full electrification goal between 2020 and 2030. According to interviews with stakeholders in the supply chain, overall sales of distribution transformers were not increasing at the moment, despite the ambitious 100 % electrification rate goal set by 2030. In fact, the demand for DT might have been flat for the last four years.

Generally, the transformer efficiency is associated with the technology type. Copper and aluminium are the two conductors used in transformer winding. Most transformers imported into Namibia use copper winding which is a more efficient. Furthermore, most existing transformers in Namibia are ONAN-cooled. No natural ester-filled distribution transformers were identified in Namibia. The survey could not conclude whether the efficiency of transformers had improved over the years. The cost of the distribution transformers, according the suppliers and the distributors, has gone up in the last 10 to 20 years. The transformer cost increase has been attributed to the introduction of high-grade steel used for the cores in the transformer.

6.4 Policies and programme landscape

6.4.1 Current and planned electrification policies and programs

Namibia's national development ambitions are guided by the Vision 2030 agenda, which was adopted in 2004. Vision 2030 foresees the provision of secure and affordable energy to the country's developing economy and its people; it provides the overall long-term development goals for the country; and it subscribes to the principle of sustainable development. The Government's medium-term goals and strategies are expressed in National Development Plans (NDPs), which are formulated

in accordance with Vision 2030 and revised every five years. Regarding energy-related developments, the national development framework described above has the following implications:

- An industrialised Namibia, as per Vision 2030, can only be realised provided secure, sufficient, and economically priced energy supplies are and remain available. This ambition has definite repercussions and implications for the country's on-going electrification and creation of access to modern energy services for its citizens, commerce, and industry.
- Economic and social upliftment of the people of Namibia includes access to modern energy services, at fair and affordable prices. Without such access, the people of Namibia cannot realise their personal development ambitions. Again, it is the country's energy industry that must ensure that the energy resources are available to power the nation and her people.

MME's electrification programme focuses mainly on the provision of grid electricity infrastructure to connect Government infrastructure such as schools and hospitals in rural areas to the national grid. In the past, the MME's grid electrification efforts were guided by the Rural Electrification Master Plan (REDMAP), however, as these were last updated in 2010, they are outdated. There also existed an Off-grid Energisation Master Plan (OGEMP) which was developed in 2007. The Ministry of Mines and Energy is currently in the process of developing a National Electrification Policy.

Rural electrification is part of the government's economic development policy to expand the electricity supply infrastructure to rural areas in order to improve the socio-economic conditions of Namibia citizens and to create the necessary incentives for economic development in the targeted areas.

The Rural Electrification Programme was initiated soon after independence in 1990, with the aim of extending the national grid to provide electricity to rural communities. The programme targets rural communities and un-electrified public institutions countrywide. Its primary objective is to provide electricity to these communities in order to improve the standard of living, increase economic and commercial activities, thereby reducing unemployment through job creation, improve the quality of health and educational services, combat adverse environmental practices (deforestation) and reduce the rate of rural-urban migration.

As at the end of 2020, over 2167 public institutions and more than 50 500 homesteads had been electrified since independence, under the government programme. This means that more than 90% of public institutions and more than 20 % of rural homesteads are now having access to electricity (MME, 2020). The Government has spent over NAD1, 5 billion (USD 107 million) towards the programme since 1990 (MME, 2020).

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

Namibia has many legislative tools for the management of chemicals. This includes the Petroleum Products and Energy Act No. 13 of 1990 as a national high-level tool which advocates for a safe disposal of petroleum products. However, these regulations are fragmented and outdated, which has curtailed their implementation.

Namibia has also ratified the MEA such as the Stockholm Convection for POPs and Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal. Again, success in attaining the intended goals is hampered by lack of administrative structures for implementation.

There are businesses that collect the used oil from the transformer refurbishing companies for recycling and reuse according to best practices. All contaminated oil is disposed of at the Kupferberg waste disposal site, outside Windhoek. Steel and cores are sold to scrap metal companies. Figure 48 depicts a transformer oil container at a local refurbishment workshop.

According to Namibia's National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants report (2014), by the Ministry of Environment and Tourism (MET), it was found that 12.2 % of transformers owned by NamPower are PCB-contaminated. In 2018 MET by then, now Ministry of Environment, Forestry and Tourism (MEFT) in collaboration with Africa Institute, undertook the National PCBs Inventory exercise in Namibia as part of the PCB Elimination project under Stockholm Convention. Oil samples from transformers manufactured before 1990 were sent to a laboratory in South Africa to be tested for the presence of PCBs in the oil as part of the inventory procedure. In total, 700 samples from various electricity distributors in Namibia including NamPower were tested. Out of 700 samples, 10 tested positive for the presence of PCBs in the oil of which one belongs to NamPower. Prior to the Inventory exercise, there were three transformers which were sampled by NamPower that tested positive for the presence of PCBs (PCB concentration more than 50 parts per million (ppm)). Therefore, NamPower have only four PCB contaminated transformers in total currently. MEFT indicated that, they are currently in the Elimination phase, where they are developing modalities of phasing out the PCB contaminated transformers in Namibia.

Furthermore, it was noted that, NamPower does not have a specific Transformer management procedure but they have a hazardous substance procedure under which transformer oils falls.

The numbers provided are a representation of data from the PCB inventory exercise conducted in 2018.

Figure 47 : Transformer oil containers at a local refurbishment workshop

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

High product costs were identified as the main barrier to transforming the distribution transformers market towards more energy-efficient transformers. An observation was made in past years that the cheaper, energy inefficient units are widely sold, resulting in a lack of drive towards energy efficient transformers.

Another barrier that was identified is that the REDs that procure transformers lack technical information of the distribution transformers they procure.

6.5 Utility's procurement specifications

NamPower has its own specifications when procuring distribution transformers guided by the IEC60076 and SANS 780 distribution transformer standards, as well as other international standards. The public procurement Act No.15, 2015 guides/governs the method of procuring or buying such transformers.

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

Electrification efforts are guided by the Off-grid Energisation Master Plan (OGEMP) of 2007 and the Rural Electrification Distribution Master Plan (REDMP), last updated in 2010. MME leads the implementation of the Rural Electrification Master Planning through allocations from the national budget and, more recently, allocations from the National Energy Fund (NEF) electricity levy, which is derived from electricity consumers.

At the project level, for rural areas and public institutions that benefit from subsidized electrification projects, as well development of Mini-grids, MME conducts annual planning processes in consultation with regional councils, other local stakeholders and NamPower in order to determine priority projects. NamPower is responsible for executing some projects before hand-over to a distributor (or NamPower Distribution) for operation, while MME implements the bulk of rural electrification before hand-over to the REDs for operation for grid electrification only.

OGEMP is implemented via the national budget. The SRF, which falls under the MME's Renewable Energy Division, provides loans to individual households for only solar home systems, solar water pumps and solar water heaters. The EIF, which falls under the MEFT provides subsidised loans and grants for households, water pumping and solar water heaters to individuals and civil organisations and the private sector. These do not touch on distribution networks; they rather focus on stand-alone systems. Additionally, off-grid mini-grids made up of 11 kVA distribution networks in Namibia are directly funded by a combination of the national budget and grant funding by international development institutions.

