TECHNICAL MARKET REVIEW

# Country Profile: Mozambique

## Climate Technology Centre & Network

**Revised Report**
**Date:** 15th 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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Keywords:
Mozambique, Market Review, Energy Efficiency


Reference to part of this report which may lead to misinterpretation is not permissible.

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# 1 EXECUTIVE SUMMARY

This report reviews the potential for increasing the energy efficiency of products in Mozambique 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 Mozambique 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

While Mozambique has significant generation potential, the distribution of power to Mozambique's population is extremely expensive due to the large size of the country and its dispersed settlement patterns. Due to poor connectivity and inadequate transmission network within the country, part of Mozambique exports power to Eskom, which in turn sells the power back to southern Mozambique at an increased rate and incurring serious technical, financial and national security implications. Furthermore, generation capacity should be increased to meet demand. Additional legislation is needed to attract private sector investment in power generation and transmission infrastructure. On the demand side, coordinated policies and programs are needed at the national and regional level to help encourage the adoption of energy efficiency products to ensure that expanded electric uses are efficient.

Underlying process

DNV GL conducted an initial desktop analysis before sending out data requests and setting up meetings with the local entities within Mozambique. These included Mozambique's Ministry of Science and Technology, Electricidade de Mozambique (EDM), Ministry of Energy, National Directorate of Energy, the University of Maputo 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.

Energy Efficiency Regulations

Regulations to govern energy efficiency have been in the pipeline since 2013 but have not been approved due to the complex relationships among multiple stakeholders.

Reducing the sales of electricity through promotion of energy efficiency effectively reduces potential revenue for the utility. 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.

National Designated Entity (NDE) prioritisation

Energy efficiency (including this project, in particular) is not the primary priority of the NDEs and the government in general. Electrification, food, water, housing and other more pressing and relevant issues understandably take priority. Thus, very little capacity remains to track or research the data required for this survey. Further to that, the NDE's receive 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 data provided.

Cost Sensitivity

Due to poverty in general 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 in, let alone track, the African market, and even less to looking at specific countries.

Subsidised electricity tariffs

Subsidised (therefore lower) tariffs result in longer payback periods for energy saving projects or energy efficient technologies, which negatively impacts the sales of these 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 more fully reflective of costs. Many people would then not be able to afford electricity, which in turn has a negative impact on both the economy and the uptake of electrification.

Conclusions

Despite the limitations noted, including low population density and low incomes, Mozambique 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 Mozambique 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 related to 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 over 1,200 GWh (1.2t $CO_2$) per annum in 2025 to around 2,200 GWh (2.2t $CO_2$) per annum in 2030. BAT projected savings for 2025 is expected to be just over 2,000 GWh (2.1t $CO_2$) per annum while savings yielded in 2030 are projected to be just over 3,800 GWh (3.8t $CO_2$).

**Table 1.1 Projected MEPS and BAT savings for Mozambique.**

| | GWh savings (2025) | GWh savings (2030) | MUSD savings (2025) | MUSD savings (2030) | GHG savings (2025) | GHG savings (2030) |
|---|---|---|---|---|---|---|
| **DNV GL Projected MEPS** | | | | | | |
| Lights | 820 | 1 219 | 190 | 454 | 745 | 1 107 |
| Aircon | 14 | 41 | 1 | 4 | 13 | 37 |
| Refrigeration | 221 | 640 | 51 | 239 | 200 | 581 |
| Motors | 34 | 100 | 2 | 10 | 31 | 91 |
| Transformers | 137 | 242 | 9 | 25 | 125 | 220 |
| **Total** | **1 227** | **2 242** | **253** | **733** | **1 114** | **2 036** |
| | | | | | | |

| | GWh savings (2025) | GWh savings (2030) | MUSD savings (2025) | MUSD savings (2030) | GHG savings (2025) | GHG savings (2030) |
|---|---|---|---|---|---|---|
| **DNV GL Projected BAT** | | | | | | |
| Lights | 1 453 | 2 181 | 336 | 813 | 1 319 | 1 980 |
| Aircon | 27 | 97 | 2 | 10 | 25 | 88 |
| Refrigeration | 324 | 801 | 75 | 299 | 294 | 727 |
| Motors | 53 | 223 | 3 | 23 | 48 | 202 |
| Transformers | 217 | 512 | 14 | 53 | 197 | 465 |
| **Total** | **2 074** | **3 815** | **430** | **1 198** | **1 883** | **3 464** |
| **U4E Targets** | | | | | | |
| Lights | 877 | 1 033 | 95 | 112 | 965 | 1 138 |
| Aircon | 56 | 108 | 6 | 12 | 62 | 119 |
| Refrigeration | 471 | 1 295 | 51 | 140 | 518 | 1 426 |
| Motors | 44 | 123 | 1 | 4 | 48 | 135 |
| Transformers | 180 | 374 | 20 | 40 | 180 | 374 |
| **Total** | **1 627** | **2 934** | **172** | **307** | **1 774** | **3 192** |

# 2 INTRODUCTION

## 2.1 General Information about Mozambique

The Republic of Mozambique lies on the east coast of Southern Africa with the Indian Ocean to the east. Malawi and Zambia are to the northwest, Zimbabwe to the west, Swaziland and South Africa to the southwest, and Tanzania to the north.


| | |
|---|---|
| Size (km$^2$) | 812,379 |
| Population (Est, 2017) [1] | 29,565,539 |

The country's extensive coastline stretches 2,515 km along the south east and east coast of Africa. Maputo is the capital of Mozambique, and other major population centres include Beira, the second largest city, which also serves as the business and transport hub for the central region of the country. [2] [3].

Mozambique is a member of the United Nations [4], the Commonwealth of Nations [5] and the Southern African Development Community (SADC) [6]. 68.74% of the population survives on less than US$1.90 a day (the international poverty line), based on 2008 statistics.

In 2016, the World Bank classified Mozapbique as a "low income" country because the annual gross national income (GNI) per capita levels are USD 1,045 or less [7].

## 2.2 Climate and Topography

Mozambique's climate varies from subtropical to tropical (south to north) and is influenced by the monsoons of the Indian Ocean and by the warm current of the Mozambique Channel. Temperatures range from 13 to 24 ° C during the dry season, which is May to September, and from 22 to 31° C during the wet season, namely October to April. The central and southern provinces are prone to severe drought, devastating cyclones and floods. Annual precipitation varies from 500 to 900 mm depending on the region with an average of 590 m. Cyclones are also common during the wet season [8].

