TECHNICAL MARKET REVIEW

Country Profile: Botswana

Climate Technology Centre & Network

Revised Report
Date: 14th May 2018

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Overall Task and Objective of project:
Review of potential for implementation of energy efficiency policies and strategies in Southern Africa for lighting, refrigerators, air-conditioning, motors and transformers

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1 EXECUTIVE SUMMARY

This report reviews the potential for increasing the energy efficiency of products in Botswana by providing a technical market assessment of current conditions and policies. Five specific product categories have been reviewed: lighting, air conditioning, refrigerators, motors and transformers.

Research conducted by DNV GL during 2017 provides context and insight in relation to the barriers and opportunities, along with a set of recommendations to support Botswana in achieving its sustainability goals. Within this context, DNV GL presents its best estimation of technical potential for each product category for policy recommendations intended to achieve savings over standard equipment using assumptions based on the research undertaken during this project.

General remarks

The high level of electrification of Botswana’s households presents significant opportunities for ensuring that new uses of electricity are of the highest level of energy efficiency. Thus, while challenges remain associated with income levels and rural electrification, encouraging adoption of more energy efficient equipment and products amongst users is an important policy opportunity. Mitigating the potential for growth in demand will also help the country achieve its energy diversification goals while limiting the need for importing electricity to meet peak power demand. Given that there is virtually no indigenous manufacturing of these products, a regional market transformation strategy, combined with regional harmonized standards and labels, in-country educational campaigns and utility support is considered the best approach achieving meaningful change in Botswana.

Underlying process

DNV GL conducted an initial desktop analysis before sending out data requests and setting up meetings with local entities within Botswana. These included the Botswana Institute for Research and Innovation, Department of Meteorological Services, Department of Energy and other local stakeholders such as contractors, suppliers and installers of technologies. Meetings and interviews were conducted over several days within the country, as well as via email and phone. Key findings are highlighted below.

National Designated Entity (NDE) prioritisation

Energy efficiency (and this project in particular) is not the primary priority of the NDEs. Electrification, food, water, housing and other more pressing and relevant issues understandably have higher priority. Thus, very little capacity remains to track or research the data required for this survey. Further to that, the NDE’s were getting very little support and feedback from the other entities within their countries (Revenue Authorities, Trade Organizations, Utilities, Stats bureau etc.), which resulted in very slow turnaround times with limited feedback and questionable accuracy of the provided data.

Cost Sensitivity

Due to generally high levels of poverty in Southern Africa, the markets are extremely price sensitive. Energy efficiency typically comes at a cost and any additional costs have large impacts on short term cashflows. For example, additional costs for a higher efficiency refrigerator must be secondary to filling the existing one.

Africa is a small market

The entire African continent consumes less than 5% of all electricity in the world. Therefore, it is understandable that manufacturers have little interest in spending time and resources to invest into, let alone track, the African market, and even less to if you look at the specific countries.

Energy Efficiency is perceived as a conflict of interest for utilities

Reducing the sales of electricity by promoting energy efficiency effectively reduces some potential revenue from the utility. On the turn side, current lack of sufficient capacity results in regular power outages, so reduced consumption could be redistributed. Since the utility is state owned, this enables the state to use the utility to drive energy efficiency roll outs, despite the apparent conflict.

Subsidised electricity tariffs

Botswana electric charges are low compared to Europe at 0.08 – 0.10 USD per kWh for residential customers. These are government subsidised tariffs, which result in longer payback periods for energy savings projects or energy efficient technologies than if full utility costs were charged. This negatively impacts the sales of higher efficiency units, compared to their cheaper but less efficient competitors. Unfortunately, the low average incomes prevent the state-owned utilities from increasing the tariffs to be fully cost reflective, as many people would then not be able to afford electricity, which in turn would adversely affect both the economy and the uptake of electrification.

Energy Policies

Like several other countries in the region, Botswana has an energy policy [1] in draft, but this is at a very high level, does not address any technologies, does not have any specific regulations and provides no enforcement mandate.

Conclusion

Despite the limitations noted, including low population density and low incomes, Botswana has much to gain by adopting energy efficient standards and technologies. The market research, data collection and analysis conducted by DNV GL during this study has been able to provide insight into the five product categories of primary energy-consuming appliances and equipment covered (lighting, air conditioning, refrigerators, motors and transformers).

The projected energy savings for Botswana when moving from the current state of technologies to Minimum Energy Performance Standards (MEPS) or to the Best Available Technologies (BAT) are shown in

Table 1.1 below. More detail on the underlying approach used to arrive at this can be found in the sections of the report for each of the individual product categories. Section 2.6 presents more detail as to the assumptions used in the modelling process.

The overall savings potentially yielded by the adoption of MEPS are expected to increase from 370 GWh (662t CO_2) per annum in 2025 to 683 GWh (1,220t CO_2) per annum in 2030. BAT projected savings for 2025 is expected to be 626 GWh (1,118t CO_2) per annum while savings yielded in 2030 are projected to be 1,216 GWh (2,172t CO_2).

Table 1.1 Projected MEPS and BAT savings for Botswana.

	GWh savings (2025)	GWh savings (2030)	MUSD savings (2025)	MUSD savings (2030)	GHG savings (2025)	GHG savings (2030)
DNV GL Projected MEPS						
Lights	261	405	36	91	467	724
Aircon	4	14	1	3	8	25
Refrigeration	41	119	6	27	73	212
Motors	25	75	4	18	44	134
Transformers	39	71	6	17	70	126
Total	**370**	**683**	**52**	**156**	**662**	**1 220**
DNV GL Projected BAT						
Lights	462	721	64	162	825	1 288
Aircon	9	32	1	8	15	58
Refrigeration	57	150	8	34	101	268
Motors	38	166	6	40	68	297
Transformers	61	146	9	35	109	261
Total	**626**	**1 216**	**88**	**279**	**1 118**	**2 172**
U4E Targets						
Lights	280	328	18	21	550	644
Aircon	29	53	2	3	58	103
Refrigeration	13	27	1	2	25	53
Motors	32	69	2	5	63	136
Transformers	57	118	4	8	102	211
Total	**411**	**594**	**27**	**39**	**798**	**1 147**

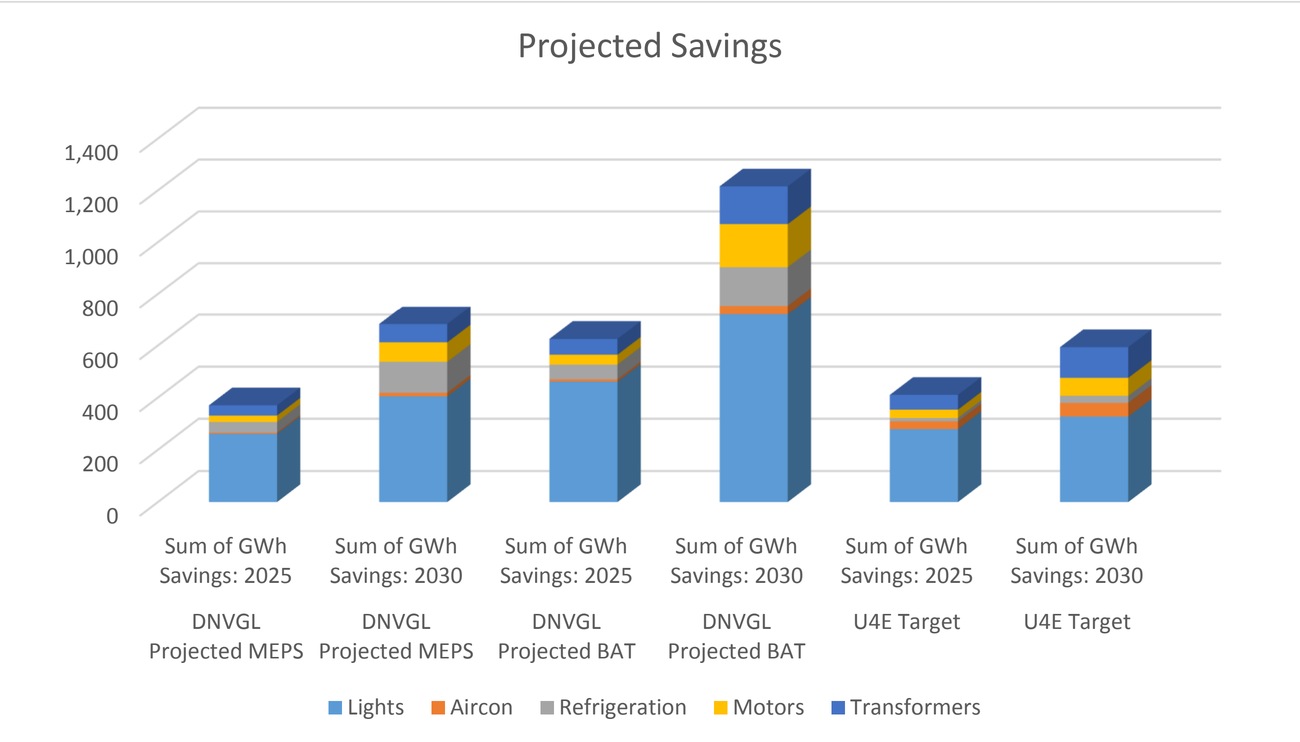

Figure 1-1: Projected Savings

2 INTRODUCTION

2.1 General Information about Botswana

The Republic of Botswana is a large, landlocked plateau in the centre of Southern Africa. South Africa borders it to the south and southeast, Namibia to the north and west, and Zimbabwe to the northeast [1].

