DNV·GL

TECHNICAL MARKET REVIEW

Country Profile: Swaziland

Climate Technology Centre & Network

Revised Report
Date: 16 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 Swaziland 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. Within this context, DNV GL presents its best estimate of technical potential for each product category and recommendations intended to achieve savings over standard equipment using assumptions based on the research undertaken during this study.

Underlying process

DNV GL conducted an initial desktop analysis before sending out data requests and setting up meetings with local energy sector stakeholders within Swaziland. These included the Ministry of Science and Technology, Ministry of Natural Resources, Energy and Environment, Swaziland Electricity Company (SEC) 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. Some key findings are highlighted below.

National Designated Entity (NDE) prioritisation

Considering the power sector's challenges, such as electrification and the urgent need of system maintenance in Swaziland, energy efficiency (and indeed the theme of this project) is understandably not a primary NDE priority. Electrification, food, water, housing and other more pressing and relevant issues also understandably take priority. Thus, little capacity to track or research the data required in this project's survey has been available.

Electricity Access

Swaziland along with Kenya, is among the Sub-Saharan African nations where the pace of electrification has grown significantly in recent years, especially between 2000 and 2016. Access to electricity has increased by more than 50% over the past 20 years. In 2015 the national electricity access rose to 75%.

Subsidised electricity tariffs

Subsidised (i.e. lower) tariffs result in longer payback periods for energy savings projects or energy efficient technologies. This can negatively impact the sales of energy efficient units, as compared to cheaper but less efficient 'competitors'. Unfortunately, the low average income level in Swaziland effectively prevents the state-owned utility from increasing its tariffs to be cost reflective of generation, as many consumers would then not be able to afford electricity; which in turn provides a negative impact on both the economy and the uptake of electrification.

Energy Policies

Like several other countries in the Southern Africa region, Swaziland's energy policy is at a very high level and lacks detail. It does not address or provide for any energy efficient technologies, have any specific energy efficiency regulations or provide a mandate to enable such regulations.

Conclusions

Because demand for energy is outpacing supply, Swaziland has much to gain by adopting energy efficiency standards, regulations 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 Swaziland 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 and Figure 1.1 below. More detail on the underlying approach used to arrive at these 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 just under 100 GWh (60t CO_2) per annum in 2025 to almost 200 GWh (122t CO_2) per annum in 2030. BAT projected savings for 2025 is expected to be around 165 GWh (106t CO_2) per annum while savings yielded in 2030 are projected to be almost 400 GWh (247t CO_2).

Table 1.1 Projected MEPS and BAT savings for Swaziland.

Swaziland	GWh savings (2025)	GWh savings (2030)	MUSD savings (2025)	MUSD savings (2030)	GHG savings (2025)	GHG savings (2030)
DNV GL Projected MEPS						
Lights	50	74	8	19	32	47
Aircon	7	20	1	7	4	13
Refrigeration	11	32	2	8	7	20
Motors	9	25	2	9	6	16
Transformers	17	39	4	14	11	25
Total	**94**	**190**	**17**	**56**	**60**	**122**
DNV GL Projected BAT						
Lights	88	131	14	33	56	85
Aircon	13	48	3	17	9	31
Refrigeration	16	40	2	10	10	26
Motors	13	56	3	20	9	36
Transformers	35	108	7	38	22	70
Total	**165**	**384**	**29**	**117**	**106**	**247**
U4E Targets						
Lights	33	48	2	4	23	34
Aircon	7	14	0	1	5	10
Refrigeration	8	16	1	1	6	12
Motors	10	20	1	2	7	14
Transformers	27	57	2	4	18	37
Total	**84**	**155**	**6**	**12**	**58**	**107**

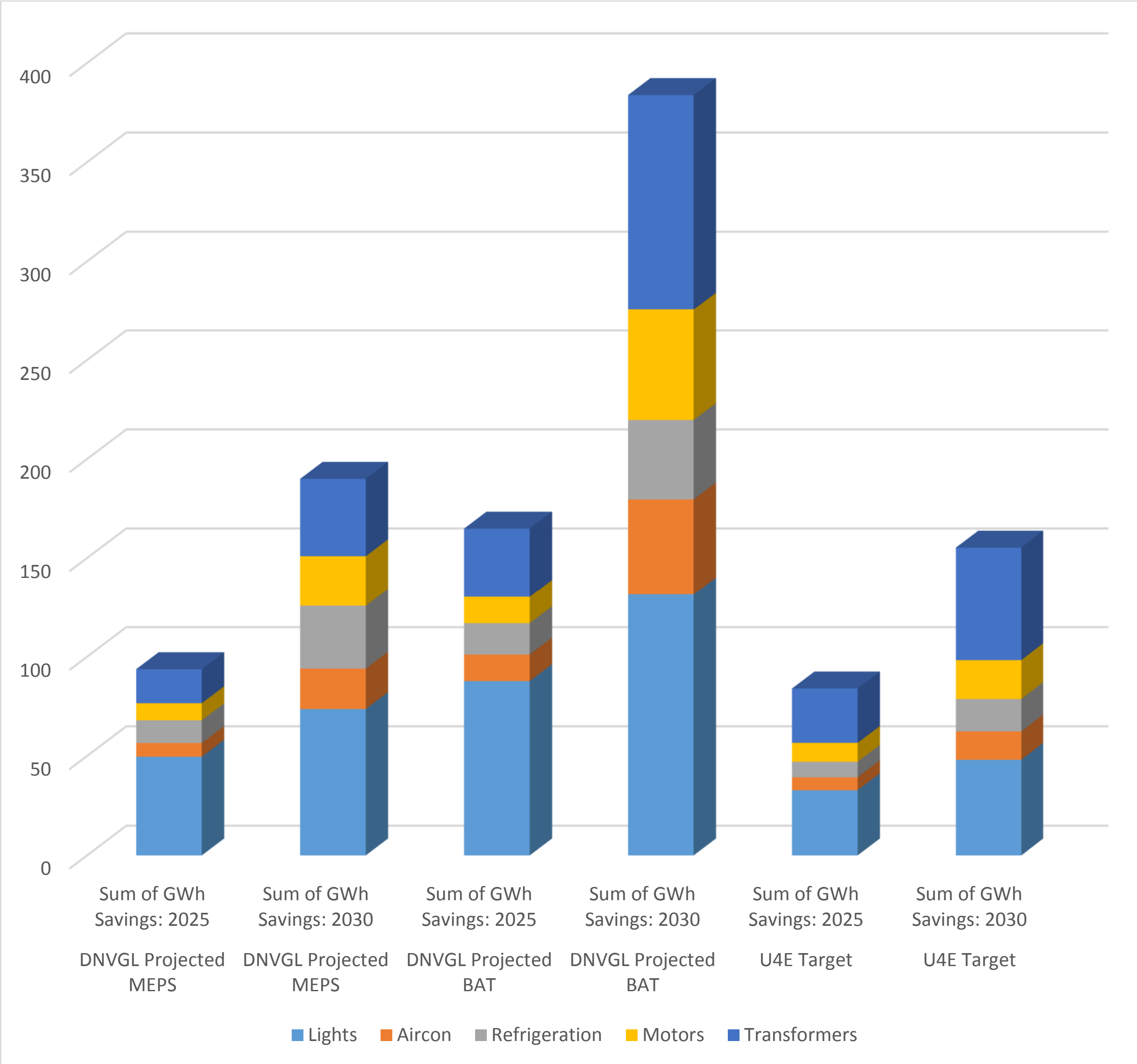


Figure 1.1 Projected annual energy savings for Swaziland.

2 INTRODUCTION

2.1 General Information

The Kingdom of Swaziland is a small landlocked country, no larger than 200 km from north to south and 130 km east to west, located in the southern part of Africa. It is bordered by the Republic of Mozambique to the east (for 105km) and by the Republic of South Africa on three sides (for 430km).

Mbabane is the administrative capital of Swaziland. Its other significant population centre is Manzini, to the west of which lies the country's primary industrial area, Matsapha [2] [3].

Swaziland is a member of the United Nations [4], the Commonwealth of Nations [5] and the Southern African Development Community (SADC) [6]. A significant percentage (42%) of the population survive on less than USD 1.90 per day (i.e. the international poverty line) [7].