The main mountain range lies north of the Zambezi, and east of Lake Chilwa, namely, the Namuli Mountains, in which Namuli Peak rises to 2,701 m, and Molisani, Mruli and Mresi attain altitudes of 1,981 to 2,438 m. These mountains are covered with magnificent forests. Farther north the river basins are divided by well-marked ranges with heights of 914 m and over. Near the south-east shore of Lake Malawi there is a high range (1,524 to 1,829 m with an abrupt descent to the lake - some 914 m in 9.7 km. The country between Malawi and Ibo is remarkable for the number of fantastically shaped granite peaks which rise from the plateau. The plateau lands west of the escarpment are of moderate elevation - averaging 610 to 762 m It is, however, only along the Zambezi and north of that river that Mozambique's territory reaches to the continental plateau. This northern plain has been categorised by the World Wildlife Fund as part of the Eastern Miombo woodlands ecoregion. The Zambezi and Limpopo rivers, two of Africa's major rivers, flow through Mozambique to the Indian Ocean. There are a number of islands on the coast including the Quirimba Archipelago in the region of Cabo Delgado, Mozambique Island in Nampula province, Chiloane Island in Sofala, the Bazaruto Archipelago in Inhambane and Inhaca Island in Maputo province [9].

## 2.3 Electricity Sector

Figure 2.1 below shows the installed energy capacity mix for 2014 and projected for 2030 in Mozambique, which reflects the replacement of Coal with Hydro sources. This has been extracted from a 2013 IRENA report entitled, Southern Africa Power Pool: Planning and Prospects for Renewable Energy.

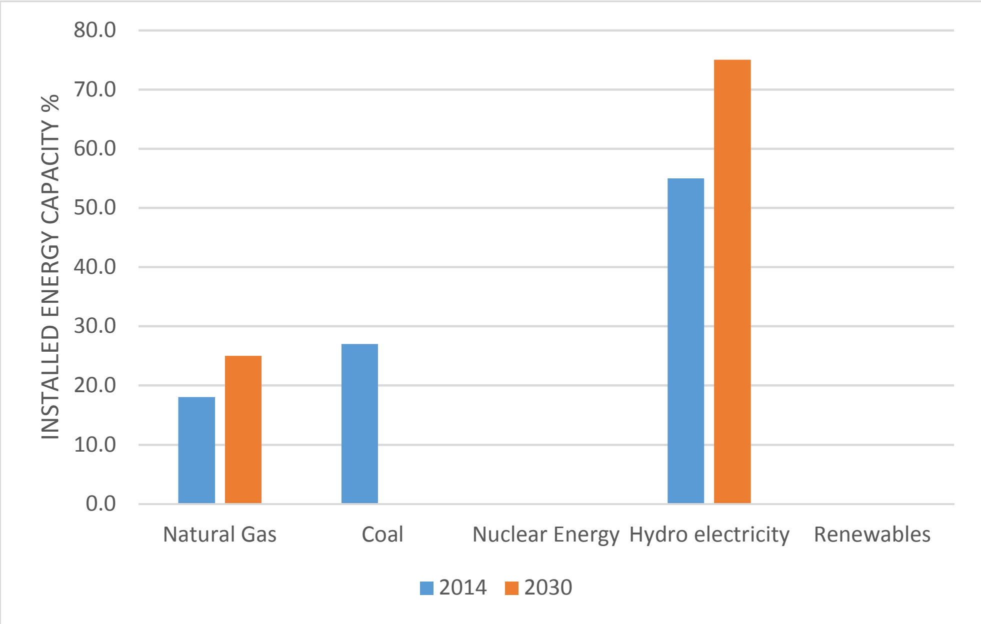


**Figure 2.1 Mozambique installed energy capacity for 2014 and 2030 [10].**

Mozambique has the second highest electricity production of the SADC countries, largely based on its hydropower capacity. Hydropower currently accounts for 92% of Mozambique's generation mix of installed capacity, mostly provided by the Cahorra Bassa dam (HCB) in the northwestern province of Tete and 3 small hydro dams. The remaining generation is from natural gas turbines, and numerous diesel generators. Yet, in 2015, about 97% of total household energy needs were still met by traditional biomass fuels such as wood and charcoal, with only about 20% of households having access to electricity. LPG consumption is limited to higher income households in a few major cities. Mozambique is a net exporter of electricity, with more than 60% of the electricity generated by HCB being exported to South Africa. Given the abundant resources in Mozambique this is a concern and is due to the country's lack of transmission capacity.

Mozambique 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. Mozambique 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 provides an overview of the extent of energy efficiency and demand-side management (DSM) activities in Mozambique.

**Table 2.1 Energy efficiency and Demand-Side Management (DSM) activities[1] in Mozambique [11].**

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mozambique | X | | | | | | | | | | | | | |

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 simply an indication of whether a particular policy target has been, or soon will be, implemented.

**Table 2.2 Mozambique's national energy efficiency targeted programmes [11].**

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

Table 2.3 below indicates Mozambique'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 Mozambique's committed targets for energy savings [12].**

| U4E Pathway to Energy Efficiency | Targeted annual GWh savings by 2030 | | | | |
|---|---|---|---|---|---|
| | Lighting | Residential refrigerators | Room air conditioners | Industrial electric motors | Transformers |
| Mozambique | 1,033.4 | 1,295.3 | 108.0 | 122.6 | 374.2 |

*(Extracted from the U44E Country Assessment, December 2016)*

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

## 2.4 Power Industry Regulation and Policies

An overview of the Power Sector Regulatory environment in Mozambique is set out below in Figure 2.2.

| | |
|---|---|
| **Organizations responsible for energy policies** | • The Ministry of Energy and Mineral Resources<br>• The Energy Fund (Fundo de Energia /FUNAE)<br>• Instituto Nacional do Petroleo (INP)<br>• Empressa Nacional de Hidrocarbonetos (ENH)<br>• Ministry for the Coordination of Environmental Affairs (MICOA) National Directorate for Electrical Energy (DNEE)<br>• National Directorate of New and Renewable Energy<br>• National Directorate of Fuel |
| **Energy regulator** | • National Electricity Council (CNELEC) |
| **Energy policy publications** | • Electricity Act, 1997<br>• Energy Policy, 1998<br>• Energy Sector Strategy, revised 2000<br>• 2009 Development Policy of Renewable Energy<br>• 2009 Strategic and Policy of Biofuel<br>• 2011 strategy for renewable energy<br>• Electricity Master Plan for Development of the National Grid 2005-2019<br>• Natural Gas Master Plan<br>• Petroleum Law |
| **Main entities in the electricity market** | • Electricidade de Mocambique (EDM)<br>• Hidroelectrica de Cahora Bassa (HCB)<br>• MOTRACO – Mozambique Transmission Company<br>• IPP |