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

Namibia entirely depends on distribution transformer imports mainly from South Africa and in a few cases from other countries from Europe and Asia, guided by procurement specifications set by the service providers.

Going forward, Namibia can benefit from the distribution transformer supplies from neighbouring countries, such as Zambia.

7 Conclusion

Namibia has clearly demonstrated its commitment to implement various strategies aimed at energy efficiency and green energy technologies. Over the past two decades, the country's electricity sector has undergone a transformation that has significantly improved the institutional and regulatory framework, increased electricity generation capacity and network expansion. The National Energy Policy of 2017 and the National Renewable Energy Policy (2016) are some of the instruments which spell out this commitment.

While Namibia still experiences an energy deficit and 50 % of the country's population still lacks access to electricity, Government recognises that the country's energy sector is of strategic importance, and is working towards enabling it to yield maximum development benefits. The National Renewable Energy Policy recognises the immense potential of the country's renewables sector and reaffirms Government's commitment to support the sector for it to reach its fullest potential. In addition, the policy advocates for the implementation of energy efficiency and demand side management and development of the National Energy Efficiency Policy for all the sectors in Namibia.

Government's decision to approach the Climate Technology Centre & Network (CTCN) for assistance in the implementation of energy efficiency policies and strategies, particularly pertaining to widely used appliances and equipment such as lighting, residential refrigerators, air conditioners, transformers and industrial electric motors, is indeed a huge step in the right direction.

However, this survey on the GCF readiness project aimed at developing national policy roadmaps for the promotion of efficient refrigerators and distribution transformers, including Minimum Energy Performance Standards (MEPS), Highest Energy Performance Standards (HEPS), labelling scheme, consumer awareness, end-users' education, capacity building for custom officials and procurement officials, and MV&E framework, as well as appropriate financing mechanisms to accelerate deployment of energy-efficient residential refrigerators and distribution transformers, revealed that a lot still needs to be done to translate this commitment to action.

For instance, there are currently no regulations promoting the uptake of energy efficient refrigerators, while local standards and labelling are also not available. The Namibian Standards Institute (NSI) currently has no infrastructure for testing for energy efficient appliances and indicated that it has no plans to set up such a facility in Namibia in the near future.

Namibia is one of the countries that have ratified the Kigali Amendment to the Montreal protocol and the phasing out on substances that deplete the Ozone layer since 2010. The report establishes that the Kigali Amendment is being implemented in the country, since most of the refrigerators are equipped with R600a, which is a low GWP refrigerant.

Furthermore, the amended Gazette No.148 of 2020 prohibited the importation of harmful refrigerant gases including R134a, R500a, R12, F502, NH3, as from January 2021. In addition, due to this country's effort of phasing out the Ozone depleting substances regulations, most of the residential refrigerators (55.6 %), refrigerator-freezers (65.2 %) and freezers (56 %) were found to be A rated energy efficient.

The baseline stock level in 2021 of 251 000 residential refrigerators was calculated based on the stock of appliances (241 000) in 2020 and the replacement rate of 8 % per annum, at a growth rate of 3.68 % per annum. The estimated lifespan of a residential refrigerator in Namibia is between 10 and 15 years, with an average price of USD 459 (NAD 6 300) per appliance. The estimated market value for residential refrigerator is USD 12.9 million (NAD 177.1 million) in Namibia in 2021 (Eco Fin Analysis, CTCN Namibia Refrigerators).

Based on our projections (Eco Fin Analysis, CTCN Namibia Refrigerators, 2021), the stock level, market size, and market value of residential refrigerators, respectively would be 346 000, 39 000, and USD 17.9 million (NAD 245.8) by 2030.

Namibia does not manufacture any refrigerators and it appears the appetite to venture into this sector is very low considering the challenges faced by manufacturers in the country. The 100 % importation

of refrigerators, mostly from South Africa and China, poses a quality control problem and a challenge in ensuring that only energy efficient refrigerators made their way into the homes of Namibians.

Another challenge observed from the survey is that energy efficient refrigerators are generally more expensive than the normal refrigerators and most consumers (over 67 %) look at the price tag of the refrigerator rather than its energy usage. In the absence of financial incentives aimed specifically at encouraging the uptake of energy efficient household appliances, such as refrigerators, most consumers are willing to spend up to 10 % more on energy efficient appliances, but are restricted by affordability.

This is compounded by the fact that Namibia has seen little or no awareness campaigns encouraging citizens to invest in energy efficient appliances. As a result, consumers are not aware of the technological and environmental benefits of energy-efficient refrigerators and hence do not see the need to invest money buying them rather than the ordinary refrigerators.

Financing energy efficient appliances does not seem to be a priority of financial institutions, despite the Bank of Namibia's appeal that the commercial banks should not only make decisions purely based on their profitability but also make deliberate decisions to promote sustainability of the environment.

One major challenge encountered during this survey was that some of the suppliers of refrigerators were hesitant to provide information because they felt the information was sensitive and did not want it to land in the hands of their competitors. As a result, the market assessment relied on the general patterns painted by the five major suppliers who responded favourably, data from the household survey, data obtained from the Namibia Statistics Agency, as well as reliable internet data.

On the distribution transformers, the survey found that the procurement of distribution transformers depends on the quantities required for maintenance and new customers induced by economic growth and the government strategy to reach full electrification by 2030. It was estimated that the total market size for distribution transformers would be 1 900 units in 2021, while subsequent stock level would be at 27 000 units in 2021. This would correspond to a total market value for distribution transformers of USD 18 million (NAD 265 million) in 2021. In addition, the report assumed the market size projections of distribution transformers would fall in line with the government strategy to reach full electrification by 2030. This would bring the projected market size figure to 2 600 units by 2030, corresponding to a market value of USD 24.7 million (NAD 363 million), while the total stock of distribution transformers would be projected to reach 38 265 units by 2030.

The market assessment found that there are no mandatory requirements or regulatory tool such as policies, MEPS, and safety standards for distribution transformers. However, the distributors and utility specify electrical losses for the distribution transformers which shall not exceed 5 %, and request bidders to provide efficiency at no load and load conditions. Their specifications are always based on IEC60076-20 and SANS 780.

In terms of environmental regulations regarding the oil transformer, IEC 62535 for Corrosive Sulphur, SANS 290/IEC60619/ASTM D4059 for PCB, ASTM D6595 for Silicon/Silicone content, IEC60666 for inhibitor/Anti-oxidant additives, and IEC 61198 for Furans are being used . In addition, all transformer oil must comply to Eskom 240-75661431. However, there are many legislative tools for the management of chemicals which are outdated. There are businesses that collect the oil from the

transformer refurbishing companies for reusing according to best practices. Oil is sold to companies who recycle or reuse it. All contaminated oil is disposed of at Kupferberg waste disposal site in Windhoek, while steel and cores are sold to scrap companies by the utility.