Size (km²)	17,364
Population (Est. 2017) [1]	1,320,681

2.2 Climate and Topography

Swaziland's climate ranges from subtropical to temperate, dependant on location. The summer months provide most of the rainfall, very often through thunderstorms, while winters are mostly dry. The west of Swaziland (the Highveld) experiences the highest annual rainfall (e.g. 1,000-2,000 mm per annum) and the east (the Lowveld) experiences somewhat less (e.g. 500-900 mm per annum). The west and east of the country also experience variations in temperature in relation to their elevation/topography, with temperatures of up to 40 °C in the Lowveld. Temperatures in the Highveld are generally temperate and rarely that hot [8]. The mountainous Highveld to the west features rivers, waterfalls and gorges and has a temperate climate of warm, wet summers and dry winters when the temperature can rise sharply during the day but with cold nights. The subtropical Middleveld, at a lower altitude, is made up of lush, fertile valleys and a warm climate that is ideal for cultivating a diversity of crops. It is here that much of the country's agricultural activities occur. Further to the east is the Lowveld which is the largest region covering about 40% of the country and is also subtropical. There are several rivers, including the Usuthu River. The main regions are the Lubombo, Highveld, Middleveld, and Lowveld. [9]

2.3 Electricity Sector

Figure 2.1 below shows the installed energy capacity for 2014 and projected for 2030 in Swaziland, which has been extracted from a 2013 IRENA report entitled, Southern Africa Power Pool: Planning and Prospects for Renewable Energy.

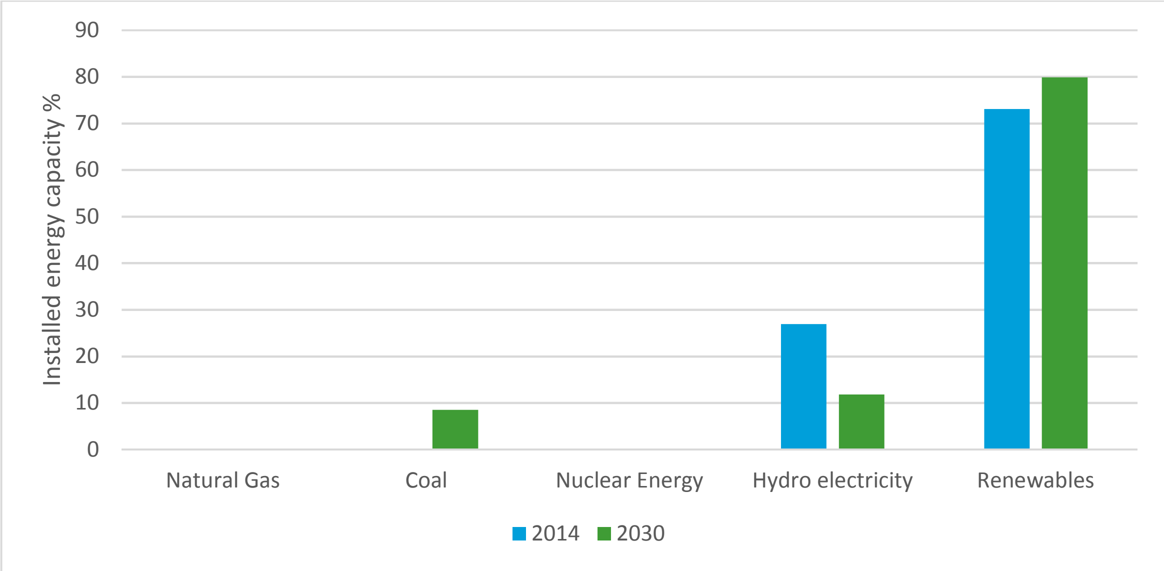


Figure 2.1 Swaziland installed energy capacity[1] for 2014 and 2030 [10].

The electricity sector is dominated by the Swaziland Electricity Company (SEC), which undertakes power generation, importation, transmission, distribution and supply. There are a few other key players, which include co-generators from the sugar industry such Ubombo Sugar limited (USL) and the Royal Swaziland Sugar Corporation (RSSC) that use bagasse and wood chips as fuel. USL has an installed capacity of 41.5 MW, which is utilised for self-sufficiency and exported to SEC. RSSC's 65.5 MW generation is currently limited to self-consumption. The Swaziland Electricity Company has four hydropower stations in operation, the Maguga, Ezulwini, Edwaleni and Maguduza Hydropower Stations. These all serve as peak and emergency power stations. These do not provide a constant supply of electricity for normal daily consumption, which is a function of base load power stations like thermal power stations. Recent droughts in Swaziland have had a major impact on local generation capacity.

Swaziland's hydropower stations have a combined installed generation capacity of 60.4 MW, and they contribute (SEC's internal generation) less than 10% of the total energy consumed in the country. Most the country's electricity needs are fulfilled through imports using bilateral power purchase agreements with Eskom, Ubombo Sugar Limited (USL), Electricidade du Mozambique (EDM) and the competitive Day Ahead Market (DAM).

In 2015 the national electricity access rose to 75%. Among the households without electricity, 76% in urban communities and 85% in rural communities indicated they could not afford the cost of connection to the electricity grid and electricity tariffs. 10% of urban households and 5% of rural households without electricity attributed the absence of electricity to lack of infrastructure. Biomass, especially wood fuel, constitutes about 90% of the total final energy consumption, and is still dominant in cooking and heating in rural areas. Biomass is not only the major fuel in households, but also the major source of electricity self-generation in the sugar, pulp and saw mill industries.

Swaziland 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. Swaziland also joined the International Renewable Energy Agency (IRENA) - a global initiative to promote and reduce barriers to the uptake of renewable energy.

[1] Note: Renewables includes Solar PV, Solar Thermal, and Biomass.

Table 2.1 indicates the extent of energy efficiency and Demand Side Management (DSM) activities in Swaziland. Compact fluorescent lighting is promoted under the CFL Exchange programme, and approximately 90% of electrified households are now using pre-paid meters. In addition to promoting efficiency in the industrial sector, a time-of-use tariff has been introduced for industrial customers (SEC, 2012). SEC has been distributing compact florescent lamps to customers for free during the roadshows. (Although the quantities distributed are low, giveaways are not considered a wise long-term strategy). The roll-out of prepaid electricity connection has seen about 95% of all domestic customers being converted from credit meters to prepaid meters. SEC has also organised public sensitisation campaigns on energy efficiency through various forms of media - newspapers, television, radio and in schools – in collaboration with various stakeholders dealing with energy efficiency issues.

Table 2.1 Energy efficiency and Demand-Side Management (DSM) activities[2] in Swaziland [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
Swaziland	X			X					X	X		X		

Swaziland's solar regime is not well documented, it is, however, estimated that annual averages could lie between 4 to 6 kWh/m2/day. A program to install solar water heaters in public institutions as an energy efficiency measure was undertaken. Wind speed measurements are continuing in the country, with preliminary results indicating a mean average wind speed of 4 m/s across the country, suggesting a moderate potential for wind energy use. The major renewable energy targets of the Government are:

a) Install solar water heaters in 20% of all public buildings by 2018;

b) Develop solar water heater standards by 2018;

c) Establish fiscal incentives to promote renewable energy by 2022; and

d) Establish a demonstration centre for renewable energy technologies by 2022.

Error! Reference source not found. below indicates Swaziland'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 2.2 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
Swaziland	48.1	16.3	14.3	19.6	57.0

(Extracted from the U44E Country Assessment, December 2016)

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

In relation to electricity consumption, the most important measure in the energy balance of Swaziland is the total consumption of 1.50 billion kWh per year. Per capita, this is an average of 1,033 kWh [13].

Swaziland can partly provide itself with self-produced energy. The total production of all energy producing facilities is 700 m kWh. That is 47% of the country's own usage. The rest of the needed energy is imported from foreign countries. Along with pure consumption, the production, imports and exports play an important role.

References: [14] [15] [16] [17] [12] [18] [19] [20].

2.4 Power Industry Regulation and Policies

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

Organizations responsible for energy policies	• Ministry of Natural Resources and Energy (MNRE)
Energy regulator	• Swaziland Energy Regulatory Authority (SERA) • The Electricity Control Board (ECB)
Energy policy publications	• National Energy Policy, 2003 • National Energy Policy Implementation Strategy, 2009 • Electricity Act, 2007 • Revised Electricity Licensing Bylaws Energy Regulatory Act, 2007 • Swaziland Electricity Company (SEC) Act • Swaziland Utilization of Renewable Action Plan, 1997 • National Development Strategy – Vision 2022, 1999 • Public Private Partnership (PPP) policy • Generation Capacity Plan 2015 - 2025
Main entities in the electricity market	• The Swaziland Electricity Company (SEC)

Figure 2.2 Swaziland's power sector regulatory environment.