**Figure 2.2 Mozambique's power sector regulatory environment.**

Mozambique's electricity sector is overseen by the Ministry of Energy, but the bulk of its generation, transmission, and distribution is undertaken by Electricidade de Moçambique (EDM), a 100% state-owned company. Other major entities include Hidroeléctrica de Cahora Bassa, which oversees Cahora Bassa plant but is 92.5% owned by the government (the remainder, 7.5% belongs to Portugal's Redes Energéticas Nacionais). The country is extraordinarily rich in resources: It has three large coal deposits at Moatize-Minjova, Senangoe, and Mucanha-Vuzi in Tete Province with reserves estimated at more than six billion tons. Meanwhile, in 2012, four of the five largest oil and gas discoveries in the world were made in offshore Mozambique. Today the country produces the bulk of its power with the 2,075-MW Cahora Bassa hydroelectric project (Figure 3)—the largest in southern Africa—which straddles a tributary of the Zambezi river system.

Table 2.4 and

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

**Table 2.4 Energy efficiency support policies initiated by 2016 in Mozambique [11].**

| 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mozambique | | | X | | | | X | | | |

**Table 2.5 Renewable energy support policies initiated by 2016 in Mozambique [22].** Note: ○ = existing national (could also include subnational).

| 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 |
|---|---|---|---|---|---|---|---|---|
| Mozambique | ○ | | | | ○ | | | |

**Table 2.6 Renewable energy fiscal incentives and public financing initiated by 2016 in Mozambique [22].** Note: □ = existing national (could also include subnational indicates the presence of the listed policy type in the country).

| 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 |
|---|---|---|---|---|---|
| Mozambique | | | □ | | □ |

## 2.5 Key Challenges and Recommendations

Key challenges in the energy sector include the fact that distribution of power to the entire population is extremely expensive due to the large size of the country and its dispersed settlement patterns. Secondly, due to poor connectivity within the country and inadequate transmission capacity, HCB exports power to Eskom, which in turn sells the power back to southern Mozambique at an increased rate, resulting in serious technical, financial and national security implications. Furthermore, generation capacity should be increased to meet demand. Legislation needs improvement to attract private sector investment in power generation and transmission infrastructure.

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

Mozambique is part of the World Bank Energy Sector Management Assistance Program (ESMAP) titled "Africa Renewable Energy Access Program (AFREA I & II)" that promotes increased access to energy, with an emphasis on renewable energy, energy efficiency and energy access.

The country is also part of the Clean Technology Fund (CTF), an initiative that has highly concessional resources to scale up the demonstration, deployment, and transfer of low carbon technologies in renewable energy, energy efficiency, and sustainable transport.

**Table 2.7 Energy efficiency opportunities and recommendations for Mozambique.**

| | OPPORTUNITIES | RECOMMENDATION |
|---|---|---|
| **Policies** | Processes and procedures to enforce and prioritize energy efficiency requirements should be put in place. | • Policies for energy efficiency in buildings, energy efficiency audits and standards & product labelling should be implemented.<br>• Evaluate reasons for this and determine if policies are required to initiate this.<br>• Building efficiency guidelines and 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.<br>• Determine what barriers exist preventing use of available funding.<br>• Harmonize donor support by source affordable financing for energy efficiency investment.<br>• 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.<br>• Provide funding to strengthen local capacities and to support RE/EE entrepreneurship. |

Note: Recommendations should be considered after checking with SACREE 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).

<u>All Scenarios</u>

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 interpretations of this data were 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 information obtained from research and the country visits, averaged and rounded.

<u>BAU</u>

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 & BAT), reducing less efficient products (below MEPS) by specific percentage of the current market share by 2025 and 2030.

<u>MEPS</u>

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.

<u>BAT</u>

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

<u>Results</u>

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

Mozambique has in the region of 15 million lighting units, the majority of which are fluorescent or compact fluorescent.

## 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 project.

| 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 3.1 Life Expectancy of Lighting [23].**

Short life expectancies lead to high replacement frequencies which are opportunities for rapid change to newer, more efficient technologies for 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 Mozambique, residential lights are often on for 4 hours in the evening and two hours in the morning all year around, totalling 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 of all types, can be found in the range of 45-100W depending on whether they are for residential, professional or outdoor use. In contrast, efficient LED lights can be found in the range of 5-25W depending on the type of 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, 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. This is especially the case in neighbouring countries, such as Mozambique. 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.

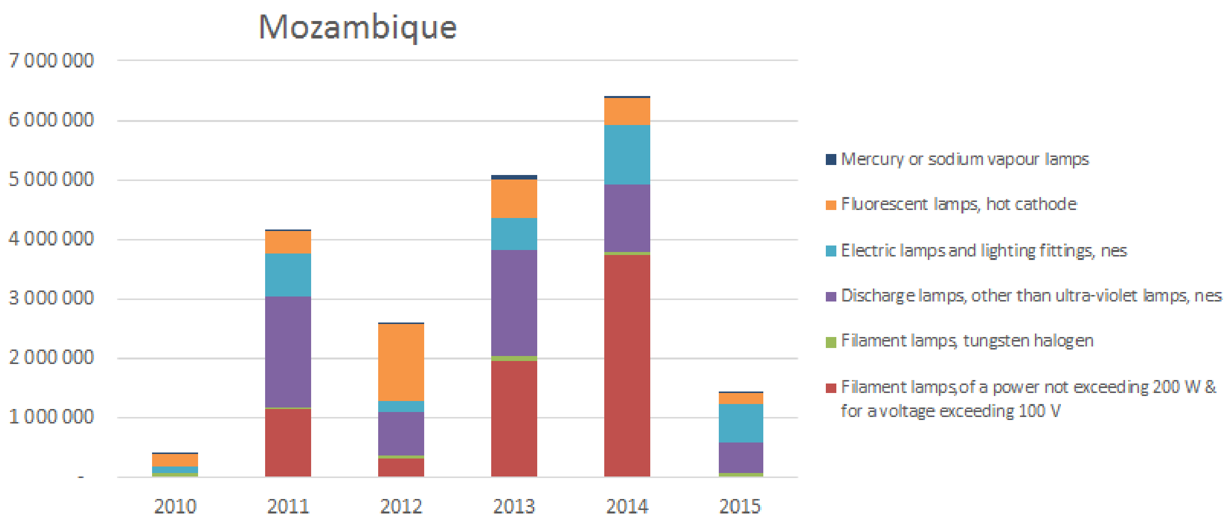


**Figure 3.2 Mozambique annual light unit imports during 2010 to 2015 [24].**

Figure 3.2 presents a summary of lighting unit imports to Mozambique for the years 2010-2015.