Size (km^2)	581,730
Population (Est, 2017)[1]	2,345,801

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

Botswana is a member of the United Nations, the Commonwealth of Nations and the Southern African Development Community (SADC) [2] [3]. 18.24% of the population subsists on less than US$1.90 a day[2] (the international poverty line), based on 2009 statistics. In 2016, the World Bank classified Botswana as an "upper middle income" country because the annual gross national income (GNI) per capita level is USD 4,126 to USD 12,735 [4] [5] [6].

2.2 Climate and Topography

Botswana lies across the Tropic of Capricorn. The climate ranges from semi-arid through subtropical to temperate. Eastern Botswana is temperate, with enough rainfall to support arable farming, but rainfall decreases and temperature range increases westwards and southwards. Summer (October–April) is the rainy season and is very hot.

The rainy season occurs with significant annual variation, with frequent periods of severe drought. Annual rainfall is erratic, ranging from 250 mm in the south west to over 600mm in the north east. Winters are dry, with temperatures dropping to an extreme of about minus 7 °C, often nearer zero, with July being the coldest month. Summer months can be very hot, although mean temperatures seldom rise above 39 °C. [7]

The country is relatively flat to gently undulating tableland, at roughly 900 metres above sea level, with occasional rocky outcrops. The Kalahari Desert (in the central and the southwest) occupies more than 70 % of the country, with valleys and pans etched across the landscape. The eastern part of Botswana contains the highest (1,500 metres) and the lowest (500 metres) points of elevation, with hills and deep valleys, whereas the flat vast western portion of the country is semi-arid with rocky outcrops. One of Southern Africa's longest rivers, the Okavango, flows into the north-western part of the country, forming the UNESCO World Heritage Site Okavango Delta. Botswana shares borders with South Africa, Namibia, Zambia and Zimbabwe. The country is divided into four drainage regions, which are sometimes indistinct due to the arid nature of the climate. Except for the Chobe, Okavango, Boteti and Limpopo rivers, most of Botswana's rivers cease to flow during the dry and early rainy seasons.

2.3 Electricity Sector

Botswana's energy capacity is thermal, mainly coal-fired, with some small diesel generators in rural areas. The bulk of domestic electricity production is generated by the Morupule coal-fired station; 20% is from thermal while only 0,1% was from solar energy in 2016. Botswana has no hydro-electric power resources. A small Independent Power Producer/IPP (Bemco) supplies the town of Ghanzi in Western Botswana. Botswana imports up to an additional 150 MW of capacity from South Africa, and also has import agreements with power utilities in Mozambique, Zambia and Namibia. Solutions being implemented and/or reviewed to address the dependence on imports include building new generation, transmission and distribution infrastructure, including the construction of a transmission line between Botswana and South Africa (BoSA), refurbishing existing infrastructure, procuring additional power through IPP's and putting energy frameworks and policies in place to promote investment. The 2010 version of the Draft Energy Policy targeted having biodiesel contributing 10% to energy mix by 2020 and for 25% peak electricity demand from renewable energy by 2030 [8] [9] [10].

In Botswana, 66% of the population have access to electricity, making it one of only five countries in SSA with electrification rates in excess of 50% in rural areas. The country's Rural Electrification Collective Scheme (RECS), which includes the roll-out of some renewable energy, has played a significant role in increasing electricity access.

Botswana is a member of the Southern African Power Pool (SAPP), which began in 1996 as the first formal international power pool in Africa, with a mission to provide reliable and economical electricity supply to consumers in SAPP member countries. Botswana also joined the International Renewable Energy Agency (IRENA), a global initiative to promote and reduce barriers to the uptake of renewable energy.

Table 2.1 indicates the presence of energy efficiency and demand-side management (DSM) activities in Botswana

Table 2.1 Energy Efficiency and Demand-Side Management (DSM) Activities[1] in Botswana [12]

Programme type	CFL exchange	Energy-saving awareness	Demand market participation	Time-of-use tariff	Hot water load control	Solar water heating	Energy efficiency in buildings	Energy efficiency audits	Prepaid meters	General rehabilitation	Transmission line upgrade	Power factor correction	Distribution loss reduction	Standards and product labelling
Botswana	X					X	X							

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

[1] 'X' indicates the presence of the listed policy type in the country.

Table 2.2 below provides a summary of energy efficiency targets by type of programme. Because most targets are qualitative rather than quantitative, the table is effectively an indication of whether a policy target has been, or soon will be, implemented.

Table 2.2 Botswana's national energy efficiency targeted programmes [13]

Target type	Lighting retrofit	Reduce electricity distribution losses	Improved cooking devices	Load management	Standards and Labelling	Financing	Revised building codes
Botswana	X	X	X	X		X	X

Table 2.3 below indicates Botswana's targeted GWh savings per product type by 2030 as identified and proposed by United4Efficiency (U4E), assuming a successful implementation of the various energy efficiency strategies.

Table 2.3 Botswana's targets for energy savings [14]

U4E Pathway to Energy Efficiency	Targeted Annual GWh savings by 2030				
	Lighting	Residential refrigerators	Room air conditioners	Industrial electric motors	Transformers
Botswana	327.5	26.7	52.5	69.1	118.1

(Extracted from the U4E Country Assessment, December 2016)

2.4 Power Industry Regulation and Policies

An overview of the Power Sector Regulatory environment in Botswana is set out below in Figure 2-1.

Organizations responsible for energy policies	• Ministry of Minerals, Energy and Water Resources (MMEWR) • Ministry of the Environment, Wildlife and Tourism (MEWT)
Energy regulator	• The Botswana Energy and Water Regulatory Agency (BEWRA)
Energy policy publications	• Electricity Supply Act of 1973 (amended 2007) • Botswana Power Corporation Act, 1970 • The National Development Vision 2016 • Draft Botswana National Energy Policy (2015) • Botswana Energy Master Plan (1996, reviewed 2003) • Biomass Energy Strategy, REFIT (2010, under review)
Main entities in the electricity market	• Botswana Power Corporation (BPC)

Figure 2-1 Botswana's power sector regulatory environment.

The regulatory framework for electricity generation in Botswana is set out in the Electricity Supply Act, with the Ministry of Minerals, Energy and Water Resources (MMEWR) responsible for the regulation of electricity generation and distribution. MMEWR, through the Energy Affairs Division, is also responsible for the formulation, direction and coordination of the national energy policy, and monitors BPC.

Botswana's Energy Master Plan was developed in 1985 and reviewed in 1996 and 2004. In December 2007, the Government of Botswana amended the Electricity Supply Act to allow for Independent Power Producers (IPPs). The establishment of an independent electricity and water regulatory authority in Botswana is currently under consideration by the Government. In 2012 the Botswana Energy and Water Regulator (BEWR) Taskforce was set up to establish a regulatory framework for the energy and water sectors. In 2016, an energy regulatory authority bill was passed that will assist in providing an efficient regulatory framework for the energy sector. A Regional Electricity Regulators Association (RERA) has also been established to coordinate and harmonize regulation in the energy sector.

The Government of Botswana has implemented several strategies to advance the use of renewable energy in Botswana. In 2010, Botswana introduced a Renewable Energy Feed-In Tariff (REFIT) for biomass, biogas landfill gas-based generation and solar PV and Concentrated Solar Production (CSP) ranging from 5kW to 5MW. The Renewable Energy Based Rural Electrification Programme for Botswana (RE Botswana) is a major programme implemented under an agreement between the Government of Botswana and Global Environment Facility (GEF) managed by United Nations Development Programme (UNDP). In 2009, Botswana's 10th National Development Plan (NDP 10) stated that the strategy for energy conservation and demand management was to "target efficient utilisation of energy in buildings, transport and industry, promotion of energy efficient equipment, and the development of policy and legislation for demand-side management including price as a regulator of demand". By 2013, activities to strengthen regulatory functions were undertaken by developing and revising several policy documents and the development of an Energy Efficiency Programme.