The electricity supply industry in Swaziland has undergone changes from both a policy and regulatory point of view. Issues such as the changing global trends towards liberalised energy markets; security of supply; achieving efficiencies; affordability; and access to electricity, amongst others, have introduced a change in the policy trajectory with regards to how Swaziland views electricity supply. Overall, the electricity supply industry in Swaziland can be broadly defined as an industry in transition, informed both by policy imperatives and regulatory reform.

The Ministry has established a programme for Energy efficiency in public buildings. Promoting procurement of efficient equipment and appliances in government institutions. The Ministry will work on a strategy to ensure that government utilises energy efficient equipment. A number of activities are already ongoing in line with the various policies and strategic plans in place, such as wind resource assessment, distribution of energy efficient woodstoves, co-generation in sugar mills, and utilisation of photovoltaics.

Table 2.3 and

Table **2.4** depict the lack of current energy efficiency and renewable energy support policies in Swaziland across a broad range of aspects, as of 2016. Notably, a few energy efficiency policies are at a developmental stage and also that renewable energy policy or regulatory instruments may in the future take shape from FITs, tendering or quotas.

Table 2.3 Energy efficiency support policies initiated by 2016 in Swaziland [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
Swaziland										

Table 2.4 Renewable energy support policies initiated by 2016 in Swaziland [21].

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
Swaziland								

References: [14] [15] [16] [17] [12] [18] [19] [20].

2.5 Key Challenges and Recommendations

Swaziland is experiencing a rural energy crisis where demand for household energy has outstripped supply. The combination of high demand, aggravated by low end-use efficiency (fuelwood is either used in open fires or in stoves designed for coal) has contributed to environmental degradation, rural poverty and rural energy shortages. Insufficient policies and regulatory frameworks for energy efficiency; as well as the need for Fiscal and financial incentives to encourage the use of energy efficient appliances and Innovative financing schemes for energy efficiency and conservation programmes, hamper effective energy efficiency and renewable energy initiatives. SEC experienced severe cash flow challenges during 2015/16 due to continued tariff increases on imports that were above inflation. Projects to reduce reliance on imports are in progress. Severe droughts also impact on the country's generation capacity, therefore renewable energy plays an important part in the future SEC electricity generation mix.

SACREE is the SADC Centre for Renewable Energy and Energy Efficiency (see Appendix A). SACREE works towards addressing SADC country challenges with respect to renewable energy and energy efficiency. Funding available to the SADC countries for energy efficiency is listed in Appendix B.

Swaziland used about 46,000 USD from a National Energy Efficiency Awareness Fund to assist funding energy efficiency campaigns and activities which will include raising awareness on energy efficiency and conservation, improving and promoting consumer cooperation towards improving energy efficiency, and promoting sustainable energy supply.

Table 2.5 Energy efficiency opportunities and recommendations for Swaziland.

	OPPORTUNITIES	RECOMMENDATIONS
Policies	Processes and procedures to enforce and prioritize energy efficiency requirements should be put in place.	• Evaluate reasons why financing is not targeted at energy efficacy programmes and determine what policies are required to enable this. • Voluntary business energy efficiency programmes may be considered.
Economic and financial	Some funding is already available regionally for energy efficiency (see Appendix B). 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 (Appendix B). • Harmonize donor support by source 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 after checking with SACREE on any new initiatives that might have been initiated.

The Integrated Energy Planning operational branch of the Department of Energy, established in May 2009, develops, implements and maintains a National Integrated Resource Plan (IRP).

2.6 Modelling and Savings Projections

For a simple savings calculation, each of the technologies has 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).

Tariffs

Residential tariffs were used for lighting and refrigerators, as the country lighting assessments indicated that the bulk of lights are found in residential dwellings and the U4E identified the focus area for refrigerators as residential (0.142 USD/kWh).

Industrial tariffs were used for motors, transformers and air conditioning units, as these are primarily found in commercial and industrial buildings (0.145 USD/kWh).

All Scenarios

For all of the scenarios of all the technologies, an average annual increase in the electrification of the country was used, using 2017 as the base year. This average was extrapolated from data provided by several sources including electric utilities and other published research.

Where necessary, conservative interpretations of this data were used by DNV GL. For Swaziland, the increase is calculated to be 5.5% for households based on the World Bank's increase in kWh per capita (as seen in **Error! Reference source not found.** above).

Technology Adoption Rates

Uptake of technologies and increases or decreases of the quantities of units are based on information gathered from various sources during several meetings that took place as part of the country visits. The numbers were interpreted, averaged and rounded.

BAU

The Business-as-Usual case assumes that the current adoption rate of energy efficiency technologies continues at the same trend due to the normal rate of rising costs of electricity (average of 8% annual increase across all tariffs, which is in line with current increases) 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.

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

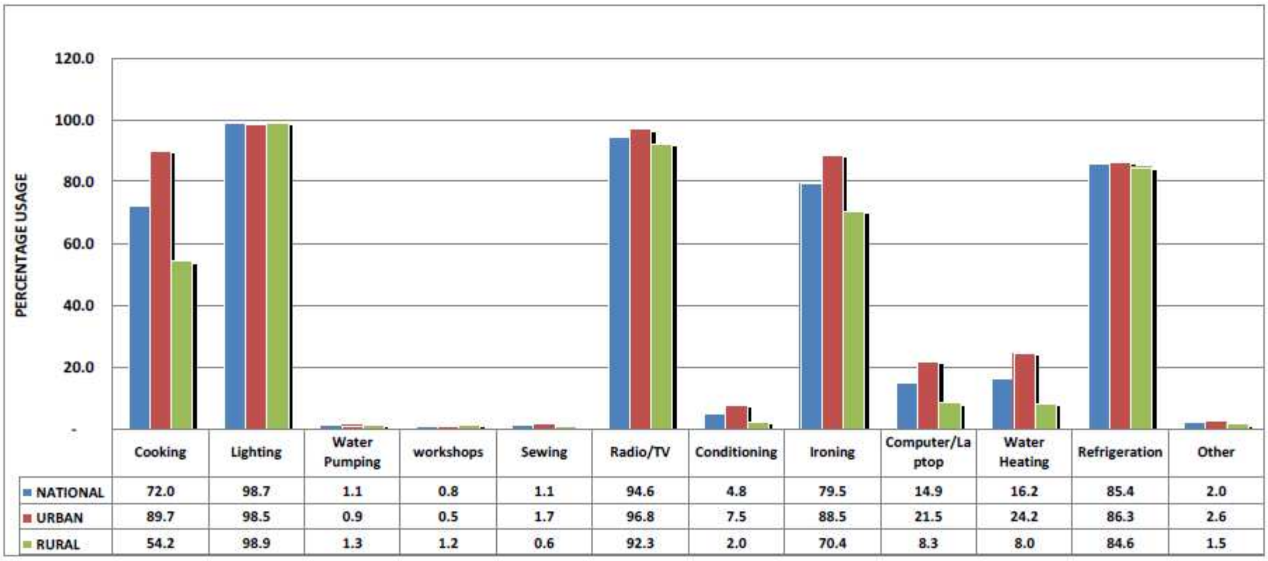
Best Available Technology implementation assumes that all implementation of new lighting is driven towards BAT standards while allowing MEPS and disallowing new sub-MEPS installation and sales.

Results

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

3 LIGHTING

In Swaziland, households that use electricity for lighting are typically using energy saving lights rather than incandescent lighting.