### 3.1.4 Barriers to overcome

Electricity is perceived to be expensive, even though Mozambique has some of the lower tariffs in Africa, at 0.03 – 0.05 USD for residential service. 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 from 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:

1. All lights except: Fluorescent (FL), Compact Fluorescent (CFL) & LEDs
2. Fluorescent (FL) & Compact Fluorescent (CFL)
3. 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. | 8 570 225 | 10 943 320 | -10% | 18 146 122 | -20% | 26 746 443 |
| **Business as Usual** | QTY CFL & FL | 5 142 135 | 6 565 992 | 13% | 13 673 744 | 9% | 27 421 857 |
| **Business as Usual** | QTY LED | 1 869 867 | 2 387 633 | 10% | 4 838 965 | 50% | 13 373 219 |
| **DNV GL Projected MEPS** | QTY Halo, Inc etc. | 8 570 225 | 10 943 320 | -50% | 10 081 179 | -20% | 14 859 135 |
| **DNV GL Projected MEPS** | QTY CFL & FL | 5 142 135 | 6 565 992 | 76% | 21 298 782 | -3% | 38 093 419 |
| **DNV GL Projected MEPS** | QTY LED | 1 869 867 | 2 387 633 | 20% | 5 278 871 | 50% | 14 588 966 |
| **DNV GL Projected BAT** | QTY Halo, Inc etc. | 8 570 225 | 10 943 320 | -80% | 4 032 472 | -20% | 5 943 655 |
| **DNV GL Projected BAT** | QTY CFL & FL | 5 142 135 | 6 565 992 | 115% | 26 027 771 | -10% | 43 361 657 |
| **DNV GL Projected BAT** | QTY LED | 1 869 867 | 2 387 633 | 50% | 6 598 589 | 50% | 18 236 209 |

Data & Assumptions:

- *Exchange Rate: 1 MZN = 0.228 ZAR = 0.016 USD.*
- *Average Residential Marginal Electricity Tariff: 0.037 USD/kWh.*
- *Average Industrial Marginal Electricity Tariff: 0.010 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.*

If 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** | 820 | 1 219 | 190 | 454 | 745 | 1 107 |
| **DNV GL Projected BAT** | 1 453 | 2 181 | 336 | 813 | 1 319 | 1 980 |
| **U4E Targets** | 877 | 1 033 | 95 | 112 | 965 | 1 138 |

### 3.2.2 Job creation or elimination from energy efficient products

Lighting surveys, retrofits, supply (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**

The utility is looking at several ways to sustain CFL uptake, because handing out CFLs is not a sustainable strategy. The bulk of the CFLs that are currently being used are produced in South Africa or Lesotho under a SAPP utilities initiative that agreed on set CFL standards.

### 3.3.1 Standards and regulations

Mozambique is a member of the International Organization for Standardization (ISO). The bureau for standards in the country is the Instituto Nacional de Normalizao e Qualidade.

A list of Mozambique's lighting standards/regulations are shown below.

- MN IEC 60598-1: 2003 ed. 6 Luminaires - Part 1: General requirements and tests Edition: 6.0
- MN IEC 60598-2-1: 1979 ed. 1 Luminaires – Part 2: Particular requirements – Section One – Fixed general purpose luminaries
- MN IEC 60598-2-2: 2002 ed. 2 Luminaires – Part 2: Particular requirements –Section 2: recessed luminaires
- MN IEC 60598-2-3: 2002 ed. 3 Luminaires – Part 2-3: Particular requirements – Luminaires for road and street lighting
- MN IEC 60598-2-4: 1997 ed. 2 Luminaires – Part 2: Particular requirements – Section 4: Portable general purpose luminaries
- MN IEC 60598-2-5: 1997 ed. 2 Luminaires – Part 2-5: Particular requirements – Floodlights
- MN IEC 60598-2-6: 1994 ed. 1 Luminaires – Part 2: Particular requirements – Section 6: Luminaires with built-in transformers for filament lamps
- MN IEC 60598-2-7:1982 ed. 1 Luminaires – Part 2: Particular requirements – Section Seven – Portable luminaires for garden use
- MN IEC 60598-2-8: ed. 2 Luminaires – Part 2-8: Particular requirements – Handlamps
- MN 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

EDM has driven energy efficiency through the handing out of CFLs as well as television advertisements, educating the viewers on energy efficiency.

### 3.3.3 Financial Mechanisms

Even though the EDM handed out several CFLs for free, there are no mechanism that provide access to financing for the implementation of energy efficient lighting.

### 3.3.4 Monitoring, Verification and Enforcement

Other than the standard ports 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

Mozambique 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

During the country visits, it was learnt that less than 1% of homes in Mozambique have air-conditioning, which is almost exclusively used in non-residential buildings. 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 not “off-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 Mozambique 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 Mozambique. Stakeholders include importers, distributor 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, resulting in a climb to 44% of market share (2007-2017), while South Africa has decreased to 32% as seen in Figure 4.1 below. There is still a tendency to enforce the South African standards of labelling for importers and exporters.