Annexes

Annex (a): Overview/List of data sources

The sources used in the report include:

- Peer reviewed articles (case studies, original research, reviews and short communication) in journals
- Online databanks (such as COMTRADE)
- Official reports from organizations
- Policy documents and legal instruments
- Books and academic reports (thesis, etc.)
- Newspaper articles and online stories from credible websites
- Information from online stores
- Company/ suppliers/ retailers/ organizations websites
- Interviews with the financial institutions, suppliers, retailers, regional electricity distributors

Annex (b): Bibliography

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Annex (c): Answered questionnaires (zip file sent separately)

Annex (d): List of Enumerators

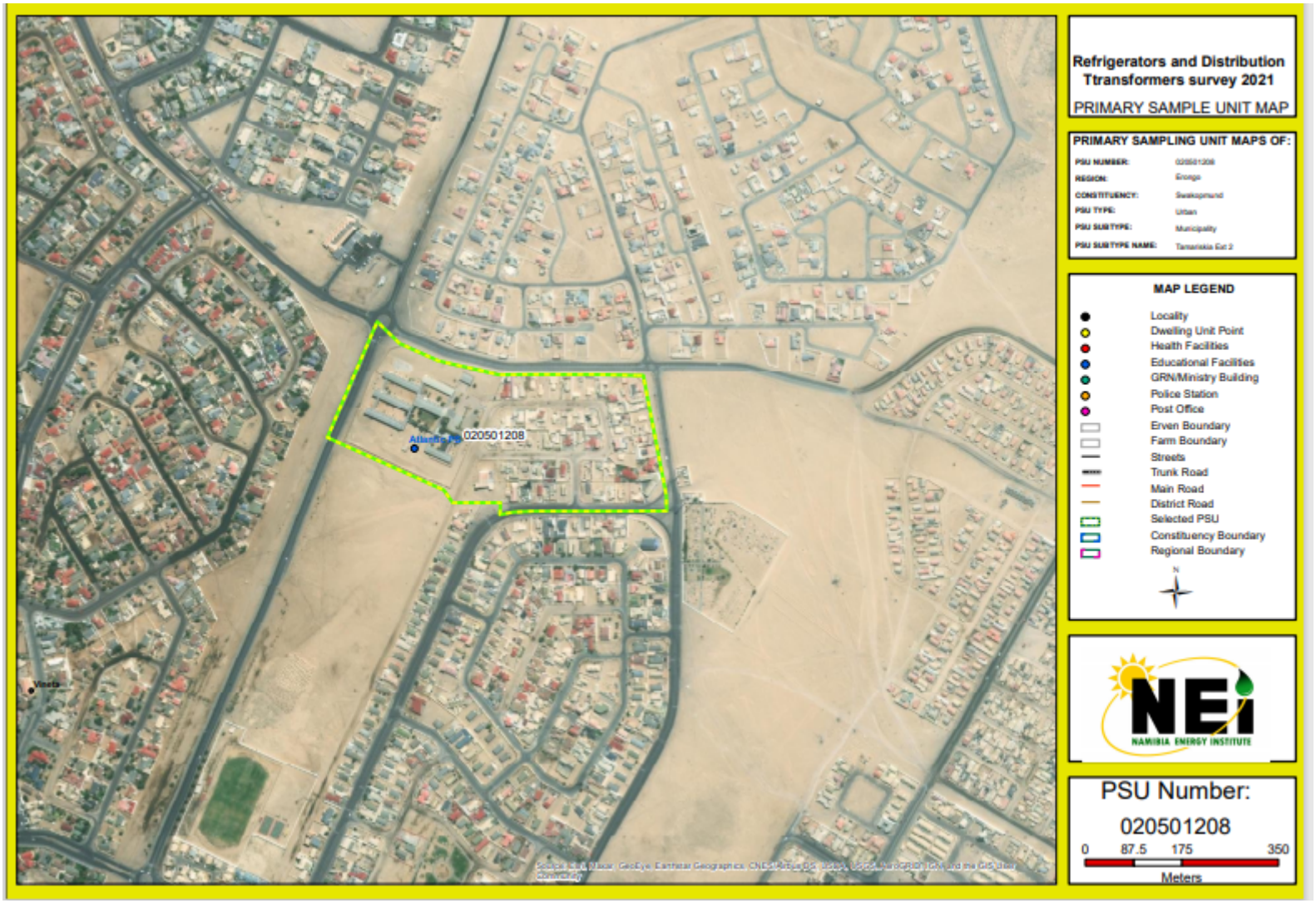
No.	Name and Surname	Gender	Location	Mobile Number	ID Number	Qualifications	Email Address	Number of Questionnaires
1	Stefanus Ndakwenongwe	Male	Keetmanshoop	812169723	820311 10136	National Certificate: Air Conditioning and Refrigeration	steventunga@gmail.com	24
2	Shigwedha Shaffa	Male	Walvis Bay & Swakopmund	812600033	871123 00077	N3 Diploma: Air Conditioning and Refrigeration	shaffashange@gmail.com	29
3	Aini MH Avia	Female	Ondangwa	812736860	951208 00149	N5 Diploma: Electrical Engineering L3: Trade Certificate: Air Conditioning and Refrigeration	ainiaviahm@gmail.com	18
4	Hinyengwa Panduleni Ndatipo	Male	Oshakati	813055569	880922 00319	N3 Diploma: Air Conditioning and Refrigeration	hpanduleni@yahoo.com	18
5	Rachel Mulyata	Female	Rundu	818566051	990607 00279	Bachelor of Science in Applied Mathematics and Statistics	mulyatarachel@gmail.com	18
6	Mikasius Gabriel	Male	Katima Mulilo	0817610585 or 0817813834	821008 10887	N6 Diploma: Product Design N3 Diploma: Air Conditioning and Refrigeration	inga.mike2@gmail.com	18
7	Aina Mpadhi	Female	Windhoek	818244703	960714 00977	BSc. Physics (Hons) Mathematics	ainampadhi@gmail.com	13
8	Joolokeni N Shangano	Female	Windhoek	812106312	980831 00226	Bachelor of Technology: Power Engineering	joololokeni8@gmail.com	13
9	Meke Kapiye	Female	Windhoek	816836315	981003 00240	Bachelor of Technology: Power Engineering	mekekapiye@gmail.com	13
10	Maija-Lisa David	Female	Windhoek	818225015	960501 00047	Bachelor of Technology: Power Engineering	maijalisadavid@yahoo.com	13

11	Klena Ketu Nekongo	Female	Otjiwarongo	814010172	94082800457	Bachelor of Science in Applied Mathematics and Statistics Bachelor of Science (Honours): Applied Statistics	Nekongo.klena@gmail.com	23
								200
Data Capturers								
12	Nanona Hipangelwa	Female	Windhoek	0812836410/0816953658	99122500766	Bachelor of Science in Applied Mathematics and Statistics	xurotia@gmail.com	
13	Bernice Zhou	Female	Windhoek	817234619	DN835868	Bachelor of Science in Applied Mathematics and Statistics	bernicyzhou@gmail.com	