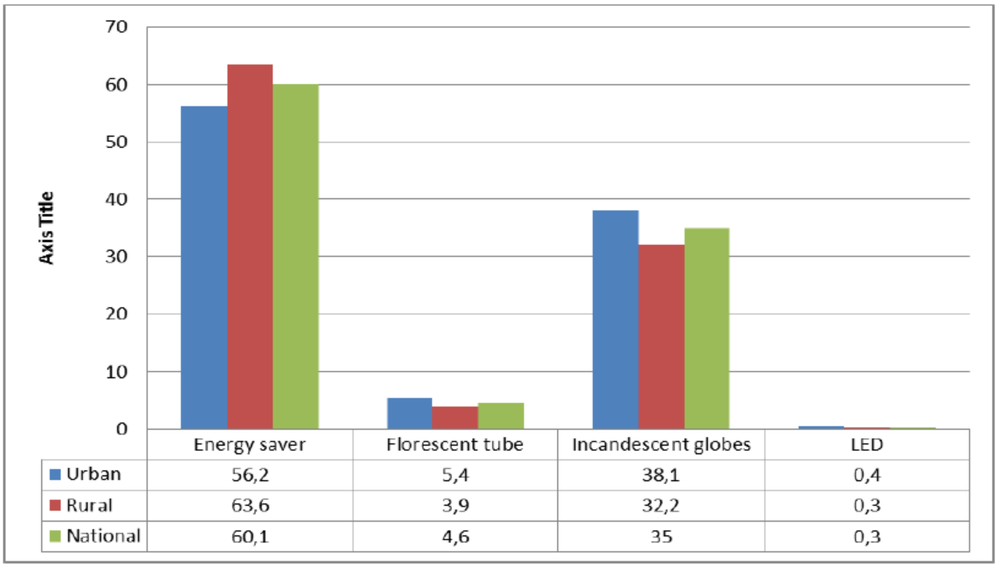


	Cooking	Lighting	Water Pumping	workshops	Sewing	Radio/TV	Conditioning	Ironing	Computer/Laptop	Water Heating	Refrigeration	Other
NATIONAL	72.0	98.7	1.1	0.8	1.1	94.6	4.8	79.5	14.9	16.2	85.4	2.0
URBAN	89.7	98.5	0.9	0.5	1.7	96.8	7.5	88.5	21.5	24.2	86.3	2.6
RURAL	54.2	98.9	1.3	1.2	0.6	92.3	2.0	70.4	8.3	8.0	84.6	1.5

Figure 3.1 Electricity usage at household level (2013).

As seen in Figure 3.1, the electricity usage at the household level shows that most residents of Swaziland use electricity for lighting purposes, followed by radio/TV, refrigeration, ironing and cooking purposes.

Smart street lighting is being installed. The sensory street lighting, designed by gridComm[3], is Internet-of-Things (IoT) equipped [22]. These energy-efficient street lights can assist with monitoring of crops and weather using data analytics. This technology can contribute to economic development of Swaziland in shaping a sustainable environment [23].



	Energy saver	Florescent tube	Incandescent globes	LED
Urban	56,2	5,4	38,1	0,4
Rural	63,6	3,9	32,2	0,3
National	60,1	4,6	35	0,3

Figure 3.2 Proportions of types of lighting used per household.

3 http://www.marketwired.com/press-release/gridcomm-somerset-group-bring-smart-street-lighting-sensory-network-to-africa-2169751.htm

According to the information gathered during the site visit, about 56.2 % (urban) and 63.6 % (rural) of households use energy saving light bulbs. The survey also shows that incandescent light bulbs (ordinary globes) are still being used by a large proportion even though it is lower than the energy savers at 35% nationally. Approximately 4.6 % of the households use florescent tubes for lighting. The high energy saving LEDs are used by only 0.3% households nationally.

3.1 Status and Trends of Lighting Products

3.1.1 Stock, sales, sale price, lifetime, projected growth rates and time of use

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 3.3 Life Expectancy of Lights [24].

3.1.2 Local manufacturers, suppliers, retailers and other stakeholders

In 2016, a Taiwanese company JMLED, had used a local company, Supa Savers as its main distributor of LED lights in Swaziland and Mozambique [26].

Further to that, distribution mostly takes place through large retail stores (Shoprite, Game, Pick & Pay, etc.) that are mostly based in South Africa with chains throughout Southern Africa, including Swaziland.

3.1.3 Import/Export

Due to historical trade relationships and proximity to South Africa, more than half of its installed stock between 2008 – 2017 is from South Africa. However, aggressively priced alternatives from China have started to flood the market in recent years.

3.1.4 Barriers to overcome

Cost

Due to the low average income per household, consumers are very sensitive to costs. The typical consumer will likely not be able to afford or justify the additional short-term expenses to gain energy efficiency and any long-term cost savings.

Availability

Very limited stock and variety of energy efficient lighting is available to the public, further diminishing the appetite for this product.

Education

During the country visits, it became apparent that consumers are not aware of environmental and cost impacts on buying low efficiency products.

Import duty & tax

There is no reduction, or wavering of, import duty or taxes on energy efficient lights (CFL or LED). This is likely to protect the local manufacturing market, that makes up a negligible portion of market share. The result is that buyers are paying a premium for energy efficient products.

Emergency lighting

LEDs are often only seen as emergency lighting solutions, rather than energy saving solutions. In this case, the LED would come paired with a battery as a stand-alone unit, rather than to replace inefficient lights in fixtures.

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

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

For the Business-As-Usual (BAU), Minimum Energy Performance Standards (MEPS) and Best Available Technologies (BAT) cases, the starting quantities are the same and indicate the current estimate of quantities installed. The percentages indicate the increase or decrease rate of the technologies during BAU, if MEPS are enforced, or if BAT is pursued.

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.	519 047	662 771	-10%	1 099 001	-20%	1 619 870
Business as Usual	QTY CFL & FL	291 475	372 185	14%	784 266	11%	1 611 065
Business as Usual	QTY LED	100 195	127 938	10%	259 289	50%	716 585
DNV GL Projected MEPS	QTY Halo, Inc etc.	519 047	662 771	-50%	610 556	-20%	899 928
DNV GL Projected MEPS	QTY CFL & FL	291 475	372 185	82%	1 249 140	-2%	2 265 864
DNV GL Projected MEPS	QTY LED	100 195	127 938	20%	282 861	50%	781 730
DNV GL Projected BAT	QTY Halo, Inc etc.	519 047	662 771	-80%	244 223	-20%	359 972

DNV GL Projected BAT	QTY CFL & FL	291 475	372 185	125%	1 544 759	-8%	2 610 389
DNV GL Projected BAT	QTY LED	100 195	127 938	50%	353 576	50%	977 161

Data & Assumptions:

- *Exchange Rate: 1 SZL = 1 ZAR = 13.5 USD.*
- *Average Residential Marginal Electricity Tariff: 0.073 USD/kWh.*[4]
- *Average Industrial marginal Electricity Tariff: 0.101 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *Operating hours: 2 hr in morning (6-8am) and 2hr in the evening (7-9pm), 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	50	74	8	19	32	47
DNV GL Projected BAT	88	131	14	33	56	85
U4E Targets	33	48	2.4	3.5	23	34

3.2.2 Job creation / elimination from EE products.

The implementation of energy savings initiatives such as lighting retrofits combined with manufacturing and distribution of lights have proven to generate a large amount of jobs in South Africa. A similar scenario for Swaziland is likely to happen if Swaziland Electricity Company (SEC) is to implement similar schemes. Temporary jobs covering a wide variety of skills will be created ranging from, for example, sales and practical labour to measurement & verification.

3.3 Status of Policies and Initiatives

3.3.1 Standards and regulations

The Swaziland National Energy Policy of 2003, has set five key objectives:

- Ensuring access to energy for all;
- Enhancing employment creation;
- Ensuring security of energy supply;
- Stimulating economic growth and development; and
- Ensuring environmental and health sustainability.

There are some on-going and planned energy sector programmes and projects. These programmes are:

[4] U4E rates were used to allow comparison

- Promotion of renewable energy
- Development of standards
- Promotion of energy efficiency
- Energy data collection

The Swaziland Electricity Company is running an extensive demand-side management programme. Compact fluorescent lighting is promoted under this programme.