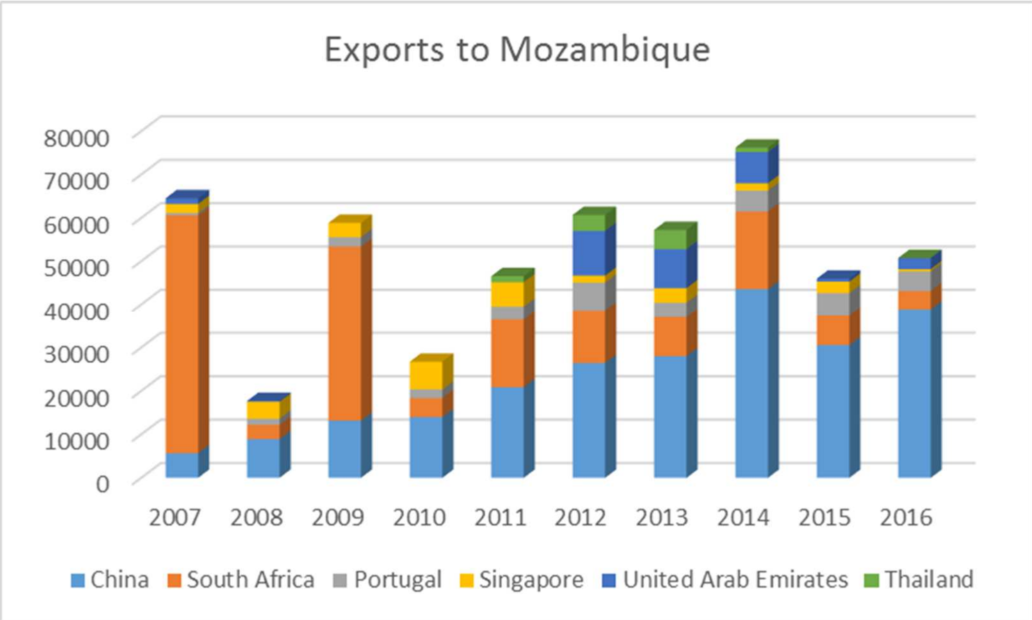


**Figure 4.1 Mozambique annual light unit imports during 2007 to 2016.**

### 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:

1. Below Class B
2. Class B - A
3. 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 | 94 500 | 120 667 | -6% | 208 982 | -7% | 358 083 |
| **Business as Usual** | Class B - Class A | 73 500 | 93 852 | 4% | 179 339 | 2% | 335 946 |
| **Business as Usual** | Class A+ & Above | 42 000 | 53 630 | 7% | 105 726 | 11% | 216 221 |

| Scenario | Description | QTY (2017) | QTY (2020) | Tech. Adopt (2025) | QTY (2025) | Tech. Adopt (2030) | QTY (2030) |
|---|---|---|---|---|---|---|---|
| **DNV GL Projected MEPS** | Lower than Class B | 94 500 | 120 667 | -28% | 160 071 | -19% | 238 886 |
| **DNV GL Projected MEPS** | Class B - Class A | 73 500 | 93 852 | 24% | 214 416 | 1% | 398 215 |
| **DNV GL Projected MEPS** | Class A+ & Above | 42 000 | 53 630 | 21% | 119 560 | 24% | 273 149 |
| **DNV GL Projected BAT** | Lower than Class B | 94 500 | 120 667 | -35% | 144 509 | -33% | 178 386 |
| **DNV GL Projected BAT** | Class B - Class A | 73 500 | 93 852 | 14% | 197 372 | -14% | 314 132 |
| **DNV GL Projected BAT** | Class A+ & Above | 42 000 | 53 630 | 54% | 152 167 | 49% | 417 733 |

*Data & Assumptions:*

- *Exchange Rate: 1 MZN = 0.228 ZAR = 0.016 USD.*
- *Average Residential Marginal Electricity Tariff: 0.037 USD/kWh.*
- *Average Industrial Marginal Electricity Tariff: 0.010 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *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** | 14 | 41 | 1 | 4 | 13 | 37 |
| **DNV GL Projected BAT** | 27 | 97 | 2 | 10 | 25 | 88 |
| **U4E Targets** | 56 | 108 | 6 | 12 | 62 | 119 |

### 4.2.2 Job creation or elimination from energy efficient products.

No direct impact on the Mozambique market, as the bulk of units are imported. Jobs may include AC technicians, installing and repairing, trading, supply.

## 4.3 **Status of Policies and Initiatives**

### 4.3.1 Standards and regulations

No standards explicitly address the energy efficiency of air-conditioning units, but due to the proximity and imports from South Africa, SANS standards (based on IEC & ISO) are likely to be implied.

### 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

Mozambique 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

The estimated percentage of households with a refrigerator is 12%, with most households only having 1 unit per house [8.7].

## 5.1 Status and Trends of Refrigeration Products

### 5.1.1 Markets and Drivers

General indications 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 [25].

### 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 from 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 Mozambique.

### 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. As can be seen in Figure 5.1, 45% of Mozambique's refrigerator imports from 2007 to 2016 came from South Africa while China supplied 37% and Singapore the balance.

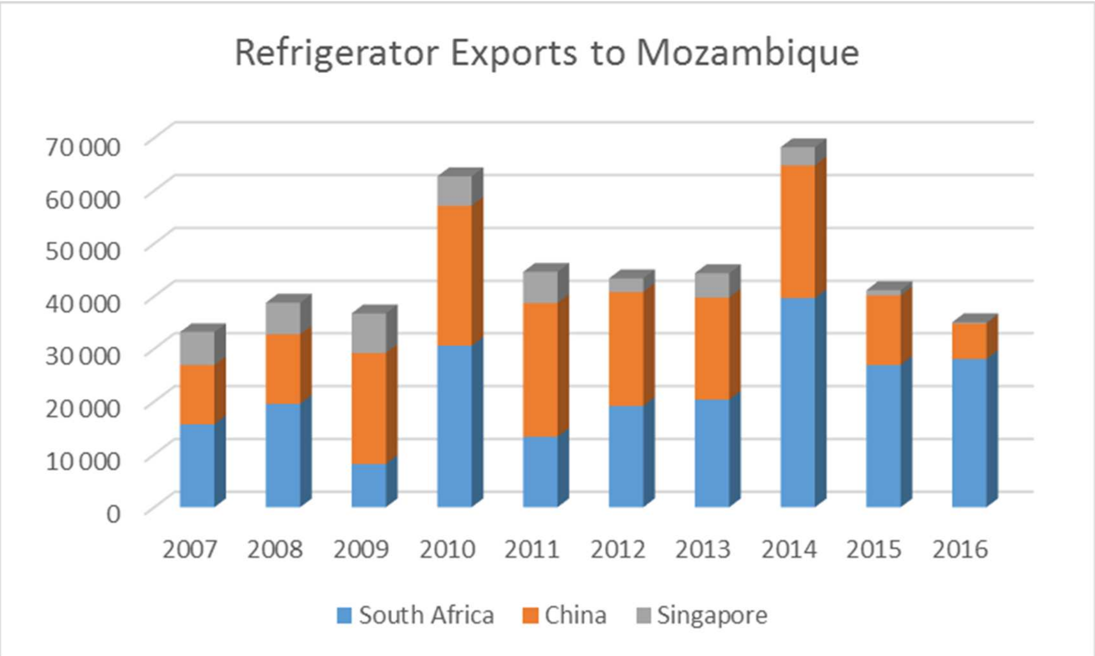


**Figure 5.1 Mozambique annual refrigerator imports during 2007 to 2016.**

### 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 Mozambique 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:

1. Below Class B
2. Class B - A
3. 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 | 1 554 900 | 1 985 452 | -5% | 3 475 163 | -7% | 5 954 569 |
| **Business as Usual** | Class B - Class A | 447 300 | 571 157 | 13% | 1 193 130 | 16% | 2 539 102 |
| **Business as Usual** | Class A+ & Above | 127 800 | 163 188 | 14% | 342 756 | 17% | 738 862 |
| **DNV GL Projected MEPS** | Lower than Class B | 1 554 900 | 1 985 452 | -49% | 1 865 614 | -61% | 1 340 536 |
| **DNV GL Projected MEPS** | Class B - Class A | 447 300 | 571 157 | 158% | 2 715 486 | 35% | 6 767 138 |
| **DNV GL Projected MEPS** | Class A+ & Above | 127 800 | 163 188 | 43% | 429 949 | 42% | 1 124 857 |
| **DNV GL Projected BAT** | Lower than Class B | 1 554 900 | 1 985 452 | -69% | 1 134 001 | -80% | 417 865 |
| **DNV GL Projected BAT** | Class B - Class A | 447 300 | 571 157 | 218% | 3 350 887 | 14% | 7 040 634 |
| **DNV GL Projected BAT** | Class A+ & Above | 127 800 | 163 188 | 75% | 526 161 | 83% | 1 774 034 |

*Data & Assumptions:*

- *Exchange Rate: 1 MZN = 0.228 ZAR = 0.016 USD.*
- *Average Residential Marginal Electricity Tariff: 0.037 USD/kWh.*
- *Average Industrial Marginal Electricity Tariff: 0.010 USD/kWh.*

- *Electricity Cost Increase: 8% per annum.*
- *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 3.2) are projected to be achieved 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.**

| | 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** | 221 | 640 | 51 | 239 | 200 | 581 |
| **DNV GL Projected BAT** | 324 | 801 | 75 | 299 | 294 | 727 |
| **U4E Targets** | 471 | 1 295 | 51 | 140 | 518 | 1 426 |

### 5.2.2 Job creation

The adoption of energy efficiency has no specific impact on the local job market. Jobs may include technicians, installing and repairing, trading, supply of equipment, but these are currently in operation.

## 5.3 Status of Policies and Initiatives

### 5.3.1 Standards and regulations

The standards catalogue does not explicitly list any current regulations regarding refrigeration units.

### 5.3.2 Supporting Policies – Labelling and consumer awareness campaigns

No supporting mechanisms were found in Mozambique 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

Mozambique 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 also 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. [26] Failure of motors can generally be grouped into electrical failure (windings, drives, etc.) and mechanical failure (bearings, mountings etc.). Electrical failures can be repaired 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 [27]. 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 as to when to repair or replace is given in Figure 6.1 below (provided by ABB).