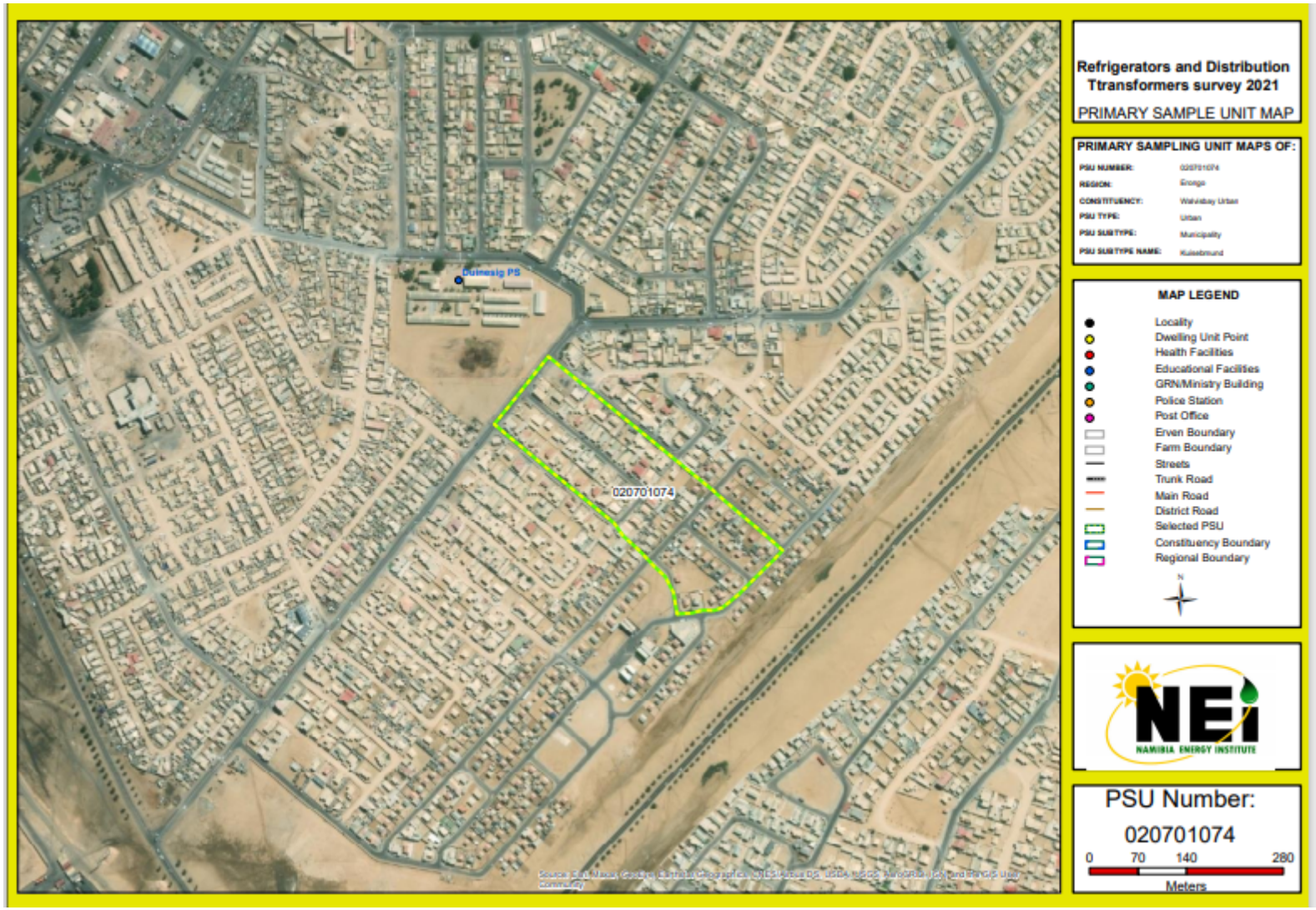
Annex (e) : PSU Maps

PSU Map: Keetmanshoop Urban: Karas Region: 010601023

PSU Map: Swakopmund: Erongo Region: 020501208