SE4ALL Objective	Prioritized Bottleneck	Prioritized Acceleration Solution	Potential Partners
Increasing energy efficiency	EE1: Lack of policy to promote energy efficiency programmes	1.Develop policy and regulatory framework for energy efficiency	Swaziland Energy Regulatory Authority – Lead Ministry of Natural Resources & Energy - Co-Lead Swaziland Standards Authority Swaziland Electricity Company
		2.Adopt and implement Minimum Energy Performance Standards of efficient lamps and refrigerators	Swaziland Energy Regulatory Authority – Lead Swaziland Standards Authority - Co-Lead Ministry of Natural Resources & Energy Swaziland Electricity Company
		3.Design, adopt and implement mandatory labelling and certification for efficient lamps and refrigerators	Swaziland Energy Regulatory Authority - Lead Swaziland Standards Authority - Co-Lead Ministry of Natural Resources & Energy Swaziland Electricity Company
	EE 2. Lack of awareness of the benefits of efficient use of energy among the public, private sector investors and financial institutions	1.Organize public education and awareness campaigns on the advantages and benefits of efficient use of energy	Ministry of Natural Resources & Energy - Lead Swaziland Electricity Company Swaziland Energy Regulatory Authority University of Swaziland
		2.Organize special education programmes for the youth in schools on the advantages and benefits of efficient use of energy	Ministry of Education & Training– Lead Ministry of Natural Resources & Energy – Co-Lead Swaziland Electricity Company University of Swaziland
		3.Implement demonstration projects on efficient	Federation of Swaziland Employers & Chamber of Commerce –

		use of energy	Lead Ministry of Natural Resources & Energy - Co-Lead Swaziland Electricity Company Swaziland Investment Promotion Authority Financial Institutions (e.g. SNPF, Fincorp, Old Mutual) Town Councils (e.g. Mbabane, Matsapha, Ezulwini) Rural Local Authorities – Tinkhundla Centres University of Swaziland Private Sector – entrepreneurs & investors
		4.Implement free distribution of efficient lamps or at subsidized cost to carefully selected communities (with retrieval and destruction of replaced incandescent lamps)	Ministry of Natural Resources & Energy - Lead Ministry of Commerce, Industry & Trade – Co-Lead Swaziland Electricity Company Financial Institutions (e.g. SNPF, Fincorp, Old Mutual) Town Councils (e.g. Mbabane, Matsapha, Ezulwini) Rural Local Authorities – Tinkhundla Centres
		5.Promote installation of efficient lighting in all new social housing projects of government	Ministry of Housing & Urban Development – Lead Ministry of Natural Resources & Energy - Co-Lead Swaziland Electricity Company Town Councils (e.g. Mbabane, Matsapha, Ezulwini) Rural Local Authorities – Tinkhundla Centres
	EE 3. Lack of incentives for the application of energy efficient	1.Facilitate development of financing schemes to cover the upfront cost of on-grid and off-grid lighting products (e.g. on-bill financing)	Ministry of Natural Resources & Energy - Lead Financial Institutions (e.g. SNPF, Fincorp) – Co-Lead Swaziland Electricity Company Town Councils (e.g. Mbabane, Matsapha, Ezulwini)

	technologies and appliances		Rural Local Authorities – Tinkhundla Centres
		2. Facilitate the availability of good quality on-grid and off-grid lighting products through bulk procurement (e.g. through reducing import duties)	Federation of Swaziland Employers & Chamber of Commerce – Lead Ministry of Commerce, Industry & Trade – Co-Lead Ministry of Natural Resources & Energy Swaziland Electricity Company Financial Institutions (e.g. SNPF, Fincorp, Old Mutua)l Town Councils (e.g. Mbabane, Matsapha, Ezulwini)

The Energy Regulatory Act of 2007 established an Energy Regulatory Authority, which is tasked with enforcing compliance standards, approving tariffs and promoting economic efficiency in the energy industry.

No regulatory mechanisms, MEPS or labelling and certification standards for efficient lighting products have been implemented in Swaziland. However, the Government of Swaziland plans to implement MEPS and a labelling system for lighting products. [27]

Current regulations include "SZNS SANS 60432-2:2006: Incandescent lamps- safety specifications Part2: Tungsten halogen lamps for domestic and similar general lighting purposes"

3.3.2 Supporting Policies – Labelling and consumer awareness campaigns

The Ministry of Natural Resources and Energy, the Swaziland Standards Association (SWASA) and other stakeholders have collaborated to establish a project to develop standards – 'Adoption of technical standards for petroleum products, LPG safety, solar PV and solar thermal technologies'. The objective of this project is to regulate and control the quality of energy products and energy equipment's imported into the country.

The Swaziland Electricity Company (SEC) has been promoting the use of CFLs since 2001 through exhibitions and trade fairs where they have distributed hundreds of free CFLs. They promote electricity savings methods on their website where they invite customers to switch inefficient incandescent lamps for CFLs. [28]

3.3.3 Financial Mechanisms

Currently, financial schemes are the one of the key issues to addressed to promote energy efficiency in Swaziland. There is a requirement for innovative financial schemes for the promotion of energy efficiency and conservation programmes.

3.3.4 Monitoring, Verification and Enforcement

No monitoring, verification and enforcement measures have been reported.

3.3.5 Environmentally Sound Management

Swaziland 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

Replace Incandescent lamps (regular light globes) with Compact Fluorescent Lamps (CFLs) (energy savers). CFLs use about 20% of the energy and last 6 to 8 times longer than Incandescent lamps. CFLs are available in two broad colour options - Warm White and Cool white. Cool white is suitable for visual tasks because it produces higher contrast. Warm white is better for living spaces because it is more flattering to skin tones and clothing. Energy efficient bulbs are now available in supermarkets and hardware shops. [29]

4 AIR-CONDITIONING

Even though the electrification rate is comparatively high in Swaziland, the low average income means that very few homes have air-conditioning units. The primary market for small air-conditioning units are non-residential buildings.

4.1 Status and Trends of Air-conditioning Products

4.1.1 Market Drivers

Replacement cycles are typically 10 years for outdoor units exposed to elements such as sun and rain, while well looked after indoor units can last 15 or even up to 20 years.

Lower end brands such as Midea are sold at between 650 – 750 USD for a medium sized (12000 Btu/h or 3.5kW) split unit, which includes supply and installation. Due to the lower initial costs, these units are taking ground in the industry dominated by a few well-established household names. More well-known brands such as LG, DAIKIN or SAMSUNG are sold and installed for around 900 – 1200 US$ for the same capacity unit, depending on the model of choice. [30] [31] [32]

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

Air-conditioning units are 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 Swaziland are Class A or better, mostly due to the supply from South Africa.

4.1.3 Local manufacturers, suppliers, retailers and other stakeholders

Local stakeholders mostly include retailers, distributors and installers. No small residential or commercial air-conditioning units are manufactured locally. All major international brands are well represented by local distributors and are contactable view phone or web.

Company	Details
Airconditioning & Refrigeration Services	lot 232, 1st Ave, Matsapha, Swaziland, Swaziland.
Ashlec Aircon & Refrigeration	Address: St Michaels Rd, Manzini, Swaziland, Swaziland.
Usizo Technical Services	60 King Sobhuza 11 Ave Ind Sites, Matsapha, Swaziland
National Refrigeration & Scale (PTY) Ltd	Sedco Estates, Manzini, Swaziland
Damnics Air Conditioners	Bishops Crt, Sandlane St, Manzini, Swaziland
Ecozone Swaziland	Sidwashini Business Corner, Sidwashini Ind Sites, Mbabane, Swaziland
Macnab's Refrigeration (PTY) Ltd	Lot 1002 Sidwashini Ind Site, Mbabane, Swaziland
Airconditioning & Refrigeration Services	lot 232, 1st Ave, Matsapha, Swaziland
VIVA	Postal Address O. Box 188 Ezulwini, Swaziland H106.

4.1.4 Import/export

South Africa is the primary supplier of air-conditioning units to the market in Swaziland, with roughly 85% of the market share. The secondary supplier is China, with a mere 13% over the past 10 years.

4.1.5 Barriers to overcome

Low average household incomes and poverty in general leads to decision-making that is very sensitive to cashflow and therefore against high fist cost of energy efficient equipment, even though the lower overall lifetime cost may be well known. This often results in the purchase of cheapest items, rather than energy efficient items.

Due to this mindset, the distribution and retail companies bring in products to satisfy the perceived needs of the clients, resulting in a lack of energy efficient options (variety & stock) available on the market.

4.1.6 New vs. Used Equipment

Not applicable to air-conditioning units, as the units are typically installed in a fixed location and the costs and effort of dismantling and relocating is likely to be more than 50% of a new unit.