In July 2017, Botswana has secured a 23 million Pula (US$2.3 million) sponsorship from the Italian government in an effort to boost the country's renewable energy sector. This came against the backdrop of a Memorandum of Understanding that was signed in 2015 by the Ministry of Environment of Italy and the Botswana Ministry of Environment, Natural Resources Conservation and Tourism to cooperate in the field of climate change, risk assessment and adaptation. In the area of energy research, the Botswana Technology Centre has signed a cooperation agreement with Regional Research Alliance (RRA), the Scientific and Industrial Research and Development Centre (SIRDC) of Zimbabwe and the Council for Scientific and Industrial Research of South Africa.

Although energy efficiency still has a low profile in Botswana, the Government, through the EAD and BPC, is trying to raise awareness for energy efficiency through leaflets and flyers encouraging consumers to switch off unnecessary loads and encouraging the adoption of efficient compact fluorescent lights. The motivation for energy efficiency derives from the high-energy import bill and the current power deficit in the SADC region [11].

Table 2.4 and

Table **2.5** indicate the range of energy efficiency and renewable energy and support policies in Botswana, as of 2016.

Table 2.4 Energy efficiency support policies initiated by 2016 in Botswana [12]

Policy Type	Industrial commercial load reduction	Residential incentives (lighting, hot water load control)	Support for efficient cooking and heating	Building efficiency guidelines	Solar water heater subsidies	Mandatory energy management for industry and buildings	Reduced distribution losses	Transport efficiency standards	Biofuels production incentives/ tax credits	Voluntary business energy efficiency programmes
Botswana	X	X	X	X	X					

Table 2.5 Renewable energy support policies initiated by 2016 in Botswana [12]

Policy Type	Renewable energy targets	Feed-in tariff / premium payment	Electric utility quota obligation	Net metering / net billing	Transport obligation / mandate	Heat obligation / mandate	Trading REC	Tendering
Botswana	○							

Note: ○ = existing national (could also include subnational).

Table 2.6 Renewable fiscal incentives & public financing initiated by 2016 in Botswana [11]

Policy Type	Capital subsidy, grant, or rebates	Investment or production tax credits	Reductions in sales, energy, vat or other taxes	Energy production payment	Public investment, loans or grants
Botswana	□		□		

Note: □ = existing national (could also include subnational indicates the presence of the listed policy type in the country).

2.5 Key Challenges and Recommendations

Key challenges in the energy sector include:

- Botswana does not have adequate power supply to meet growing demand;
- Expected access rates and the tariffs charged for electricity are not fully cost reflective, therefore BPC cannot reinvest as they should in the infrastructure, and;
- Existing legal / policy structures may not be particularly conducive to the implementation of renewable energy (RE);
- High technical losses, typically due to poor maintenance or to inefficient or undersized power transmission infrastructure.
- Botswana also suffers from high non-technical losses (which include electricity theft from illegal connection, vandalism of electrical equipment and maintenance backlog) which contributes to continued system instability and load shedding. [13]

SACREE is the SADC Centre for Renewable Energy and Energy Efficiency and works towards addressing SADC country challenges with respect to renewable energy and energy efficiency. Funding is available to the SADC countries for energy efficiency.

Table 2.7 Energy efficiency opportunities and recommendations for South Africa.

	OPPORTUNITIES	RECOMMENDATION
Policies	Processes and procedures to enforce and prioritize energy efficiency requirements should be put in place.	• As per Table 2.1 above, policies for standards and product labelling should be implemented. • As per Table 2.4 above, voluntary business energy efficiency programmes may be considered.
Economic and financial	Some funding is already available regionally for energy efficiency. These may need to be supplemented by providing affordable financing for energy efficiency investment and/or by leveraging funding from public (government and development partners) and private stakeholders. There may be limited exposure of local Financial Institutions to RE/EE investment projects and limited experience on special purpose soft loans for RE/EE projects for SMEs and low-income sections of the population.	• Clarify if any funding is currently used for EE. • Determine what barriers exist preventing use of available funding. • Harmonize donor support by source for affordable financing for energy efficiency investment. • Develop guarantee funds to cover for deflationary risk.
Informational	Limited information and knowledge about the benefits of energy efficiency. Expertise on energy efficiency opportunities and benefits assessments is currently inadequate.	• Provide funding to promote energy-saving awareness. • Provide funding to strengthen local capacities and to support RE/EE entrepreneurship.

Note: Recommendations should be considered <u>after</u> checking with SACREE to confirm if any new initiatives have started.

2.6 Modelling & Savings Projections

For a simple savings calculation, each of the technologies have been grouped into three categories:

1. Substandard efficient units (low efficiencies, old technologies, etc.)
2. Standard efficiencies that comply with or fall within industry accepted Minimum Energy Performance Standards (MEPS).
3. Best available technologies (BAT).

All Scenarios

For all the scenarios, an average increase in the electrification of the specific country per year was used. These are long-term averages for the specific countries as provided by the electric utilities and conservative interpretation of this data was used by DNV GL.

Increases of the quantities of units were used in direct correlation with the increase in electrification. Increases and decreases in adoption rates were taken from the country visits, averaged and rounded.

BAU

The "Business as Usual" case assumes that the current adoption rate of energy efficient technologies continues the same trend due to the normal rate of rising costs of electricity and increased public awareness.

The information gathered during the country visits indicated an adoption of efficient technologies (MEPS and BAT) reducing less efficient products (below MEPS) by specific percentage of the current market share by 2025 and 2030.

MEPS

If "Minimum Energy Performance Standards" are to be implemented by means of regulations or incentives, an increased adoption of both the MEPS and BATS will take place. Current stock in the market is assumed to be sold, but no new stock of lower standard technologies will be allowed into the market. Currently, installed units are expected to last their normal operating lifetime, after which they will be replaced with MEPS or BAT.

BAT

"Best Available Technology" implementation assumes that all implementation of new lighting is driven towards BAT standards while allowing MEPS and disallowing new sub-MEPS installation and sales.

Results

The information gathered during the country visits included the expected adoption of efficient technologies (MEPS & BAT) reducing less efficient products (below MEPS) by specific percentages of the current market share by 2025 and 2030. The resultant quantity of lights and market shares are shown in the following sections.

3 LIGHTING

Figure 3-1 shows that of the roughly 4.5 million lighting units in Botswana, most are fluorescent or compact fluorescent. A survey conducted by UNEP indicated a high penetration of CFLs within households, while linear fluorescent tubes are prevalent in industrial and commercial sectors.

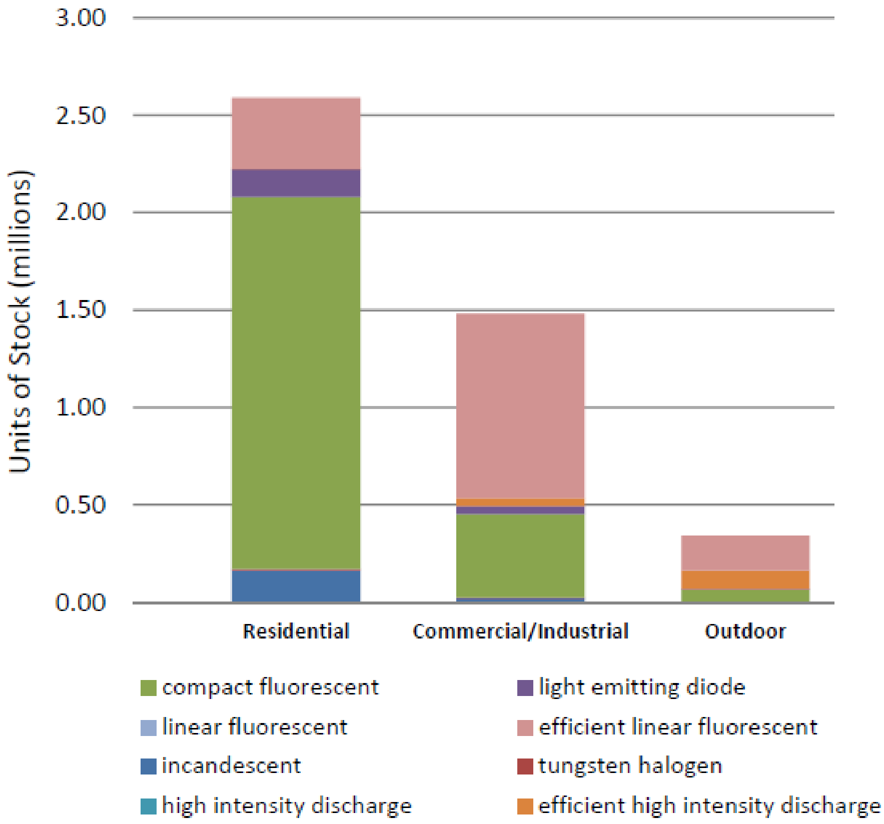

Figure 3-1 Units of lighting stock within Botswana [13].