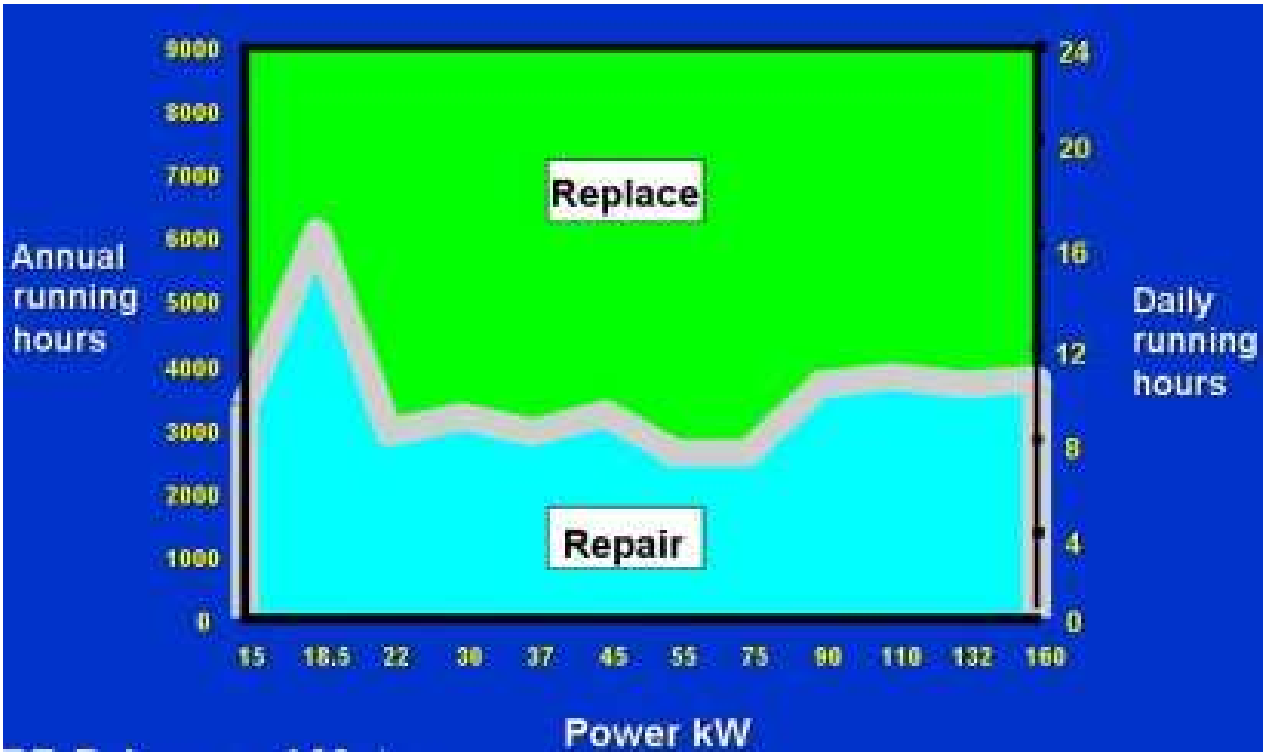


**Figure 6.1 Repair/Replace power-time chart [28].**

## 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 are 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.

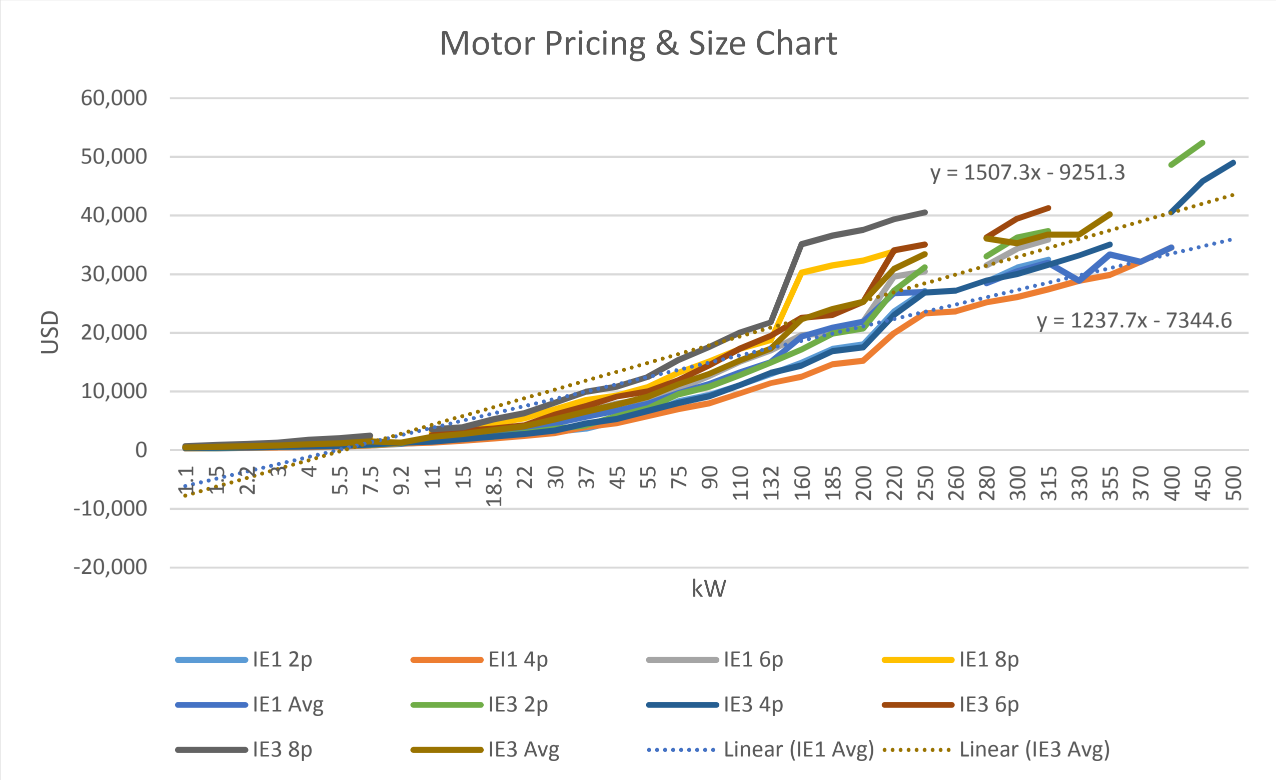


**Figure 6.2 Motor pricing versus size.**

## 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 providing 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 Mozambique 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

Mozambique is almost exclusively an importer of motors. Even though it borders South Africa, China is the biggest supplier (48%) while South Africa provides 13% of motor imports [29].

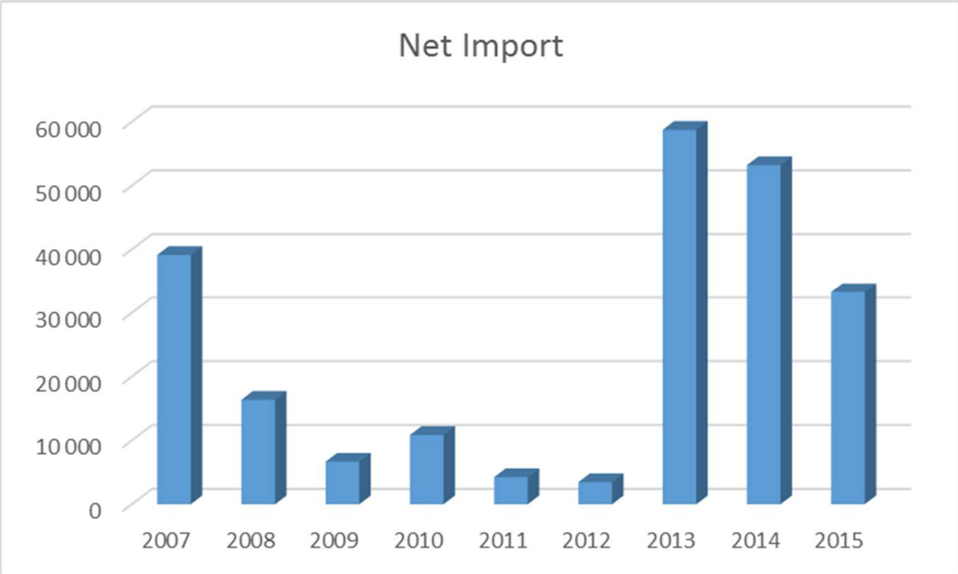


**Figure 6.3 Mozambique's net import of motors during 2007-2015 [29].**

### 6.1.6 Barriers to overcome

<u>Overall Inefficient Systems</u>

Due to the low (subsidized) historical price of electricity in Mozambique, 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.

<u>Negligible Savings</u>

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.

<u>Rewinding Perception</u>

Further to the above, the fact that motors can be rewound to perform at the same efficiency reduces the drive to buy new equipment. However, very few rewinders actually perform the rewinding to the same standards and 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 to speak of.

## 6.2 Potential Savings from Energy-Efficient Motors

Modelling of the different scenarios is explained in Section 2.