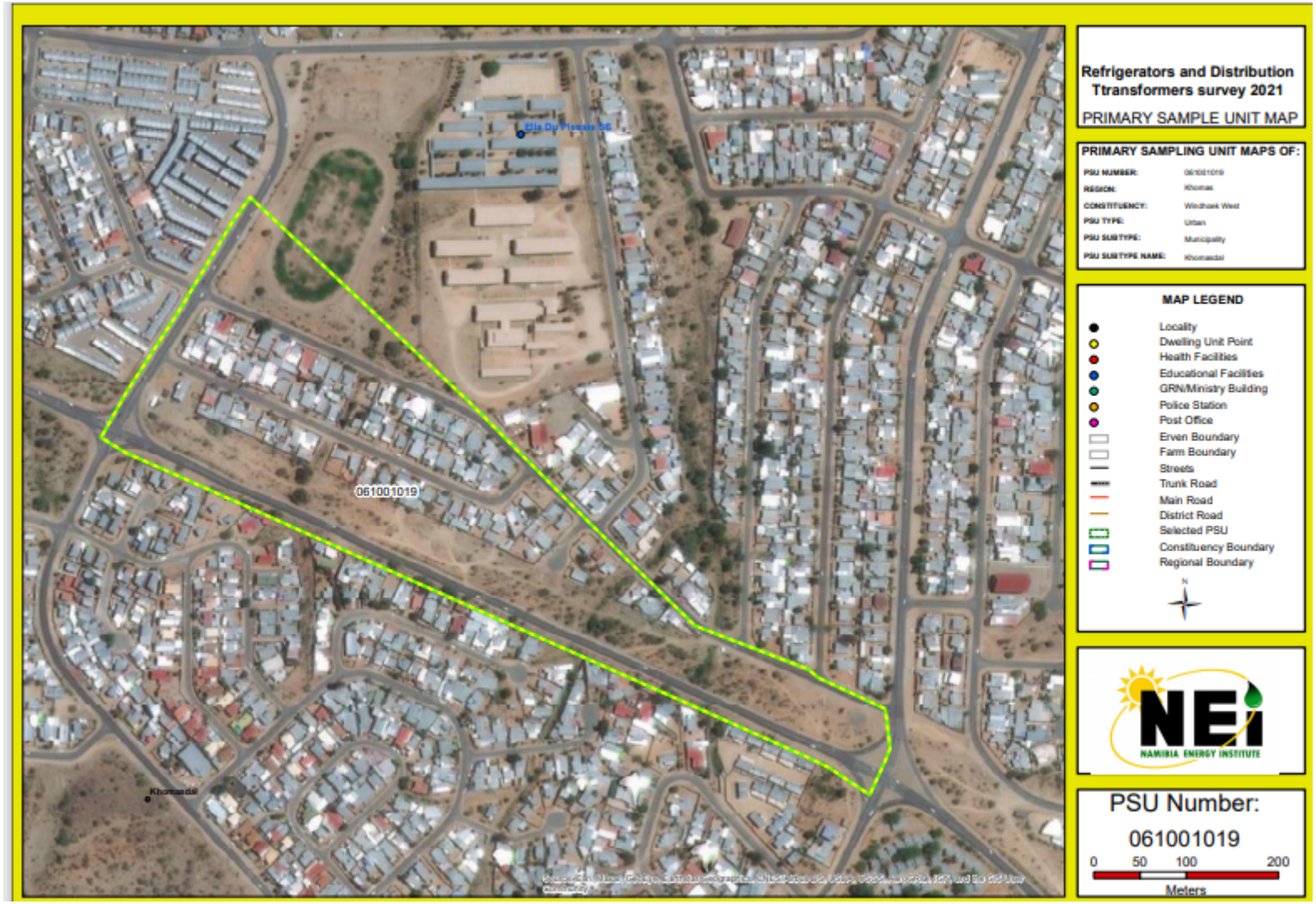


PSU Map: Walvis Urban: Erongo Region: 020701074



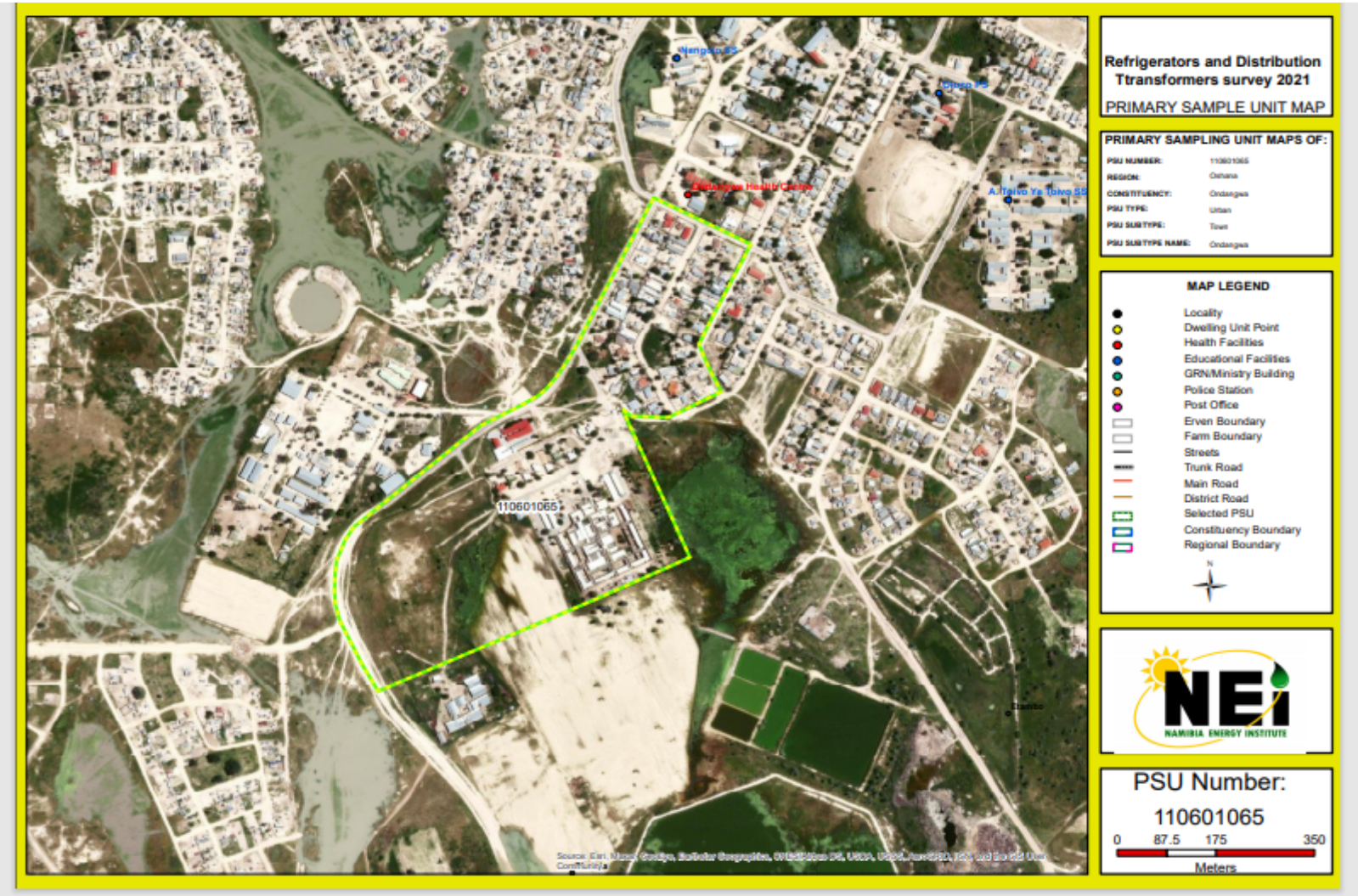
PSU Map: Rundu Urban: Kavango East Region: 040601121