3.1 Status and Trends of Lighting Products

3.1.1 Market Drivers

Lights have a relatively short life expectancy compared to other electrical equipment considered in this study.

Average Rated Lifetime Hours					
	INCANDESCENT	FLUORESCENT	CFL	HALOGEN	LED
TYPICAL RANGE (HOURS)	750-2,000	24,000-36,000	8,000-20,000	2,000-4,000	35,000-50,000

Figure 3-2 Life Expectancy of Lights [14].

Short life expectancies lead to high replacement frequencies which are opportunities for rapid change to newer, more efficient technologies within lighting. The small size of individual units, adoption of new technologies and the sheer volume of sales continually drive down the costs of both old and new types of lights.

Offices, factories and other operations that require light during daytime (Mon – Fri, 07h00 – 19h00) would have lights on for roughly 3000 hours per annum. In Botswana, residential lights are often on for 4 hours in the evening and two hours in the morning all year around, totaling 2190 hours per annum.

The report published in 2014 from U4E and for the SADC countries also presents the average lamp wattage for various technologies. The values differ for different types of users, as well, regarding the locations. As an example, Incandescent lamps, which are the most energy consuming, can be found in the range of 45-100W depending on whether they are for residential, professional or outdoor use. On the other hand, efficient LED lights can be found in the range of 5-25W depending on the type of the lamp.

3.1.2 Local manufacturers, suppliers, retailers and other stakeholders

Lighting products are mostly purchased by households and small businesses from retail outlets, including Shoprite, General Supermarkets, Game, and OK Furniture. Online purchases are negligible in volume. Most popular brands include Phillips, OSRAM and EUROlux. Feedback from the survey indicates that 60% of the products represent unknown brands while 40% are from established brands.

3.1.3 Import/Export

Most household appliances in the SADC region are either manufactured in, or distributed by, South African companies. Although the South African presence in this market has been mitigated somewhat by increasingly aggressive importing of cheaper appliances from China, there is a tendency to enforce the South African standards of labelling for importers and exporters.

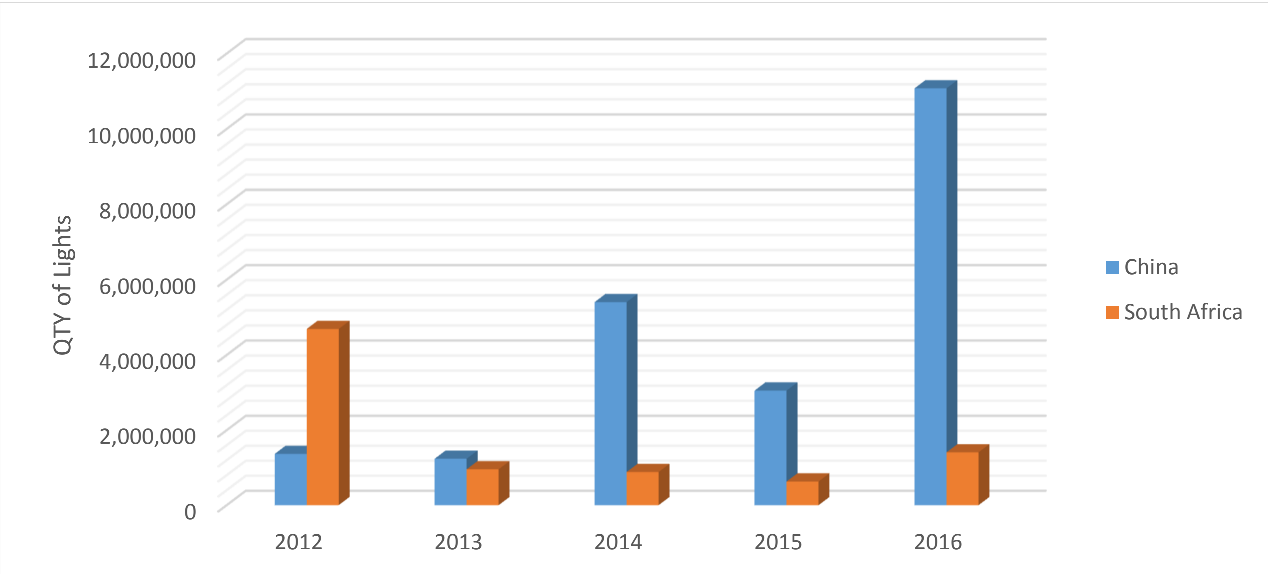

Figure 3-3 Botswana annual light unit imports during 2012 to 2016 [15].

Figure 3-3 presents a summary of imports to Botswana for the years 2012-2016. There is a clear indication of an increase of lighting imported from China (71% total from 2012 – 2016), as compared to South Africa (28% total from 2012-2017).

3.1.4 Barriers to overcome

Electricity is perceived to be expensive, even though Botswana has some of the lowest tariffs in Africa. Availability of power lines (and general access to electricity) is valued over energy efficiency. This is amplified by the lack of funding, resulting in the purchase of cheapest options, rather than efficient items. Lastly, a general perception of poor quality products in the market discourage consumers changing from current, trusted technologies to newer technologies.

3.1.5 New vs. Used Equipment

Lights are mostly replaced on burn-out and with life expectancies of around 2 years on average. There is practically no market for used equipment. One scenario where lights are re-used is when lights are replaced for energy savings reasons and the old lights are donated to organizations that rely on public funding or charities such as hospitals, schools or libraries.

3.2 Potential Savings from Energy-Efficient Lighting

Modelling of the different scenarios has been explained in Section 2.

For a simple savings calculation, lights have been grouped into three categories:

- All lights except Fluorescent (FL), Compact Fluorescent (CFL) & LEDs
- Fluorescent (FL) & Compact Fluorescent (CFL)
- LEDs.

3.2.1 Benefits of Energy Efficiency – 3 Scenarios

Table 3.1 BAU, MEPS, BAT scenarios for lighting.

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
Business as Usual	QTY Halo, Inc etc.	2 573 411	3 344 405	-10%	5 795 430	-20%	8 926 884
Business as Usual	QTY CFL & FL	1 517 815	1 972 552	14%	4 335 627	13%	9 454 013
Business as Usual	QTY LED	424 774	552 036	10%	1 169 188	50%	3 376 757
DNV GL Projected MEPS	QTY Halo, Inc etc.	2 573 411	3 344 405	-50%	3 219 683	-20%	4 959 380
DNV GL Projected MEPS	QTY CFL & FL	1 517 815	1 972 552	79%	6 805 083	0%	13 114 537
DNV GL Projected MEPS	QTY LED	424 774	552 036	20%	1 275 478	50%	3 683 736
DNV GL Projected BAT	QTY Halo, Inc etc.	2 573 411	3 344 405	-80%	1 287 873	-20%	1 983 752
DNV GL Projected BAT	QTY CFL & FL	1 517 815	1 972 552	122%	8 418 023	-6%	15 169 230
DNV GL Projected BAT	QTY LED	424 774	552 036	50%	1 594 347	50%	4 604 668

Data & Assumptions:

- *Exchange Rate: 1 Pula = 1.35 ZAR = 0.1 USD.*

- *Average marginal[2] Residential Electricity Tariff: 0.065 USD/kWh*
- *Average marginal Industrial Electricity Tariff: 0.070 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *Operating hours: 2 hr in morning (6-8am) and 4hr in the evening (6-10pm), 365 days per annum.*

Assuming these adoption rates are accurate, the following savings (Table 3.2) are projected to be achieved under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 3.2 Projected savings for lighting under MEPS And BAT scenarios.

	Sum of GWh Savings (2025)	Sum of GWh Savings (2030)	Sum of Million USD Savings (2025)	Sum of Million USD Savings (2030)	Sum of GHG Savings (2025)	Sum of GHG Savings (2030)
DNV GL Projected MEPS	261	405	36	91	467	724
DNV GL Projected BAT	462	721	64	162	825	1 288
U4E Targets	280	328	18	21	550	644

3.2.2 Job creation or elimination from energy efficient products

Lighting surveys, retrofitting, supplying (importing, exporting, distribution) and the energy efficiency industry in general will benefit from and drives related promotion of energy efficient lighting technologies.

3.3 **Status of Policies and Initiatives**

Botswana Power Corporation's (BPC) energy efficiency in households' initiative has achieved 30 MW savings through its 1 million CFL's project. Phasing out the import and commercialisation of incandescent light bulbs resulted in further savings and increased uptake in energy efficient technologies.

The utility is looking at several ways to sustain CFL uptake by lobbying for removal of VAT on CFLs. The bulk of the CFLs that are currently being used are produced in Lesotho under a SAPP utilities initiative that agreed on set CFL standards.

3.3.1 Standards and regulations

A list of Botswana's lighting standards/regulations are shown below [16].