4.2 Potential Savings from Energy-Efficient Air-conditioning

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	46 688	59 616	-6%	103 248	-7%	176 912
Business as Usual	Class B - Class A	36 313	46 368	4%	88 603	2%	165 975
Business as Usual	Class A+ & Above	20 750	26 496	7%	52 234	11%	106 824
DNV GL Projected MEPS	Lower than Class B	46 688	59 616	-28%	79 084	-19%	118 023
DNV GL Projected MEPS	Class B - Class A	36 313	46 368	24%	105 933	1%	196 740
DNV GL Projected MEPS	Class A+ & Above	20 750	26 496	21%	59 069	24%	134 950
DNV GL Projected BAT	Lower than Class B	46 688	59 616	-35%	71 395	-33%	88 132

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
DNV GL Projected BAT	Class B - Class A	36 313	46 368	14%	97 512	-14%	155 198
DNV GL Projected BAT	Class A+ & Above	20 750	26 496	54%	75 178	49%	206 381

Data & Assumptions:

- *Exchange Rate: 1 SZL = 1 ZAR = 13.5 USD.*
- *Average Residential Marginal Electricity Tariff: 0.073 USD/kWh.*
- *Average Industrial marginal Electricity Tariff: 0.101 USD/kWh.*
- *Operating hours: 8 hours per day x 125 days per annum = 1 000 hours.*
- *Average cooling capacity: 3.5kW.*
- *Electricity Cost Increase: 8% per annum.*

QTY and adoption of technologies based on information from stakeholder interviews.

Assuming these adoption rates are accurate, the following savings are projected (

Table 4.2) to be achieved under the MEPS and BAT scenarios. The U4E targets are also shown as benchmarks.

Table 4.2 Projected savings for air conditioning 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	7	20	1	7	4	13
DNV GL Projected BAT	13	48	3	17	9	31
U4E Targets	7	14	0	1	5	10

4.2.2 Job creation / elimination from EE products.

No direct impact on the market is expected, as the bulk of units are imported.

4.3 **Status of Policies and Initiatives**

4.3.1 Standards and regulations

Since almost all air-conditioning units are imported from South Africa, the regulations, published in the South African Government Gazette No. R944 (28th November 2014), in which the compulsory specifications relating to the 'Labelling of Electrical and Electronic apparatus' (VC 9008) were specified have a direct impact on Swaziland. An amendment was published (Government Gazette No. 38232) that accelerated the implementation phase for air conditioners and heat pumps, requiring compliance by 28 November 2016.

SANS 941:2014 'Energy efficiency of electrical and electronic apparatus', which states:

"1.1 Air conditioners not exceeding 7.1kW (24 000btu/h) cooling capacity, for wall-mounted split, window and portable types and heat pumps for space heating and cooling…"

Further to that, the National Regulator for Compulsory Specifications (NRCS) GG 944 specification states under section 4, 4.1 that "Air conditioners and heat pumps shall comply with SANS 941, shall have a minimum energy efficiency rating of Class B."

4.3.2 Supporting Policies – Labelling and consumer awareness campaigns

As stated above, compulsory specification for Energy Efficiency and Labelling of electrical and electronic apparatus (VC 9008), dated 28 November 2014 includes air conditioners. Companies are encouraged to manufacture and sell appliances which are energy efficient i.e. Samsung and Phillips have already signed the voluntary accord and other companies are following suit. Air conditioners shall comply with SANS 941, and shall have a minimum energy efficiency rating of Class B.

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

The National Regulator for Compulsory Specifications (NRCS) GG 944 specification states under section 4, 4.1 that "Air conditioners and heat pumps shall comply with SANS 941, shall have a minimum energy efficiency rating of Class B." However, testing and verification of compliance is not found to be enforced.

4.3.5 Environmentally Sound Management

Swaziland 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

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

5 REFRIGERATORS

5.1 Status and Trends of Refrigeration Products

5.1.1 Stock, sales, sale price, lifetime, projected growth rates, repairs and time of use.

During 2016, refrigerator sales were just over an estimated 34,000 units. The average life expectancy of a refrigerator is determined by the quality of construction and how the item is maintained. Properly maintained refrigerators can last between 14 and 17 years, depending on model and size. [33]

Market surveys and census done during 2011 indicated that around 17.5% of households in Swaziland have refrigerators. This totals just under 90,000 fridges currently in operation.

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. Some of the large retailers include GAME, BEARS, Furniture City, Morkels, Russel's, House & Home and HiFi Corporation. Most refrigerators have the standard energy efficiency labels displayed on the outside front and a variety of efficiencies were available at all the stores, ranging from MEPS (Class B) to BAT (Class A+++).

5.1.3 Local manufacturers, suppliers, retailers and other stakeholders

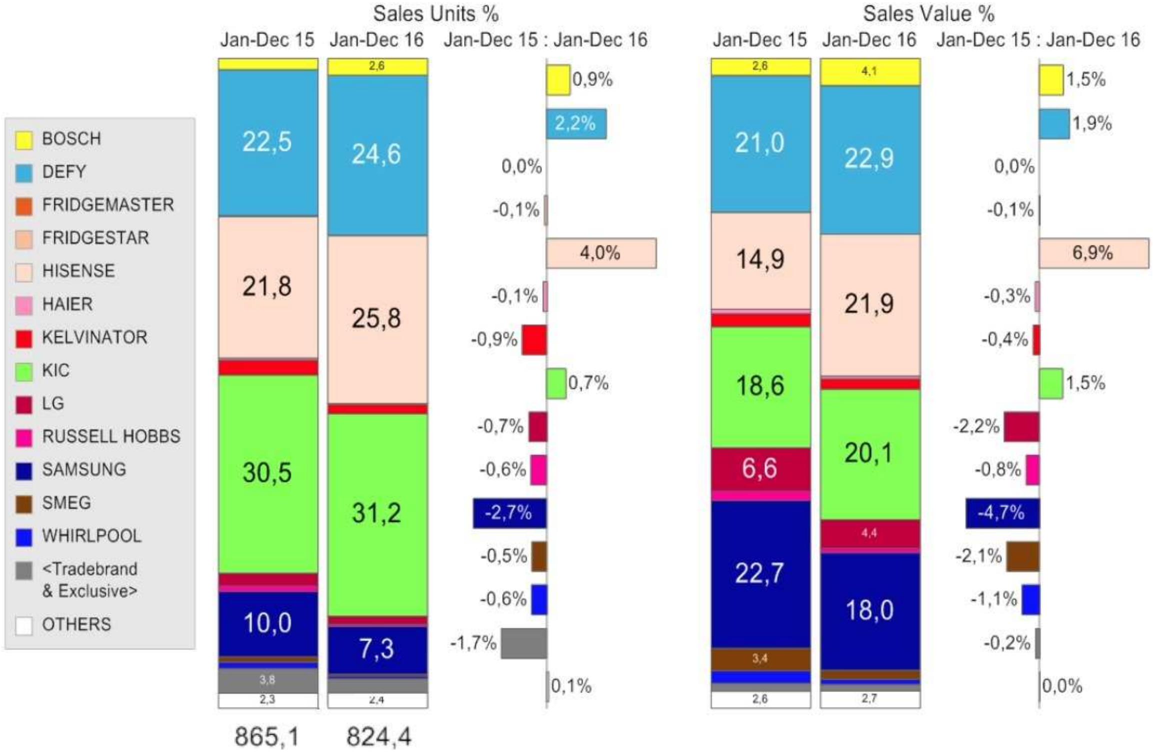


Figure 5.1 Refrigerator Market Share.

DEFY is the largest manufacturer of refrigerators in Southern Africa and holds a market share of 24.6%. Other strong competitors include Hisense and KIC, both of which come in at cheaper prices. One local manufacturer was identified: The Fridge Factory, King Mswati 3rd Avenue SIDC Factory Park Matsapha, Swaziland

5.1.4 Import/Export

South Africa is the primary supplier of refrigerators to the market in Swaziland.

5.1.5 Barriers to overcome

Old refrigerators were built to last. Therefore, some very old units are still in operation throughout Swaziland and the users are typically not willing to let these go. When new refrigerators are bought, old units are often kept as "backup", but are left running in the basement or attic. Alternatively, old refrigerators are given to friends or family who do not have the financial means to purchase their own units. The result is that these inefficient units are not removed from the system and the purchase of new units simply increases the overall number of refrigerators in the market.

