Botswana Minimum Energy Performance Standards for Refrigerating Appliances.

Draft version 2

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1. Scope of Covered products

1.1 Scope

This harmonized standard applies to all refrigerating appliances of the vapor compression type, with a rated volume at or above 10 Liters (L) and at or below 1,500 L, powered by electric mains and offered for sale or installed in any application.

1.2 Exemptions

This standard does not apply to:

a) wine storage appliances,
b) refrigerating appliances with a direct sales function,
c) mobile refrigerating appliances,
d) appliances where the primary function is not the storage of foodstuffs through refrigeration,
e) other products that do not meet the definition of a Refrigerator, Refrigerator-Freezer, or Freezer, and
f) other refrigerating appliances different than vapor compression type.

2. Terms & Definitions

Definitions of the relevant terms in this document are listed below. Unless otherwise specified, these definitions are harmonized with those in Botswana IEC 62552:2015 *Household refrigerating appliances – Characteristics and test methods (Part 1, 2, and 3)*.

Ambient Temperature
Temperature in the space surrounding the refrigerating appliance under test or assessment.

Adjusted Volume (AV)
Volume for the storage of foodstuff adjusted for the relative contribution to the total energy consumption according to the different temperatures of the storage compartments. AV shall be calculated on the basis of the volume, as described in Clause 3.

Automatic Defrost
Defrosting where no action is necessary by the use to initiate the removal of frost accumulation at all temperature-control settings or to restore normal operation, and the disposal of the defrost water is automatic.

Compartment
An enclosed space within a refrigerating appliance, which is directly accessibly through one or more external doors, which may itself be divided into sub-compartments.

Fresh food compartment

Compartment for the storage and preservation of unfrozen foodstuff.

Freezer compartment
Compartment that meets three-star or four-star requirements (In certain instances, two-star sections and/or sub-compartments are permitted within the compartment.)

Frozen food compartment
Any of the following compartment types: one-star, two-star, three-star, four-star

One-star compartment
Compartment where the storage temperature is not warmer than –6 °C.

Two-star compartment
Compartment where the storage temperature is not warmer than –12 °C.

Three-star compartment
Compartment where the storage temperature is not warmer than –18 °C.

Four-star compartment
Compartment where the storage temperature meets three-star conditions and where the minimum freezing capacity meets the requirements of Clause 8 of Botswana IEC 62552-2:2015.

Competent Authority

The authority in Botswana charged with the responsibility to implement requirements on the refrigerators.

Conformity Assessment Report (CAR) or Certificate of Conformity
Documentation prepared by the manufacturer or importer of the product which contains the compliance declaration or certificate of conformity, the evidence and the test reports to demonstrate that the product is fully compliant with all applicable regulatory requirements.

Foodstuff
Food and beverages intended for consumption.

Freezer
Refrigerating appliance with only frozen compartments, at least one of which is a freezer compartment.

Frost-free refrigerating appliance
Refrigerating appliance in which all compartments are automatically defrosted with automatic disposal of the defrosted water and at least one compartment is cooled by a frost-free system.

Global Warming Potential (GWP)

A measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon, relative to an equal mass of carbon dioxide in the atmosphere. GWPs in this document refer to those measured in the IPCC's Fifth Assessment Report over a 100-year time horizon.

Manual Defrost
Defrost that is not an automatic defrost.

Mobile refrigerating appliance
A refrigerating appliance that can be used where there is no access to the mains electricity grid and that uses extra low-voltage electricity (<120 V DC) or fuel or both as the energy source for the refrigeration functionality, including a refrigerating appliance that, in addition to extra low voltage electricity or fuel, or both, can be electric mains operated.

Ozone Depletion Potential (ODP)
Amount of degradation to the stratospheric ozone layer an emitted refrigerant causes relative to trichlorofluoromethane (CFC-11). ODPs in this document refer to *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, Twelfth Edition, annexes A, B, C, and F*.

Professional Refrigerated Storage Cabinet
An insulated refrigerating appliance integrating one or more compartments accessible via one or more doors or drawers, capable of continuously maintaining the temperature of foodstuffs within prescribed limits at chilled or frozen operating temperature, using a vapor compression cycle, and used for the storage of foodstuffs in non-household environments but not for the display to or access by customers.

Refrigerating Appliance
Insulated cabinet with one or more compartments that are controlled at specific temperatures and are of suitable size and equipped for residential or light commercial use, cooled by natural convection or a forced convection system whereby the cooling is obtained by one or more energy-consuming means.