- BOS IEC 60598-1: 2003 ed. 6 Luminaires - Part 1: General requirements and tests Edition: 6.0
- BOS IEC 60598-2-1: 1979 ed. 1 Luminaires – Part 2: Particular requirement – Section One – Fixed general-purpose luminaries
- BOS IEC 60598-2-2: 2002 ed. 2 Luminaires – Part 2: Particular requirement –Section 2: recessed luminaires
- BOS IEC 60598-2-3: 2002 ed. 3 Luminaires – Part 2-3: Particular requirement – Luminaires for road and street lighting
- BOS IEC 60598-2-4: 1997 ed. 2 Luminaires – Part 2: Particular requirements – Section 4: Portable general-purpose luminaires
- BOS IEC 60598-2-5: 1997 ed. 2 Luminaires – Part 2-5: Particular requirements – Floodlights
- BOS IEC 60598-2-6: 1994 ed. 1 Luminaires – Part 2: Particular requirements – Section 6: Luminaires with built-in transformers for filament lamps

[2] Marginal rates are incremental average charges excluding fixed charges; the latter would not be affected by reduced usage and/or peak

- BOS IEC 60598-2-7:1982 ed. 1 Luminaires – Part 2: Particular requirements – Section Seven – Portable luminaires for garden use
- BOS IEC 60598-2-8: ed. 2 Luminaires – Part 2-8: Particular requirements – Handlamps
- BOS IEC 60598-2-9: 1987 ed. 2 Luminaires – Part 2: Particular requirements – Section Nine – Photo and film luminaires (non-professional)

3.3.2 Supporting Policies – Labelling and consumer awareness campaigns

Awareness of the impacts of energy efficient lighting is driven by the BPC (Botswana Power Corporation). Their website has a page that describes the savings potential [17] as well as a brochure that promotes the use of CFL lighting [18].

Figure 3-4 BPC website page extract on savings potential and CFL promotion [17] [18].

3.3.3 Financial Mechanisms

Even though the BPC distributed several CFLs for free, there are no mechanisms that provide access to financing for the implementation of energy efficient lighting.

3.3.4 Monitoring, Verification and Enforcement

Other than the standard port authorities that check the compliance to import and export regulations, very little is done to verify or enforce the adoption of energy efficient lighting.

3.3.5 Environmentally Sound Management

Botswana is bound by the SADC Protocol on Energy 1996, which states that: "Energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications".

3.3.6 Other on-going projects/initiatives

No ongoing initiatives are currently in place.

4 AIR-CONDITIONING

Air conditioning of homes in Botswana is negligible, as it is almost exclusively used in commercial buildings (offices and shops). There is a variety of types of air conditioning systems used in buildings, with room air conditioning being the most dominant. Room air conditioners can be segmented into window air conditioners, portable air conditioners and at least 3 sub-categories of split systems per cooling capacity (e.g. 9’000 btu/h, 12’000 btu/h and 18’000 btu/h).

It is estimated that air conditioning accounts for up to 70% of the electrical load of office buildings, with commercial buildings and hotels having a similar profile. This implies that significant gains can be made by improving the efficiency of air conditioners and possibly controlling their loads. Commercial load contributes a large part of the daytime national peak.

4.1 Status and Trends of Air-conditioning Products

4.1.1 Market Drivers

General industry trends have seen replacement cycles of typically around 10 years for outdoor units exposed to elements such as sun and rain, while well-maintained indoor units can last 15 or even up to 20 years.

4.1.2 Purchase of air-conditioning products, including source and availability of energy efficient products

Air-conditioning units are generally not “of-the-shelf” items, as these are typically supplied and installed by a solution or service provider. Most of these service providers will partner with one or a few brands and act as local distributors and installers. A wide variety of brands provide almost all sizes and performance ratios available.

MEPS require all air-conditioning units to be at least Class B. However, the bulk of units available in Botswana are Class A or better, mostly since roughly 70% is supplied from South Africa.

4.1.3 Local manufacturers, suppliers, retailers and other stakeholders

No local manufacturing of air-conditioning units take place in Botswana. Stakeholders include importers, distributors and installers, most of which are part of the building industry.

4.1.4 Import/Export

Most household appliances in the SADC region are either manufactured in or distributed by, South African companies. Although the South African presence in this market has been mitigated somewhat by aggressive importing of cheaper appliances from China (25% of market share between 2012 – 2015), there is a tendency to enforce the South African standards of labelling for importers and exporters.

4.1.5 Barriers to overcome

Lack of proper maintenance often results in early system failure or significant decreases in efficiency. The perception that the cost of services outweighs the benefits, which often results in little to no regular maintenance on air-conditioning units.

4.1.6 New vs. Used Equipment

Information gathered from observing local trends suggests that air-conditioning units are typically installed in a fixed location and not removed or resold as second hand.

4.2 Potential Savings from Energy-Efficient Air-conditioning

Modelling of the different scenarios has been explained in Section 2.

For a simple savings calculation, units have been grouped into three categories:

- Below Class B
- Class B - A
- Class A+ and better.

4.2.1 Benefits of Energy Efficiency – 3 Scenarios

Table 4.1 BAU, MEPS, BAT scenarios for air-conditioning.

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
Business as Usual	Lower than Class B	28 332	36 820	-6%	66 640	-7%	119 328
Business as Usual	Class B - Class A	22 036	28 638	4%	57 188	2%	111 952
Business as Usual	Class A+ & Above	12 592	16 365	7%	33 715	11%	72 056
DNV GL Projected MEPS	Lower than Class B	28 332	36 820	-28%	51 044	-19%	79 607
DNV GL Projected MEPS	Class B - Class A	22 036	28 638	24%	68 374	1%	132 704
DNV GL Projected MEPS	Class A+ & Above	12 592	16 365	21%	38 126	24%	91 026
DNV GL Projected BAT	Lower than Class B	28 332	36 820	-35%	46 081	-33%	59 446
DNV GL Projected BAT	Class B - Class A	22 036	28 638	14%	62 938	-14%	104 682
DNV GL Projected BAT	Class A+ & Above	12 592	16 365	54%	48 524	49%	139 209

Data & Assumptions:

- *Exchange Rate: 1 Pula = 1.35 ZAR = 0.1 USD.*
- *Average marginal Residential Electricity Tariff: 0.065 USD/kWh.*
- *Average marginal Industrial Electricity Tariff: 0.070 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *Operating hours: Operating hours: 8 hours per day x 125 days per annum = 1 000 hours*
- *Average cooling capacity: 3.5kW.*

Assuming these adoption rates are accurate, the following savings (Table 4.2) are projected to be achievable under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 4.2 Projected savings for lighting under MEPS And BAT scenarios.

	Sum of GWh Savings (2025)	Sum of GWh Savings (2030)	Sum of Million USD Savings (2025)	Sum of Million USD Savings (2030)	Sum of GHG Savings (2025)	Sum of GHG Savings (2030)
DNV GL Projected MEPS	4	14	1	3	8	25
DNV GL Projected BAT	9	32	1	8	15	58
U4E Targets	29	53	2	3	58	103

4.2.2 Job creation or elimination from energy efficient products.

No direct impact on the Botswana market is projected, as the bulk of units are imported. Jobs may include AC technicians, installation and repair, trading, and supply.

4.3 Status of Policies and Initiatives

4.3.1 Standards and regulations

BOBS catalogue explicitly states that there are no current regulations regarding air-conditioning units [19].

4.3.2 Supporting Policies – Labelling and consumer awareness campaigns

No policies or awareness campaigns are in place, likely due to the low number of units in the market.

4.3.3 Financial Mechanisms

No financial mechanisms are available to consumers, manufacturers or importers to drive the adoption of energy efficient models.

4.3.4 Monitoring, Verification and Enforcement

Due to the lack of standards, no monitoring, verification or enforcement can take place.

4.3.5 Environmentally Sound Management

Botswana is bound by the SADC Protocol on Energy 1996, which states that: "Energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications".

4.3.6 Other on-going projects/initiatives

There are no current projects or initiatives to drive the adoption of energy efficient air-conditioning units instead of standard efficiency units.

5 REFRIGERATORS

An estimation of the percentage of households with a refrigerator in the home is 12%, with mostly 1 unit per house [8.7].

5.1 Status and Trends of Refrigeration Products

5.1.1 Markets and Drivers

General indication of the average life expectancy for a properly maintained refrigerator is between 14 and 17 years depending on the model and size. Compact refrigerators typically run for 14 years on average, while a standard refrigerator will run up to 17 years. The life expectancy of refrigerators is affected by how well it is maintained and its construction. Some models may last only about 10 years, while others may run for up to 19 years [20].

5.1.2 Purchase of refrigeration products, including where and availability of energy efficient products

Refrigerators are typically sold at furniture or white good stores, with some by large retailers. Most refrigerators have standard energy efficiency labels displayed on the outside front, with a variety of efficiencies available at all the stores, ranging from MEPS (Class B) to BAT (Class A+++).