5.1.6 New vs. Used

Refrigerators are very seldom repaired in Swaziland, but the economic crunch is forcing consumers to consider repair rather than replacement. 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

Current minimum energy performance standards in Swaziland requires fridges to be at least of Class B. 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. [34]

For a simple savings calculation, fridges 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	74 360	94 950	-5%	166 192	-7%	284 764
Business as Usual	Class B - Class A	26 636	34 012	9%	68 122	10%	138 554
Business as Usual	Class A+ & Above	9 989	12 755	14%	26 790	17%	57 750
DNV GL Projected MEPS	Lower than Class B	74 360	94 950	-52%	83 971	-61%	60 337
DNV GL Projected MEPS	Class B - Class A	26 636	34 012	128%	143 059	27%	334 095
DNV GL Projected MEPS	Class A+ & Above	9 989	12 755	45%	34 075	38%	86 638
DNV GL Projected BAT	Lower than Class B	74 360	94 950	-69%	54 231	-80%	19 983

Scenario	Description	QTY (2017)	QTY (2020)	Tech. Adopt (2025)	QTY (2025)	Tech. Adopt (2030)	QTY (2030)
DNV GL Projected BAT	Class B - Class A	26 636	34 012	165%	165 749	6%	322 428
DNV GL Projected BAT	Class A+ & Above	9 989	12 755	75%	41 125	83%	138 659

Data & Assumptions:

- *Exchange Rate: 1 SZL = 1 ZAR = 13.5 USD.*
- *Average Electricity Marginal Price to consumer: 0.073 USD/kWh.*
- *Electricity Cost Increase: 8% per annum.*
- *QTY and adoption of new technologies based on information from stakeholder interviews.*

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

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

Row Labels	Sum of GWh Savings (2025)	Sum of GWh Saving (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	11	32	2	8	7	20
DNV GL Projected BAT	16	40	2	10	10	26
U4E Targets	8	16	1	1	6	12

5.2.2 Job creation / elimination from EE products.

The adoption of energy efficiency has no specific impact on the local job market. Status of Policies and Initiatives

5.2.3 Standards and regulations

No specific standards or regulations are listed for refrigeration units in Swaziland, although SANS standards are assumed to be enforced.

5.2.4 Supporting Policies – Labelling and consumer awareness campaigns

Compulsory Specification for Energy Efficiency and Labelling of electrical and electronic apparatus (VC 9008), dated 28 November 2014, includes refrigerators. Companies are encouraged to manufacture and sell appliances which are energy efficient i.e. Samsung and Phillips have already signed the voluntary accord and other companies are following suit. Refrigerators shall comply with SANS 941, and shall have a minimum energy efficiency rating of Class B.

5.2.5 Financial Mechanisms

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

5.2.6 Monitoring, Verification and Enforcement

MEPS standards are monitored and enforced on imported and locally manufactured items by ensuring compliance to SANS.

5.2.7 Environmentally Sound Management

Swaziland 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".

5.2.8 Other on-going projects/initiatives

The SEC mentions energy efficiency on its website where they list several energy-saving tips.

Refrigerators and Freezers [35]

- Avoid opening the refrigerator or freezer often. The fresh air increases the temperature of the refrigerator thus increase the energy required by the compressor to keep the temperature at set point.
- Regularly defrost the fridge to avoid frost build-up. Frost build-up increases the amount of energy required to keep the compressor running.
- Allow hot foods to cool before refrigerating or freezing.
- Make sure door seals are in good condition and airtight.
- Vacuum the coils in the back of your refrigerator twice a year to maximize efficiency.
- Make sure the fridge is not exposed to direct sunlight, which can make the appliance work harder.

6 MOTORS

Many factors affect adoption and efficiency of motors, particularly the 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 [36]. 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 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 [37].

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.

An indicative guide of when to repair or when to replace a motor is depicted below in **Error! Reference source not found.** (provided by ABB).

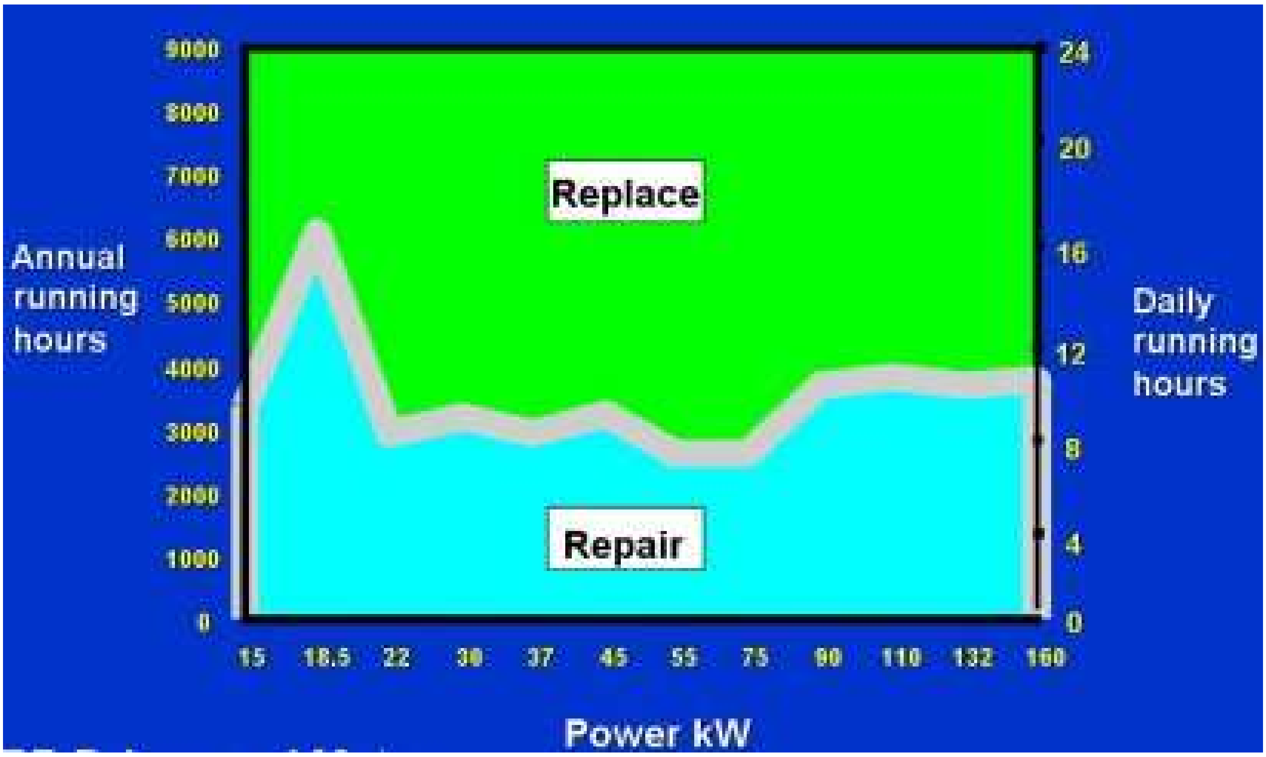


Figure 6.1 Repair/Replace power-time chart [38].

6.1.2 Price

Motors are categorized as IE1 (least efficient), IE2 (more efficient) and IE3 (most efficient). 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 cost, in countries where initial capital plays a major factor, this is one of the biggest market barriers.

A list of comparative motor prices is shown in **Figure 6.2** below.