PSU Map: Windhoek West: Khomas Region: 061001019

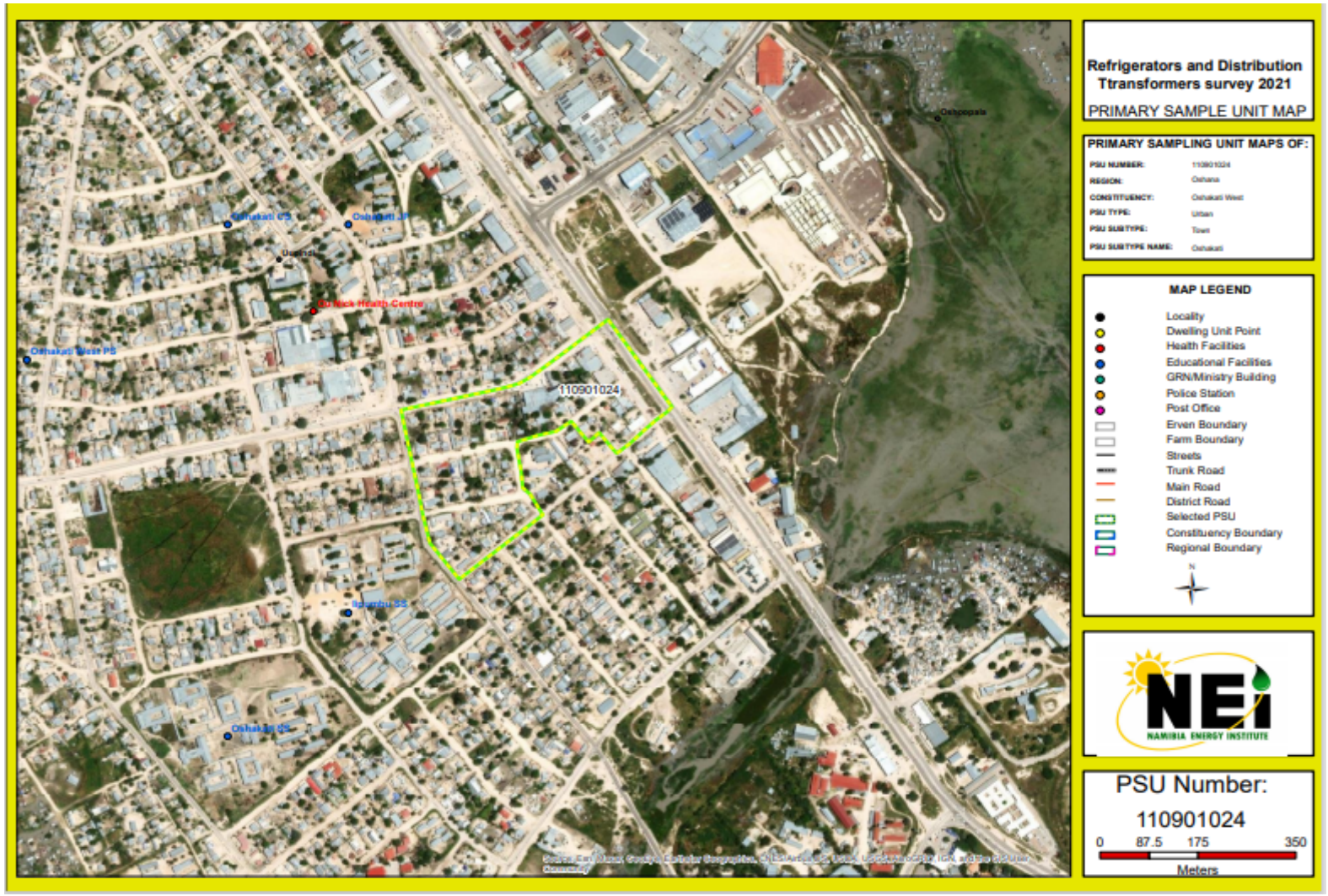


PSU Map: Windhoek West: Khomas Region: 061001149

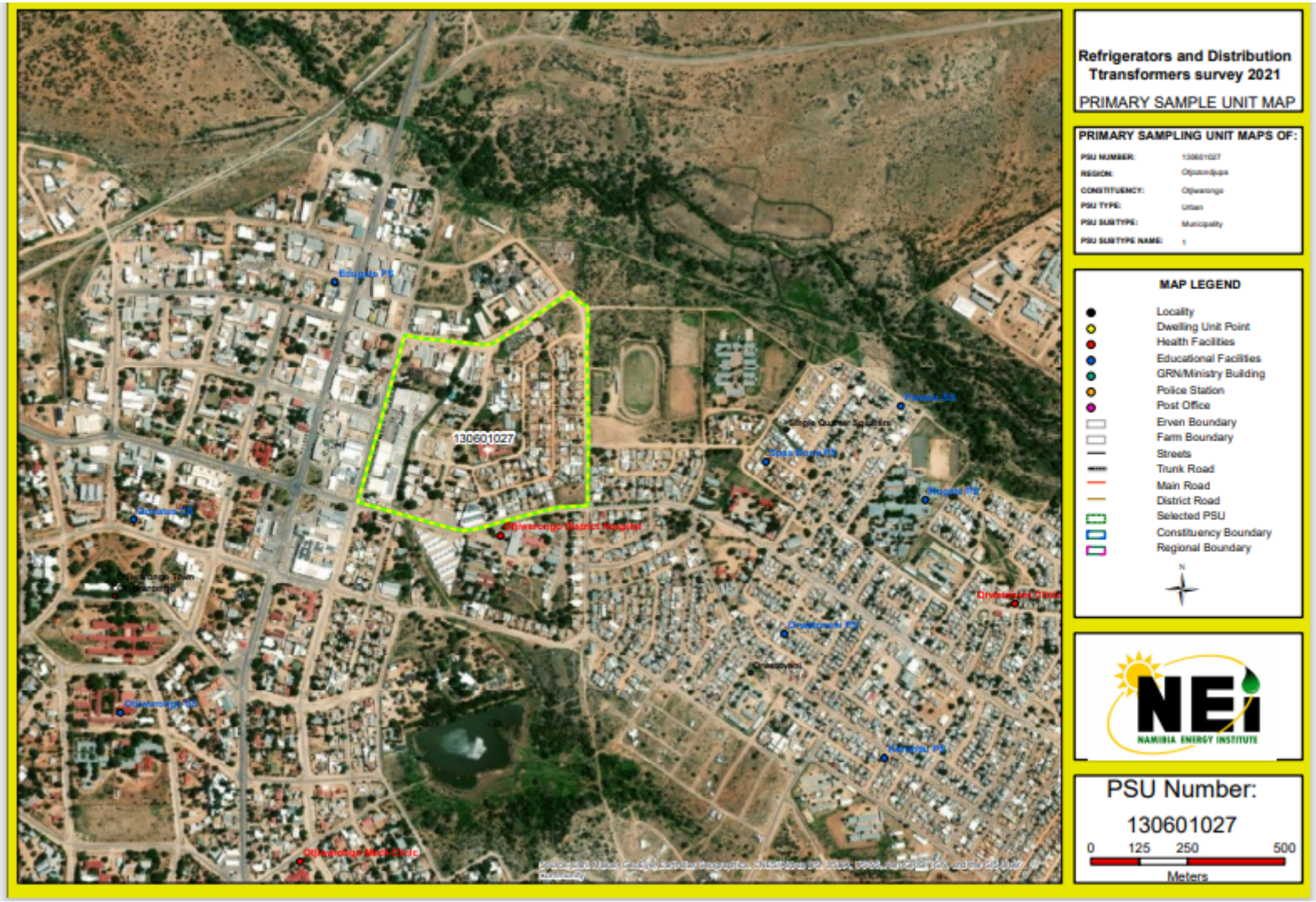
PSU Map: Ondangwa: Oshana Region: 110901024