5.1.3 Local manufacturers, suppliers, retailers and other stakeholders

No local manufacturing of refrigerators takes place in Botswana.

5.1.4 Import/Export

Most household appliances in the SADC region are either manufactured in, or distributed by, South African companies. Although the South African presence in this market has been mitigated somewhat by aggressive importing of cheaper appliances from China, there is a tendency to enforce the South African standards of labelling for importers and exporters.

5.1.5 Barriers to overcome

High costs of energy efficient units drive consumers to purchase lower quality, entry level units at the expense of efficiency.

5.1.6 New vs. Used

Refrigerators are very seldom repaired in Botswana after their warranty period. Some very small refrigerator repair industries can be found in low-income areas, but accurate data is not available.

5.2 Potential Savings from Energy-Efficient Refrigeration Products

Modelling of the different scenarios has been explained in Section 2.

For a simple savings calculation, units have been grouped into three categories:

- Below Class B
- Class B - A
- Class A+ and better.

5.2.1 Benefits of Energy Efficiency – 3 Scenarios

Table 5.1 BAU, MEPS, BAT scenarios for refrigerators.

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
Business as Usual	Lower than Class B	250 164	325 113	-5%	594 678	-7%	1 064 852
Business as Usual	Class B - Class A	89 611	116 458	9%	243 757	10%	518 107
Business as Usual	Class A+ & Above	33 604	43 672	14%	95 859	17%	215 945
DNV GL Projected MEPS	Lower than Class B	250 164	325 113	-52%	300 469	-61%	225 626
DNV GL Projected MEPS	Class B - Class A	89 611	116 458	128%	511 898	27%	1 249 309
DNV GL Projected MEPS	Class A+ & Above	33 604	43 672	45%	121 926	38%	323 966
DNV GL Projected BAT	Lower than Class B	250 164	325 113	-69%	194 053	-80%	74 726
DNV GL Projected BAT	Class B - Class A	89 611	116 458	165%	593 088	6%	1 205 684
DNV GL Projected BAT	Class A+ & Above	33 604	43 672	75%	147 152	83%	518 491

Data & Assumptions:

- *Exchange Rate: 1 Pula = 1.35 ZAR = 0.1 USD.*
- *Average marginal Residential Electricity Tariff: 0.065 USD/kWh.*
- *Average marginal Industrial Electricity Tariff: 0.070 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*

Assuming these adoption rates are accurate, the following savings (Table 5.2) are projected to be achievable under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 5.2 Projected savings for lighting under MEPS And BAT scenarios.

Row Labels	Sum of GWh Savings (2025)	Sum of GWh Savings (2030)	Sum of Million USD Savings (2025)	Sum of Million USD Savings (2030)	Sum of GHG Savings (2025)	Sum of GHG Savings (2030)
DNV GL Projected MEPS	41	119	6	27	73	212
DNV GL Projected BAT	57	150	8	34	101	268
U4E Targets	13	27	1	2	25	53

5.2.2 Job creation

The adoption of energy efficiency has no specific impact on the local job market, as there are no manufacturing jobs in Botswana. Jobs include technicians, installation and repair, trading, and supply of equipment, primarily related to operation currently.

5.3 **Status of Policies and Initiatives**

5.3.1 Standards and regulations

BOBS catalogue explicitly states that there are no current regulations regarding refrigeration units [20].

5.3.2 Supporting Policies – Labelling and consumer awareness campaigns

No supporting mechanisms were found in Botswana related to refrigerators.

5.3.3 Financial Mechanisms

No financial mechanisms are currently in place to promote the adoption of energy efficient refrigerators.

5.3.4 Monitoring, Verification and Enforcement

Due to the lack of standards, no monitoring, verification or enforcement can take place.

5.3.5 Environmentally Sound Management

Botswana is bound by the SADC Protocol on Energy 1996, which states that: "Energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications".

5.3.6 Other on-going projects/initiatives

There are no ongoing projects or initiatives to drive the improvement of energy efficiency in the refrigerator market.

6 MOTORS

Many factors affect the adoption and efficiency of motors, particularly life expectancy. These factors include input power problems, improper mechanical installations, malfunctions in the load, and environmental factors, among others.

6.1 Status and Trends of Motors

6.1.1 Life Expectancy

If motors are operated under normal conditions, sized correctly for the application and within the manufacturer's design requirements, they can last 15 years or more. [23] Failure of motors can generally be grouped into electrical failure (windings, drives, etc.) and mechanical failure (bearings, mountings etc.). Repair of electrical failures can be done by rewinding the motor. This typically only takes place after a catastrophic failure in the motor's insulation and winding, which usually happens due to a thermal breakdown. Motors are frequently replaced rather than rewound due to costs, convenience and the claim that rewinding may reduce the motor's efficiency [24]. When looking at the mechanical failures, motor bearings or mountings might fail due to improper mechanical installation, causing undesirable forces acting on the bearings and mountings, or simply due to poor maintenance.

A rough guide for when to repair or when to replace is given in Figure 6-1 below (provided by ABB).

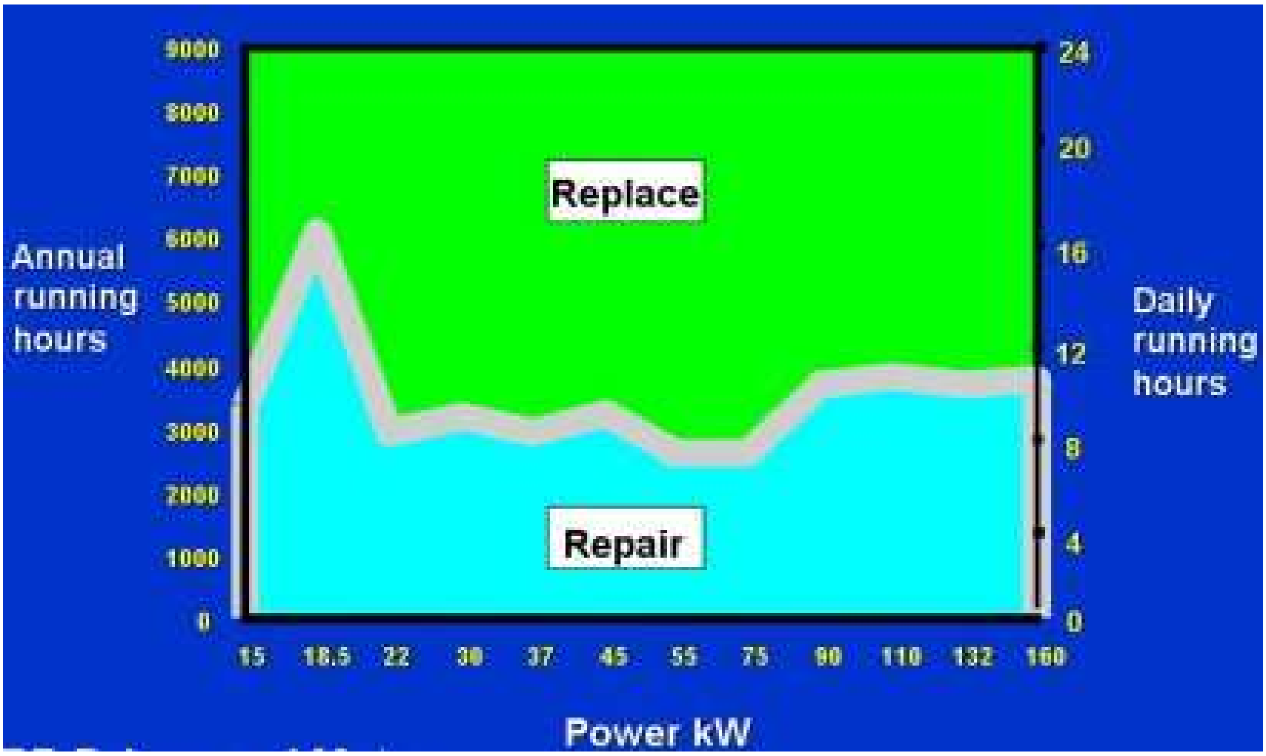

Figure 6-1 Repair or Replace [24].

6.1.2 Price

Motors are categorized as IE1 (least efficient), IE2 (more efficient) and IE3 (most efficient). A list of comparative motor prices is shown in Figure 6-2 below. IE3 motors are typically between 15 – 20% more expensive than their IE1 counterparts. Even though the operating costs of a typically motor is roughly 50% of the annual overall cost, additional costs are one of the biggest market barriers in countries where initial capital plays a major factor.