Current minimum energy performance standards in Mozambique requires motors to be at least of Class IE1. 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, motors have been grouped into three categories:

1. IE1 and below
2. IE3
3. 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 | 213 750 | 272 937 | -5% | 477 725 | -7% | 818 565 |
| **Business as Usual** | Class IE3 | 166 250 | 212 285 | 2% | 398 385 | 1% | 742 244 |
| **Business as Usual** | Class IE4 | 95 000 | 121 306 | 8% | 241 378 | 12% | 498 090 |
| **DNV GL Projected MEPS** | Class IE1 & below | 213 750 | 272 937 | -11% | 447 553 | -13% | 717 391 |
| **DNV GL Projected MEPS** | Class IE3 | 166 250 | 212 285 | 7% | 417 382 | 9% | 838 971 |
| **DNV GL Projected MEPS** | Class IE4 | 95 000 | 121 306 | 13% | 252 553 | 8% | 502 538 |
| **DNV GL Projected BAT** | Class IE1 & below | 213 750 | 272 937 | -13% | 437 496 | -20% | 644 846 |
| **DNV GL Projected BAT** | Class IE3 | 166 250 | 212 285 | 4% | 407 325 | 6% | 796 136 |
| **DNV GL Projected BAT** | Class IE4 | 95 000 | 121 306 | 22% | 272 668 | 23% | 617 919 |

*Data & Assumptions:*

- *Exchange Rate: 1 MZN = 0.228 ZAR = 0.016 USD.*
- *Average Residential Marginal Electricity Tariff: 0.037 USD/kWh.*
- *Average Industrial Marginal Electricity Tariff: 0.010 USD/kWh.*
- *Electricity Cost Increase: 8% 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.*

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** | 34 | 100 | 2 | 10 | 31 | 91 |
| **DNV GL Projected BAT** | 53 | 223 | 3 | 23 | 48 | 202 |
| **U4E Targets** | 44 | 123 | 1 | 4 | 48 | 135 |

### 6.2.2 Job creation/elimination from EE 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. On the other hand, 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 Mozambique, 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

Mozambique 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 Mozambique is owned and operated by EDM. The power networks are mostly distributed at the endpoints by pole mounted distribution transformers, some 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.

### 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 [30]:

- The Transformer is continuously loaded at rated kVA and rated voltage.
- The 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).
- The 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 EDM. Very low standards (compared to other international standards) for energy efficiency of transformers are enforced. 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 close 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 take place in Mozambique.

### 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 so 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:

1. Not Rated
2. SEAD[2] Tier 3 or similar
3. 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 | 8 235 | 10 515 | -8% | 17 823 | -20% | 26 270 |
| **Business as Usual** | SEAD Tier 3 or similar | 7 137 | 9 113 | 5% | 17 582 | 9% | 35 299 |
| **Business as Usual** | SEAD Tier 5 or similar | 2 928 | 3 739 | 11% | 7 647 | 26% | 17 752 |
| **DNV GL Projected MEPS** | Not Rated | 8 235 | 10 515 | -46% | 10 462 | -25% | 14 457 |
| **DNV GL Projected MEPS** | SEAD Tier 3 or similar | 7 137 | 9 113 | 43% | 23 980 | -2% | 43 131 |
| **DNV GL Projected MEPS** | SEAD Tier 5 or similar | 2 928 | 3 739 | 25% | 8 611 | 37% | 21 735 |
| **DNV GL Projected BAT** | Not Rated | 8 235 | 10 515 | -63% | 7 168 | -66% | 4 490 |
| **DNV GL Projected BAT** | SEAD Tier 3 or similar | 7 137 | 9 113 | 48% | 24 793 | -8% | 42 136 |
| **DNV GL Projected BAT** | SEAD Tier 5 or similar | 2 928 | 3 739 | 61% | 11 091 | 60% | 32 695 |

*Data & Assumptions:*

- *Exchange Rate: 1 MZN = 0.228 ZAR = 0.016 USD.*
- *Average Residential Marginal Electricity Tariff: 0.037 USD/kWh.*
- *Average Industrial Marginal Electricity Tariff: 0.010 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *Average Transformer Size: 315 kVA, 11kV/0.4kV*
- *Average Operating Hours: 24 hours per day, 365 days per annum.*
- *QTY and adoption of new technologies based on information from stakeholder interviews.*

[2] 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 are projected (Table 7.2) to be achieved under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

**Table 7.2 Projected savings for transformers 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** | 137 | 242 | 9 | 25 | 125 | 220 |
| **DNV GL Projected BAT** | 217 | 512 | 14 | 53 | 197 | 465 |
| **U4E Targets** | 180 | 374 | 20 | 40 | 180 | 374 |

### 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 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. Mozambique 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 Mozambique 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 Mozambique

### 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

Mozambique 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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# APPENDICES

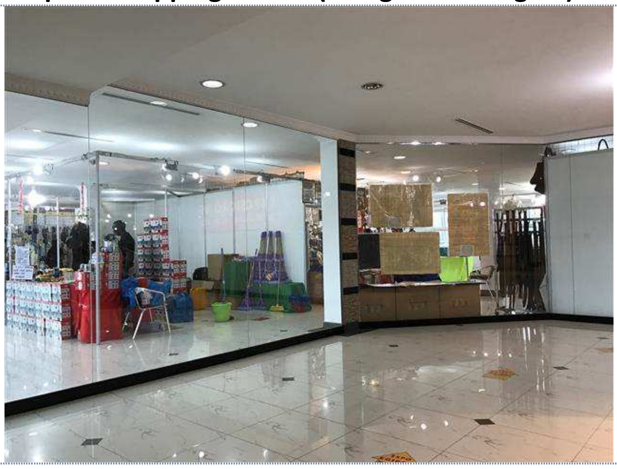
## A. Indicative evidence of lighting and air-conditioning units in use

**Various lighting in hotel: CFL**

**Various lighting in hotel: traditional bulb**

**Very few air-conditioners in Mozambique (<1%)**


**Maputo Shopping Centre (halogen downlights)**



## B. Price lists

See ZEST WEG Motors price lists: http://www.zestweg.com/assets/documents/product-categories/electric-motors/invicta-vibrator-motors/Zest-WEG-Group-Motor-Price-List-2016.pdf

Incledon Motors Pricelist: http://www.incledon.co.za/pricelist/99E.html

## 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.