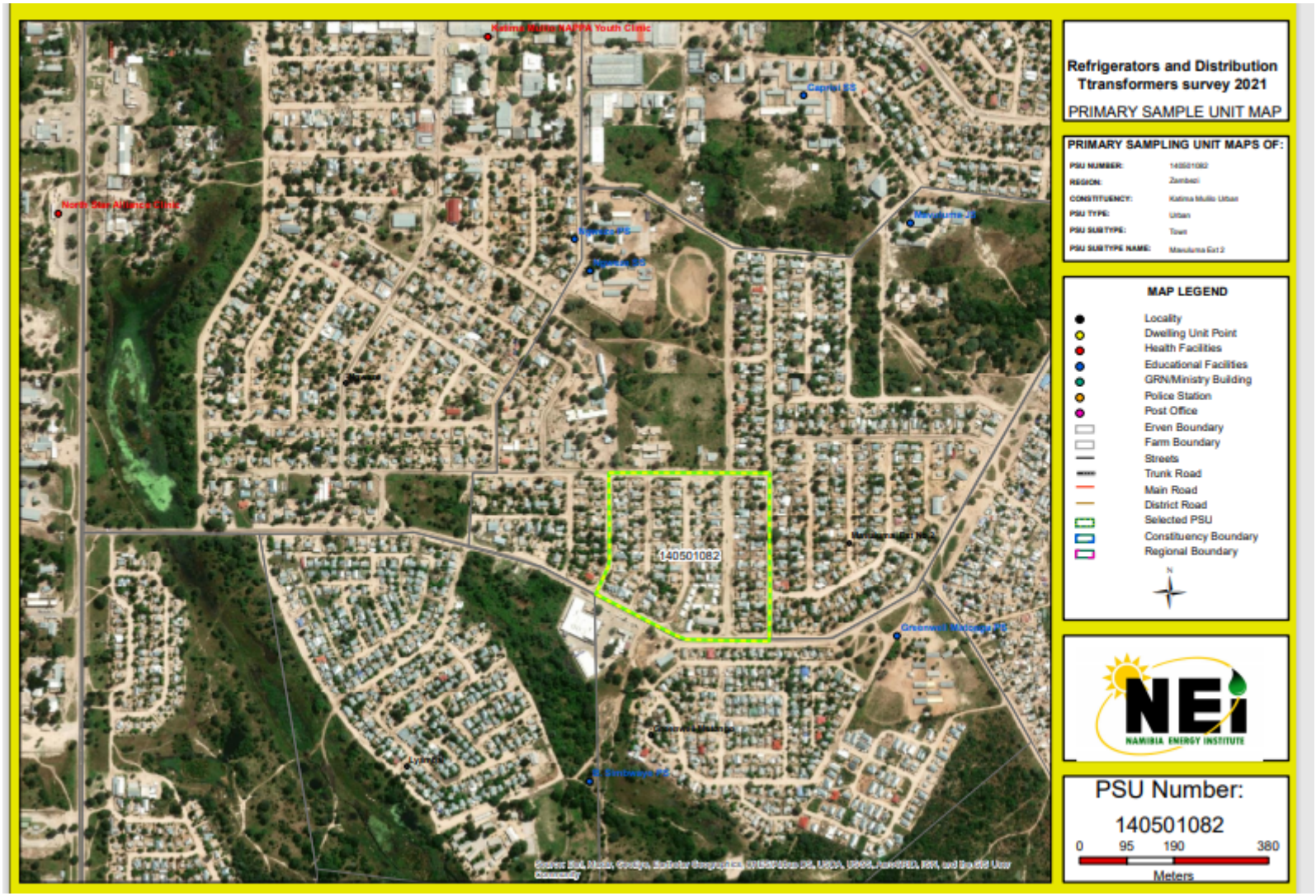
PSU Map: Oshakati West: Oshana Region: 110601065



PSU Map: Otjiwarongo: Otjozondjupa Region: 130601027



PSU Map: Katima Mulilo: Zambezi Region: 140501082



Annex (f) : Interview guides

- Distribution transformers interview guide

As part of the Green Climate Fund (GCF) project on 'Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers'. The implementation of the projects will be led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative. Additionally, the in-country implementation will be managed by three implementers: (i) CLASP, (ii) Basel Agency for Sustainable Energy (BASE) with ICA and SACREEE, and (iii) Pegasys. The projects will support development of a framework for energy-efficient refrigerators and transformers. We request your support in the work to gather this information.

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

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

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

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

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

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

6) **Refurbishment practices and End of Life** – what is the typical lifetime of a transformer installed in your country and what happens to units that have been decommissioned? Once taken out of service, how are these units most often treated? Are they reconditioned and put back into service, or disassembled and recycled or scrapped?

7) **Stock estimate** – do you know whether the electric utility, or government ministry maintains an asset database of the installed stock of transformers in your country? Do you have any estimate of the installed stock? Is there any information on the years those individual units were commissioned?

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

1. Policies and programmes

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

1.1) Policies and Standards

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

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

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

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

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

1.2) Voluntary Programmes and Incentives

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

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

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

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

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

2. Channels to Market

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

2.1) Suppliers

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

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

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

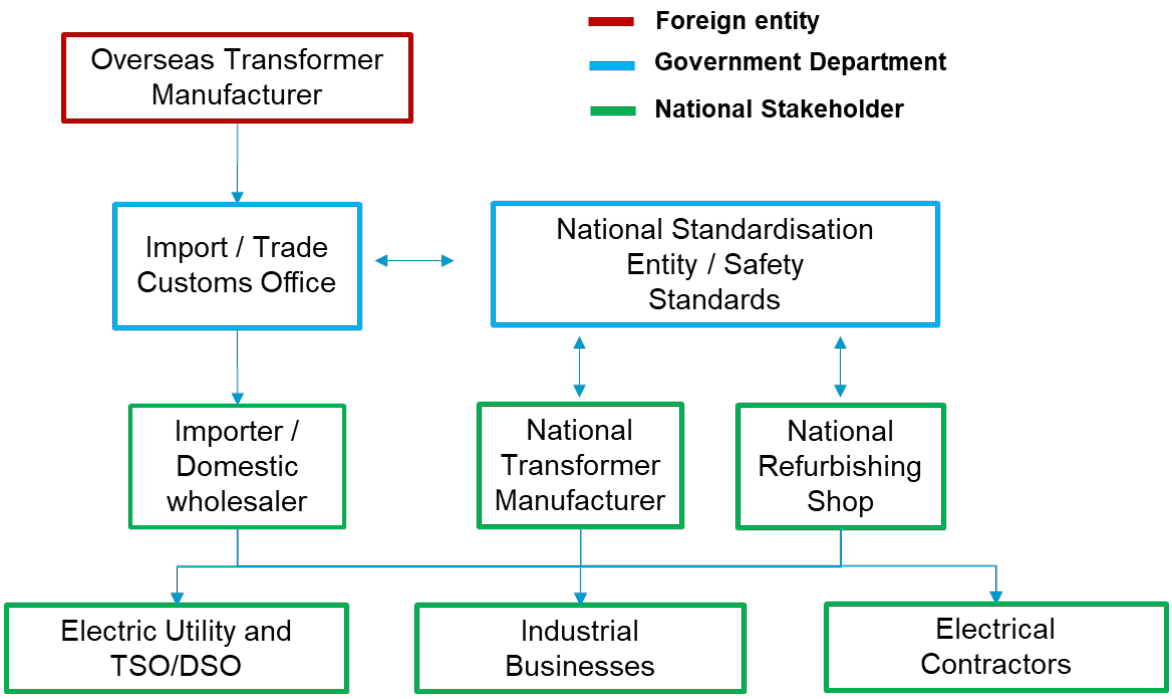
2.2) Procurement

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

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

2.3) Market Flow

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



3. Sales volume

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

3.1) Unit shipments/Sales

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

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

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

3.2) Refurbishments

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

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

3.3) Electricity demand growth forecast

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

3.4) National electrification programme

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

4. Typical losses

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

4.1) Losses or Efficiency

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

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

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

400			
500			
630			
800			
1000			
1250			
1600			
2000			
2500			
3150			

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

4.2) Loss Evaluation (A and B factors)

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

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

5. Refurbishment Practices and End of Life

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

5.1 Lifetime

The average service life of a transformer can vary with the kVA rating. For example, larger kVA ratings often tend to have a longer service life because they benefit from greater circuit protection,

aggregation of loads, and maintenance and servicing attention. Smaller kVA ratings can have shorter service lives, due to a lack of lightning or surge protection, peak load in localities that exceeds its rated capacity, or limited/no maintenance checks. Service life can also vary by application, due to environmental conditions (such as lightning, rain, heat and humidity) but also due to the loading such as sustained high levels of load, as well as brief occurrences of overloading.