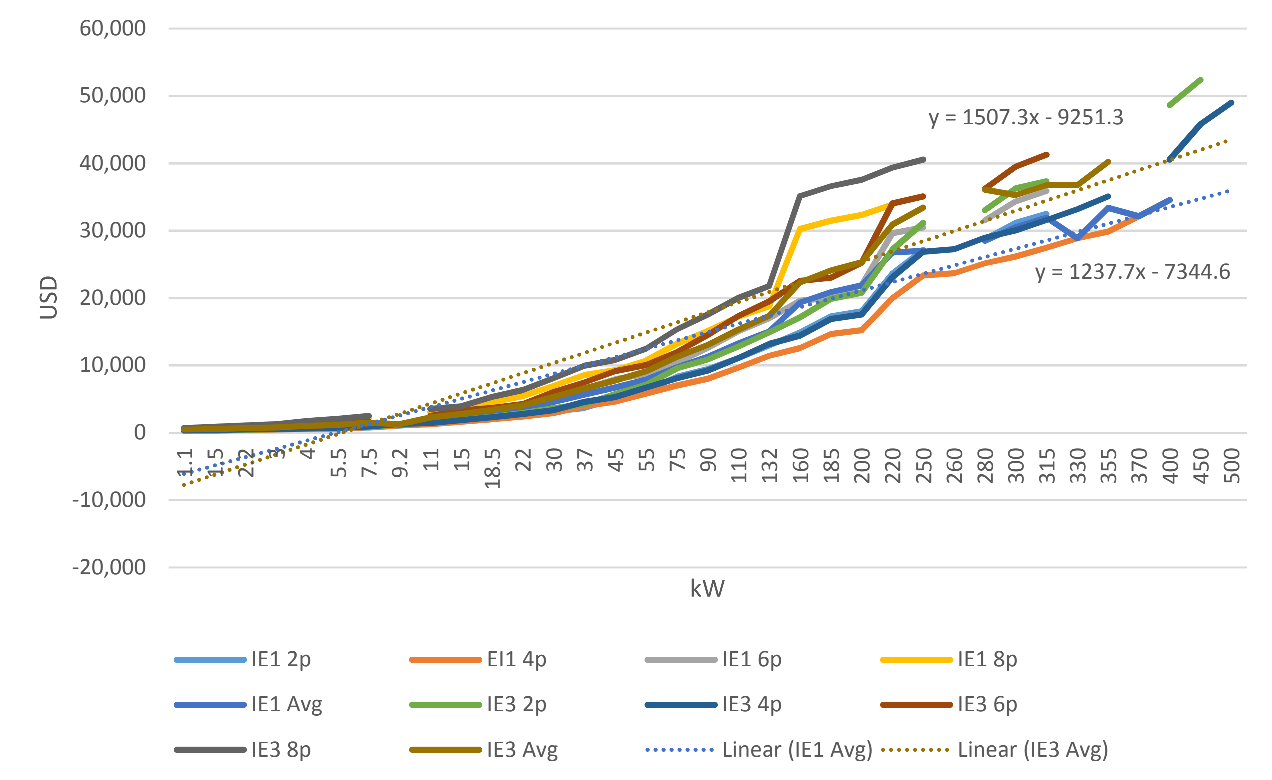

Figure 6-2 Motor pricing versus size.

6.1.3 Purchase of motors, including where and availability of energy efficient products

Electrical motors are generally available from a wide variety of distributors and installers and include anything from old rewound motors to new premium efficiency motors.

Motors are not “off the shelf” items and are usually sold as part of a project, machine or installation. Therefore, the end user is often not in direct contact with the motor manufacturer or supplier during new installations. The motors are typically procured by a “project company” or solution provider selling the motor as part of a solution to the end user. The project companies are likely to provide “back to back” guarantees as provided by the motor manufacturers and are likely to administrate the service, repair and replacement of these motors on behalf of the client.

After the initial maintenance period provided by the motor supplier/installer, the client would typically take ownership of maintenance of the motor and might deal directly with the OEM suppliers or other local service companies to maintain the motors.

6.1.4 Local manufacturers, suppliers, retailers and other stakeholders

Due to the small market size of Botswana and the proximity to South Africa, no manufacturing of motors takes place in the country. Some isolated parts of motors are manufactured locally, primarily for very specific types of industries where typical motors do not meet the requirements of the local clients. In some instances, motors are assembled locally per the needs of the local clients. However, this is a negligible amount and for all practical purposes, one can say that all motors are imported.

6.1.5 Import/Export

Botswana is almost exclusively an importer of motors. South Africa is the biggest origin, supplying 56%, while China makes up 41% of motors in the country [25].

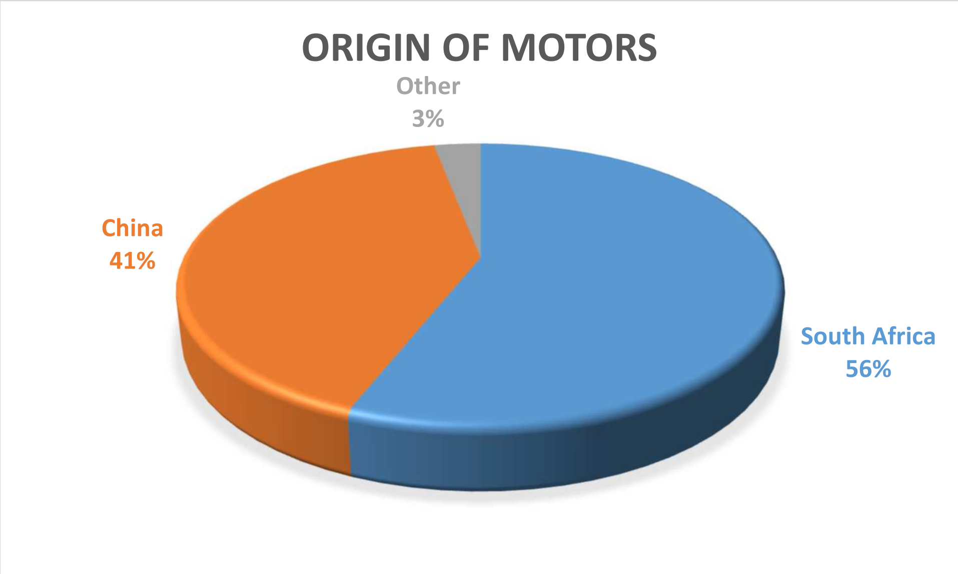

Figure 6-3: Origin of Motors

6.1.6 Barriers to overcome

Overall Inefficient Systems

Due to the low (subsidized) historical price of electricity in Botswana, most industrial and commercial systems and processes (which include electrical motors) were designed for low installation costs which did not necessarily take efficiency into consideration.

Negligible Savings

Apart from the fact that more efficient motors are more expensive, there is a general perception that the savings from high efficiency motors are negligible when added to an overall inefficient system.

Rewinding Perception

The fact that motors can be rewound to perform at the same efficiency reduces the drive to buy new equipment. However, very few rewinders actual perform the rewinding to the same standards, so optimal efficiencies are hardly ever reached.

6.1.7 New vs. Used

Motors are typically used at their point of installation until a failure occurs. In the cases where repair or rewinding takes place, motors are mostly re-installed in their initial position and will continue to be used there until the end of life. Therefore, there is little to no second-hand electrical motor industry.

6.2 **Potential Savings from Energy-Efficient Motors**

Modelling of the different scenarios has been explained in Section 2.

Current minimum energy performance standards (MEPS) in Botswana requires motors to be at least Class IE1. The tables below consider the current scenario (BAU-Business as Usual) as well as the adoption of improved MEPS and best available technologies (BAT) if these were to be driven by policies and regulations.

For a simple savings calculation, motors have been grouped into three categories:

- IE1 and below
- IE3
- IE4 and premium.

6.2.1 Benefits of Energy Efficiency – 3 Scenarios

Table 6.1 BAU, MEPS, BAT scenarios for motors.

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
Business as Usual	Class IE1 & below	143 550	186 558	-5%	341 241	-7%	611 038
Business as Usual	Class IE3	111 650	145 100	2%	284 566	1%	554 063
Business as Usual	Class IE4	63 800	82 914	8%	172 415	12%	371 807
DNV GL Projected MEPS	Class IE1 & below	143 550	186 558	-11%	319 689	-13%	535 514
DNV GL Projected MEPS	Class IE3	111 650	145 100	7%	298 136	9%	626 267
DNV GL Projected MEPS	Class IE4	63 800	82 914	13%	180 398	8%	375 128
DNV GL Projected BAT	Class IE1 & below	143 550	186 558	-13%	312 505	-20%	481 361
DNV GL Projected BAT	Class IE3	111 650	145 100	4%	290 952	6%	594 292
DNV GL Projected BAT	Class IE4	63 800	82 914	22%	194 765	23%	461 254

Data & Assumptions:

- *Exchange Rate: 1 Pula = 1.35 ZAR = 0.1 USD*
- *Current Average Marginal Electricity Price to consumer: 0.065 USD/kWh*
- *Electricity Cost Increase: 14% per annum*
- *Average Motor Size: 10kW (Source: ESKOM DSM Energy Efficient Motor Program)*
- *Average Operating Hours: 8 hours per day, 5 days per week, 50 weeks per annum.*
- *QTY and adoption of new technologies based on information from stakeholder interviews (BPC, Rewinders & others).*

Assuming these adoption rates are accurate, the following savings (Table 6.2) are projected to be achieved under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 6.2 Projected savings for motors under MEPS And BAT scenarios.