Refrigerant
Fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and at a low pressure of the fluid and rejects heat at a higher temperature and at a higher pressure of the fluid, usually involving changes of phase of the fluid.

Refrigerator
Refrigerating appliance intended for the storage of foodstuff, with at least one fresh food compartment.

Refrigerator-Freezer
Refrigerating appliance having at least one fresh food compartment and at least one freezer compartment.

Reference Ambient Temperature

Representative ambient temperature during the year for a specific region.

Steady State
Stable operating conditions in which a refrigerating appliance mean temperatures and energy consumption comply with the relevant stability requirements as defined and meet the criteria as specified in Annex B of Botswana IEC 62552-3:2015

Through-the-door-device
A device that dispenses chilled or frozen load on demand from a refrigerating appliance, through an opening in its external door and without opening that external door, such as are ice-cube dispensers or chilled water dispensers.

Wine Storage Appliance
A dedicated refrigerating appliance for the storage of wine, with precision temperature control for the storage conditions and target temperature of a wine storage compartment.

Winter Switch
A control feature for a refrigerating appliance that has more than one compartment type with one compressor and one thermostat, consisting of a switching device that guarantees, even if it would not be required for the compartment where the thermostat is located, that the compressor keeps on working to maintain the proper storage temperatures in the other compartments.

3. Requirements

Refrigerating appliances falling within the scope of Clause 1 shall meet the energy efficiency requirements of Clause 3.

3.1 Test Methods and Energy Use Calculation

Compliance with the energy efficiency requirements shall be tested according to Botswana IEC 62552:2015*, Household refrigerating appliances – Characteristics and test methods* (Botswana IEC 62552). For refrigerating appliances with through-the-door devices that can be switched on and off by the end-user, the through-the-door devices shall be switched on during the energy consumption measurement but not operating.

Energy consumption is determined, according to Botswana IEC 62552: 2015, from measurements taken when tested as specified at 16°C and at 32°C.

3.2 Daily Energy Use Calculation

All values of energy consumption and power shall be converted to daily energy consumption values in accordance with the following equations for each temperature control setting and ambient temperature.

For refrigerating appliances without a defrost control cycle, the daily energy consumption for each ambient temperature and each temperature control setting is given by:

Equation 1. $E_{daily} = P \times 24$ **in Wh**

where

E_{daily} is the energy in Wh over a period of 24 hours, and

P is the steady state power in watt for the selected temperature control setting as per Annex B of Botswana IEC 62552-3.

The measured steady state temperature for each compartment shall be recorded with this value for the test report and/or for interpolation. When interpolation is performed in order to obtain a more optimum estimate of the daily energy consumption for a given ambient temperature, the calculations for each compartment temperature and energy consumption determined in accordance with 6.8.2 shall be used as set out in Annex E of Botswana IEC 62552-3.

For refrigerating appliances with one defrost system (with its own defrost control cycle), the daily energy consumption for each ambient temperature and each temperature control setting is based on the steady state power consumption as determined in accordance with Annex B of Botswana IEC 62552-3, the incremental defrost and recovery energy determined in accordance with Annex C of Botswana IEC 62552-3 and the defrost interval determined in accordance with Annex D of Botswana IEC 62552-3 as follows:

Equation 2. $E_{daily} = P \times 24 + \frac{\Delta E_{df} \times 24}{\Delta t_{df}}$ **in Wh**

where

E_{daily} is the energy in Wh over a period of 24 hours,

P is the steady state power in watt for the selected temperature control setting as per Annex B of Botswana IEC 62552-3,

ΔE_{df} is the representative incremental energy for defrost and recovery in Wh in accordance with Annex C of Botswana IEC 62552-3, and

Δt_{df} is the estimated defrost interval in hours in accordance with Annex D of Botswana IEC 62552-3.

Where there are additional defrost systems (each with its own defrost control cycle), the value of term based on ΔE_{df} and Δt_{df} is also added in Equation 2 for each additional defrost system.