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

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

5.2 Refurbishment and End of Life

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

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

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

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

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

6. Stock Estimate

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

6.1 Asset Database

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

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

6.2 Estimates

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

- Interview guide for household survey on residential refrigerators

As part of the Green Climate Fund (GCF) project on 'Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers'. The implementation of the projects will be led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative. Additionally, the in-country implementation will be managed by three implementers: (i) CLASP, (ii) Basel Agency for Sustainable Energy (BASE) with ICA and SACREEE, and (iii) Pegasys. The projects will support development of a framework for energy-efficient refrigerators and transformers. We request your support in the work to gather this information.

This survey covers the follow critical aspects of refrigerators in your country.

Household survey

Description

<Include Surveyor details>

<Include Respondent details including Name, gender, title, email, phone, location, profession >

---

1. **Total number of family members (above the age of 8) who reside in your house** _____

2. **What is your average monthly electricity payment?**[14]

Range	Tick option
X	
X	
X	

3. **What is the size of your house in BHK (bedroom, hall and kitchen)? Please <u>tick (☑) any 1</u> option.**

1 BHK	2 BHK	3 BHK	>3BHK

4. **How many appliance(s) do you own in your house? Please <u>tick (☑) any 1</u> option.**

	0	1	2	3	>3	New	Second-hand
Refrigerator							
Refrigerat							

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

or – Freezer							
Freezer							

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

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

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

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

–Freezer 3				
Freezer 1				
Freezer 2				

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

	Volume by compartment (liters)	Annual energy consumption (kWh)[15]	Refrigerant	Energy Efficiency Class (i.e. A or B/stars)	Label	Number of Doors
Refrigerator 1						
Refrigerator 2						
Refrigerator 3						
Refrigerator –Freezer 1						
Refrigerator –Freezer 2						
Refrigerator –Freezer 3						
Freezer 1						
Freezer 2						
Freezer 3						

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

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

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

Refrigerator –Freezer 2			
Refrigerator –Freezer 3			
Freezer 1			
Freezer 2			
Freezer 3			

9. Please indicate your average annual revenue[16].

Range	Tick option
X	
X	
X	

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

No	Yes

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

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

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

No	Yes

13. If yes, please also indicate if you have ever taken a loan from the institution. If so what was the tenor

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

period of the loan?

No	Yes

14. Do you own the house where you live?

No	Yes

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

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

16. If you don't have refrigerator, refrigerator-freezer or freezer, would you prefer to own or lease the refrigerator if possible?

No	Yes, to own	Yes, to lease

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

Factors	**None**	**Low**	**Medium**	**High**
Price of the equipment				
Warranty				
Look/Design/color				
Functional/Practical				
Energy consumption				
Access to financing				
Capacity / size				
Brand				
Quality				
Recommendation from people you know				

Availability of transport, installation and maintenance services				
Other (please specify)				

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

- Interview guide for supply chain of residential refrigerators

As part of the Green Climate Fund (GCF) project on 'Developing a national framework for leapfrogging to energy efficient refrigerators and distribution transformers'. The implementation of the projects will be led by Climate Technology Centre and Network (CTCN) in coordination with the United Nations Environment Programme's (UNEP) United for Efficiency (U4E) initiative. Additionally, the in-country implementation will be managed by three implementers: (i) CLASP, (ii) Basel Agency for Sustainable Energy (BASE) with ICA and SACREEE, and (iii) Pegasys. The projects will support development of a framework for energy-efficient refrigerators and transformers. We request your support in the work to gather this information.

This survey covers the follow critical aspects of refrigerators in your country.

Supply chain survey

Section I: Product Supply and Distribution

1.1 Is there any local refrigerator manufacturer in YOUR COUNTRY?

☐ Yes ☐ No (please go to question 1.3)

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

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

_____*%*

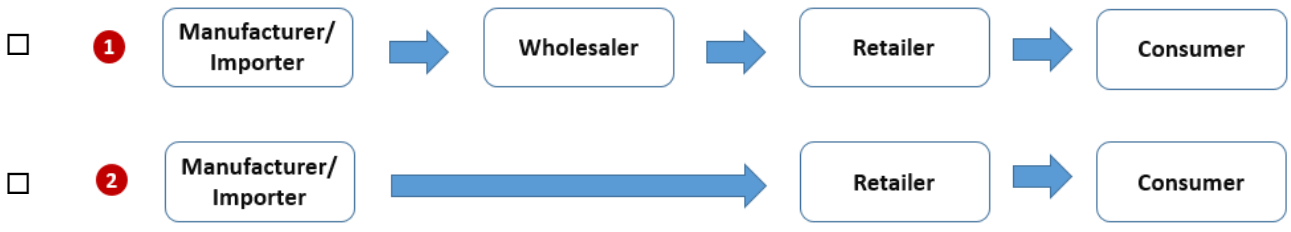
1.3 What is the role of your company? (You can cross *(x)* more than 1 option)

☐ Distributor/ Wholesaler ☐ Importer

☐ Exporter ☐ Manufacturer

☐ Assembler ☐Others, please specify_____

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



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

1. Manufacturer_____ Brand_____

2. Manufacturer _____ Brand_____

3. Manufacturer _____ Brand_____

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

1. Importer_____ Brand_____

2. Importer_____ Brand_____

3. Importer_____ Brand_____

Section II: Awareness and general questions

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

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

2.2 What is your view on the future/key trends for new refrigerators that will impact your customer's satisfaction? Please refer to the answered questionnaires for supply chain

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

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

Section III: Annual Market Size

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

_____ Refrigerator - Inverter	**%**
_____ Refrigerator – Non-inverter	%
_____ Freezer	**%**
_____ Refrigerator-freezers - Inverter	**%**
_____ Refrigerator-freezers – Non-inverter	**%**
_____Others, please specify	**%**

3.2 In your view, please estimate total refrigerator market size in YOUR COUNTRY in 2020.

_____ units

3.3 In your view, who are the three leading refrigerator BRANDS in YOUR COUNTRY'? If known, please identify their market shares in 2020.

1. Brand_____ Market Share_____%

2. Brand_____ Market Share_____%

3. Brand_____ Market Share_____%

Section IV: Details on type of products sold **Please refer to the answered questionnaires for supply chain**

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

Refrigerators

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

>600L				
Total (Units)				

Freezers

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

Refrigerator-freezers

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

Other, please specify_____

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

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

4.2 Please provide a list of refrigerant gases by model number used in residential refrigerators manufactured/sold in "YOUR COMPANY"

Model	Refrigerant gas

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

Type	Annual Energy Consumption	Energy Efficiency Performance Class (i.e. A+++, A++, A+, B)
Refrigerator - Inverter		
Refrigerator – Non-inverter		
Freezer		

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

Section V: Contact Information

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

First Name:

_____

Surname:

_____

Position:

_____

Company Name:

_____

Address:

_____

_____

__

Country:

_____

Telephone Number (including international country code):

_____

Mobile Telephone Number (including international country code):

_____

Email: _____