	Sum of GWh Savings (2025)	Sum of GWh Savings (2030)	Sum of Million USD Savings (2025)	Sum of Million USD Savings (2030)	Sum of GHG Savings (2025)	Sum of GHG Savings (2030)
DNV GL Projected MEPS	25	75	4	18	44	134
DNV GL Projected BAT	38	166	6	40	68	297
U4E Targets	32	69	2	5	63	136

6.2.2 Job creation/elimination from energy efficient products

Strict implementation of high EE standards might result in a reduced amount of motors being rewound. This will have a negative impact on the local motor rewinding industry, although that industry is considered small. In contrast, this will drive the import of new, high-efficiency motors, which, in turn, will result in jobs in the distribution and sales sectors.

6.3 Status of Policies and Initiatives

6.3.1 Standards and regulations

No standards or regulations were found for motors in Botswana, however SANS standards are expected to take precedence.

6.3.2 Supporting Policies – Labelling and consumer awareness campaigns

All electric motors are expected to, but not required to comply with IE/SANS labelling standards.

6.3.3 Financial Mechanisms

Currently, no funding mechanisms are in place to drive minimum energy performance standards.

6.3.4 Monitoring, Verification and Enforcement

Due to the lack of regulations, no monitoring, verification or enforcement can take place.

6.3.5 Environmentally Sound Management

Botswana is bound by the SADC Protocol on Energy 1996, which states that: “Energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications”.

6.3.6 Other on-going projects/initiatives

There are no on-going initiatives to enhance the adoption of efficient motors.

7 TRANSFORMERS

7.1 Status and Trends of Transformers

The power network in Botswana is owned and operated by the "Botswana Power Corporation" (BPC). The power networks are mostly distributed at the endpoints by pole mounted distribution transformers. some of them dating back to the mid 1900's. Distribution transformers built with amorphous iron cores have 70 % lower no-load losses compared to the best conventional designs, achieving up to 99,7 % efficiency for a 100-kVA unit. High efficiency transformers not only yield a net economic gain, but are advantageous to the environment, reducing greenhouse gas emissions [40].

7.1.1 Markets and Drivers

When a Transformer is operated under ANSI / IEEE basic loading conditions (ANSI C57.96), its normal life expectancy is about 20 years. The ANSI / IEEE basic loading conditions for Transformer are [26]:

- Transformer is continuously loaded at rated kVA and rated Voltage.
- Average temperature of the ambient air during any 24-hour period is equal to 30°C (86 °F) and at no time exceeds 40°C (104 °F).
- Height where the transformer is installed does not exceed 3300 feet or 1000 meters.

7.1.2 Purchase of transformers, including where and availability of energy efficient products

Transformers are purchased directly from the manufacturers and are often part of competitive tender processes, especially when being bought by BPC. Very low standards are enforced in comparison to other international standards for energy efficiency of transformers. Thus, there was no drive to adopt or produce energy efficient transformers.

7.1.3 Local manufacturers, suppliers, retailers and other stakeholders

Due to the proximity of South Africa and the fact that South Africa has a large transformer manufacturing industry, no local manufacturing is necessary or feasible and therefore currently doesn't takes place in Botswana.

7.1.4 Import/export – Principle ports of entry and primary sources of products

Most transformers in the SADC region are either manufactured in or distributed by South African companies. The same is true for transformers, with almost 98% coming from South Africa.

Costs of energy efficient transformers are still significantly higher than standard efficiency units and the relatively low (subsidized) cost of electricity, combined with a general acceptance of system losses, results in the very slow adoption of energy efficient transformers in Southern Africa. Further to that, the long-life expectancy of typical transformers further reduces the potential uptake of energy efficient units.

7.1.5 New vs. Used

Due to the nature of transformer installations, transformers are typically not resold and there is little to no market for second-hand distribution transformers.

7.2 Potential Savings from Energy-Efficient Transformers

Modelling of the different scenarios has been explained in Section 2.

Due to the variable load on distribution transformers, it is very hard to build a hypothetical simulation. However, an attempt has been made and is shown in the table below.

The tables below consider the current scenario (BAU- Business as Usual) as well as the adoption of improved minimum energy performance standards (MEPS) and best available technologies (BAT) if these were to be driven by policies and regulations.

For a simple savings calculation, transformers have been grouped into three categories:

- Not Rated
- SEAD[3] Tier 3 or similar
- SEAD Tier 5 or similar.

7.2.1 Benefits of Energy Efficiency – 3 Scenarios

Table 7.1 BAU, MEPS, BAT scenarios for transformers.

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
Business as Usual	Not Rated	2 240	2 911	-8%	5 156	-20%	7 942
Business as Usual	SEAD Tier 3 or similar	2 750	3 574	4%	7 160	8%	14 915
Business as Usual	SEAD Tier 5 or similar	616	801	11%	1 712	26%	4 153
DNV GL Projected MEPS	Not Rated	2 240	2 911	-46%	3 027	-25%	4 371
DNV GL Projected MEPS	SEAD Tier 3 or similar	2 750	3 574	32%	9 074	0%	17 556
DNV GL Projected MEPS	SEAD Tier 5 or similar	616	801	25%	1 928	37%	5 086
DNV GL Projected BAT	Not Rated	2 240	2 911	-63%	2 074	-66%	1 358
DNV GL Projected BAT	SEAD Tier 3 or similar	2 750	3 574	38%	9 472	-1%	18 006
DNV GL Projected BAT	SEAD Tier 5 or similar	616	801	61%	2 483	60%	7 649

Data & Assumptions:

- *Exchange Rate: 1 Pula = 1.35 ZAR = 0.1 USD.*
- *Average marginal Residential Electricity Tariff: 0.065 USD/kWh.*
- *Average marginal Industrial Electricity Tariff: 0.070 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- Average Transformer Size: 315 kVA, 11kV/0.4kV.

[3] The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative is a voluntary collaboration among governments working to promote the manufacture, purchase, and use of energy-efficient appliances, lighting, and equipment worldwide. SEAD is an initiative under the Clean Energy Ministerial (CEM) and a task of the International Partnership for Energy Efficiency Cooperation (IPEEC).

Assuming these adoption rates are accurate, the following savings (Table 7.2) are projected to be achieved under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 7.2 Projected savings for lighting under MEPS And BAT scenarios.

Row Labels	Sum of GWh Savings (2025)	Sum of GWh Savings (2030)	Sum of Million USD Savings (2025)	Sum of Million USD Savings (2030)	Sum of GHG Savings (2025)	Sum of GHG Savings (2030)
DNV GL Projected MEPS	39	71	6	17	70	126
DNV GL Projected BAT	61	146	9	35	109	261
U4E Targets	57	118	4	8	102	211

7.2.2 Job creation/elimination from EE products

Implementation of strict energy efficiency standards might result in an increase in replacements of current distribution transformers, which in turn will result in jobs in the regional manufacturing industry and local support industry.

7.3 Status of Policies and Initiatives

7.3.1 Standards and regulations

Power efficiency is generally determined by the instantaneous load power and the power losses in a system. However, since SANS 780 is based on the IEC transformer standards, the transformer rating is based on the rated input (primary side) parameters and not load side parameters or load side measurements. Botswana does not specifically require SANS 780, but due to the import from South Africa, the transformers are expected to comply with this standard.

7.3.2 Supporting Policies – Labelling and consumer awareness campaigns

There is no labelling scheme in Botswana to differentiate between the performances of transformers based on rating.

7.3.3 Financial Mechanisms

There are no visible and effective state or industry-funded programmes or initiatives to drive the adoption of energy efficient distribution transformers in Botswana.

7.3.4 Monitoring, Verification and Enforcement

No specific regulations are enforced, but due to the importation from South Africa, SANS 780:2009 will be applicable, which specifies energy performance standards for distribution transformers and is enforced by the South African Bureau of Standards (SABS).

7.3.5 Environmentally Sound Management

Botswana is bound by the SADC Protocol on Energy 1996, which states that: “Energy efficiency and conservation applications have minimal adverse impact on the environment, relative to other energy applications”.

7.3.6 Other on-going projects/initiatives

No ongoing initiatives or projects are currently in place to drive the adoption of energy efficient transformers.

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About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.