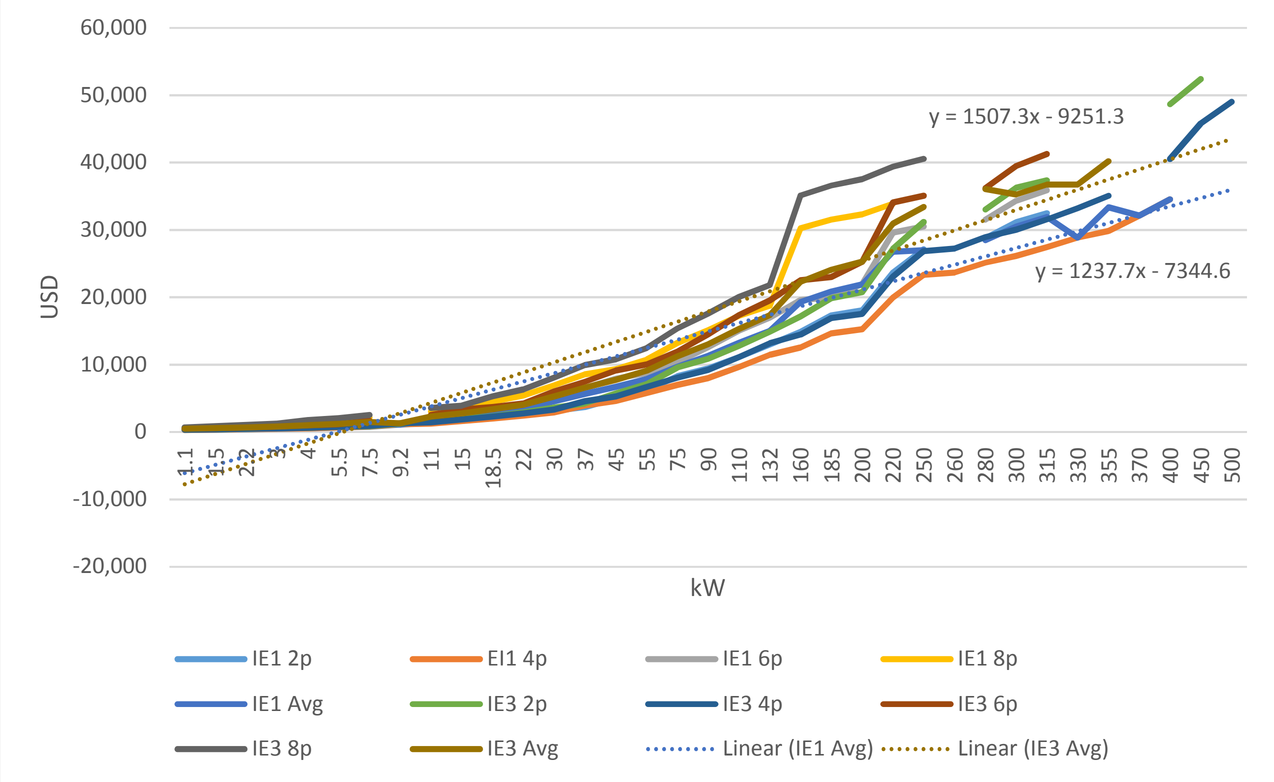


Figure 6.2 Motor Prices versus Size.

6.1.3 Purchase of motors, including where and availability of EE 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 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 Swaziland and the close 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. Local manufacturers identified include Hoageys Ltd, 56 Prairie Street (Rosettenville), Bosch Diesel Electric (Manzini) and Masterfridge. However, this is a negligible amount and for all practical purposes, one can say that most motors are imported. [39]

6.1.5 Import/Export

South Africa acts as primary point of entry into the African market for many manufacturers and distributors and therefore exports a large amount of motors to the neighboring countries. However, the majority of motors are imported from China (70%), with fewer motors coming in from the USA, Brazil, Czechia, Italy & South Africa combined, although they all represent significant market shares.

6.1.6 Barriers to overcome

Overall Inefficient Systems

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

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 actual perform the rewinding to the same standards, and optimal efficiencies are hardly ever reached. [40]

6.1.7 New vs. Used

Motors are typically used at their point of installation until 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 end of life. Therefore, there is little to no second hand electrical motor industry to speak off.

6.2 Potential Savings from Energy-Efficient Motors

Current minimum energy performance standards in Swaziland 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	53 697	68 566	-5%	120 012	-7%	205 636
Business as Usual	Class IE3	41 764	53 329	2%	100 080	1%	186 462
Business as Usual	Class IE4	23 865	30 474	8%	60 638	12%	125 128
DNV GL Projected MEPS	Class IE1 & below	53 697	68 566	-11%	112 432	-13%	180 219
DNV GL Projected MEPS	Class IE3	41 764	53 329	7%	104 852	9%	210 761
DNV GL Projected MEPS	Class IE4	23 865	30 474	13%	63 445	8%	126 245
DNV GL Projected BAT	Class IE1 & below	53 697	68 566	-13%	109 906	-20%	161 996
DNV GL Projected BAT	Class IE3	41 764	53 329	4%	102 326	6%	200 001
DNV GL Projected BAT	Class IE4	23 865	30 474	22%	68 499	23%	155 232

Data & Assumptions:

- *Exchange Rate: 1 SZL = 1 ZAR = 13.5 USD*
- *Current Average Marginal Electricity Price to consumer: 0.101 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 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.

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	9	25	2	9	6	16
DNV GL Projected BAT	13	56	3	20	9	36
U4E Targets	10	20	1	2	7	14

6.2.2 Job creation or elimination from energy efficient products

Strict implementation of high energy efficient 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

Although the Energy Policy talks about the development and implementation of energy efficiency strategies and programmes, no mention is made regarding any specific technologies.

6.3.2 Supporting Policies – Labelling and consumer awareness campaigns

All electric motors are 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

Verification of motor specification compliance is enforced by the SABS.

6.3.5 Environmentally Sound Management

Swaziland 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

No ongoing initiatives or projects are in place.

7 TRANSFORMERS

The power network in Swaziland is owned and operated by the "Swaziland Electricity Company", commonly referred to as SEC. The power networks are mostly distributed at the endpoints by pole mounted distribution transformers, some dating back to the early 1960'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 also advantageous to the environment, reducing greenhouse gas emissions. [41]

7.1 Status and Trends of Transformers

7.1.1 Markets & Drivers

SEC provided information indicating that it has approximately 4,700 distribution transformers in its distribution network.

7.1.2 Purchase of transformers, including where and availability of EE products

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

7.1.3 Local manufacturers, suppliers, retailers and other stakeholders

Some manufacturing of transformers does take place in Swaziland, specifically two manufacturers were identified: Synergy Transformers and HPCS Global Power Systems Private Limited. However, little information is available related to the sales volumes and their market share.

7.1.4 Import/ Export

The bulk of export and import is to and from South Africa.

7.1.5 Barriers to overcome

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 very slow adoption of energy efficient transformers in South Africa. Further to that, the long-life expectancy of typical transformers further reduces the potential uptake of energy efficient units.

7.1.6 New vs. Used

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

7.2 Potential Savings from Energy-Efficient Transformers

Due to the variable load on distribution transformers, it is difficult 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 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	803	1 026	-8%	1 739	-20%	2 563
Business as Usual	SEAD Tier 3 or similar	2 308	2 947	-5%	5 170	-14%	8 179
Business as Usual	SEAD Tier 5 or similar	1 589	2 028	11%	4 147	26%	9 627
DNV GL Projected MEPS	Not Rated	803	1 026	-46%	1 021	-25%	1 411
DNV GL Projected MEPS	SEAD Tier 3 or similar	2 308	2 947	-1%	5 365	-27%	7 170
DNV GL Projected MEPS	SEAD Tier 5 or similar	1 589	2 028	25%	4 671	37%	11 790
DNV GL Projected BAT	Not Rated	803	1 026	-63%	699	-66%	438
DNV GL Projected BAT	SEAD Tier 3 or similar	2 308	2 947	-20%	4 341	-73%	2 197
DNV GL Projected BAT	SEAD Tier 5 or similar	1 589	2 028	61%	6 016	60%	17 735

Data & Assumptions:

- *Exchange Rate: 1 SZL = 1 ZAR = 13.5 USD*
- *Current Average Marginal Electricity Price to consumer: 0.101 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.*

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.

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	17	39	4	14	11	25
DNV GL Projected BAT	35	108	7	38	22	70
U4E Targets	27	57	2	4	18	37

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 (small) local and regional manufacturing 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.

7.3.2 Supporting Policies – Labelling and consumer awareness campaigns

There is no labelling scheme in Swaziland to differentiate the performance levels of transformers based on the same rating, as in India (1 - 5 Star scheme), China (Grade 1 – 3 (CRGO), Australia/New Zealand (MEPS and HEPL levels), and EU (Harmonised HD428: List A – C)

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. Examples that exist elsewhere include EU (Strategies for Development and Diffusion of Energy Efficient Distribution Transformers (SEEDT) project), Australia and New Zealand [Australian and New Zealand Minerals and Energy Council (ANZMEC) Policy (1999); National Appliance and Equipment Energy Efficiency Program (NAEEEP 2002 - 2004); Regulatory Impact Statement (RIS) (2002).

7.3.4 Monitoring, Verification and Enforcement

SANS 780:2009 specifies energy performance standards for distribution transformers and is enforced by the South African Bureau of Standards (SABS) and adopted by the Swaziland government and the LEC.

7.3.5 Environmentally Sound Management

Swaziland 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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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.