The average temperature for each compartment for this temperature control setting and energy consumption is given by:

Equation 3. $T_{average} = T_{ss} + \frac{\Delta Th_{df}}{\Delta t_{df}}$

where

$T_{average}$ is the average temperature for the compartment over a complete defrost control cycle,

T_{ss} is the average steady state temperature in the compartment for the temperature control setting in °C in accordance with Annex B of Botswana IEC 62552-3,

ΔTh_{df} is the representative accumulated temperature difference over time for defrost and recovery (relative to the steady state temperature) in degree Kelvin-hour (Kh) for the relevant compartment in accordance with Annex C of Botswana IEC 62552-3,

Δt_{df} is the estimated defrost interval in hours in accordance with Annex D of Botswana IEC 62552-3.

3.2 Maximum Energy Use

Energy performance for all refrigerating appliances within the scope of this document shall meet the maximum energy use requirements described below.

Annual Energy Consumption (AEC), as calculated per Equation 4, shall be less than or equal to Maximum Annual Energy Consumption (AEC_{Max}), as calculated per Table 2.

Equation 4. $AEC = EC_T \times (365/1000)$ in kWh per year

where EC_T is energy consumption in Wh per 24 hours based on ambient temperature T, as calculated per Equation 5 and rounded to nearest integer.

Equation 5. $EC_T = a \times E_{daily,16} + b \times E_{daily,32}$ in Wh per day

where $E_{daily,16}$ is energy consumption measured at ambient temperature 16°C and $E_{daily,32}$ is energy consumption measured at ambient temperature 32°C, in accordance with Botswana IEC 62552-3.

The reference ambient temperature for determining maximum energy use requirements is 24 °C and coefficients *a* and *b* from Table 1 can be used for Equation 5.

Table 1. Reference Ambient Temperature and Coefficients a and b for Equation 5

Reference Temperature (°C)	*a*	*b*
24	0.5	0.5

Table 2. Maximum Annual Energy Consumption (AEC_{Max})

Reference Ambient Temperature	Product Category	AEC_{Max} (kWh/year)
24°C	Refrigerators	0.163×AV+102
	Refrigerator-Freezers	0.222×AV+161
	Freezers	0.206×AV+190

where AV is Adjusted Volume, as calculated per Equation 6

Equation 6. $\boldsymbol{Adjusted\ Volume\ (AV) = \sum_{i=1}^{n}(V_i \times K_i \times F_i)}$

where V_i is volume in ith compartment, K_i is volume adjustment factor as calculated per Equation 7 and rounded to two decimal places, and F_i is frost adjustment factor.

Equation 7. $\boldsymbol{K = \frac{T_1 - T_c}{T_1 - T_2}}$

T_1 is reference ambient temperature, T_2 is temperature of fresh-food compartment (4°C), and T_c is temperature of the individual compartment concerned.

F=1.1 for frost-free (automatic defrost) is applied only to frozen food compartments. F=1.0 is applied to all other compartments and manual defrost frozen food compartments.

Table 3. Examples of Volume Adjustment Factor (K) Calculation

Reference Temperature	Fresh food compartment	Frozen food compartment	
T_1=24°C	K=1 (T_2=4°C)	T_c=-6°C	K=1.50
		T_c=-12°C	K=1.80
		T_c=-18°C	K=2.10

The AEC_{Max} calculation shall be rounded off to the nearest kWh per year. If the calculation is halfway between the nearest two kWh per year values, the AEC_{Max} shall be rounded up to the higher of these values.

For a product to meet the high efficiency grade, the performance shall be calculated per equation 8, rounded to two decimal places, and it shall meet the requirements in Table 4**. Minimum R Requirements for Refrigerating Appliances**

Category	R (CONSIDERATION 2023)	R (CONSIDERATION 2026)
Refrigerators	1.00	1.25
Refrigerator-Freezers	1.00	1.25
Freezers	1.00	1.25

Table 5.

Equation 8. $\boldsymbol{R = \frac{AEC_{Max}}{AEC}}$

R=1 where AEC is equivalent to AEC_{Max}

Table 4. Minimum R Requirements for Refrigerating Appliances

Category	R (CONSIDERATION 2023)	R (CONSIDERATION 2026)
Refrigerators	1.00	1.25
Refrigerator-Freezers	1.00	1.25
Freezers	1.00	1.25

Table 5. Labeling Requirements for Refrigerating Appliances

Category	Low	Intermediate 1	Intermediate 2	High
Refrigerators	$1.00 \leq R < 1.25$	$1.25 \leq R < 1.50$	$1.50 \leq R < 1.75$	$1.75 \leq R$
Refrigerator-Freezers	$1.00 \leq R < 1.25$	$1.25 \leq R < 1.50$	$1.50 \leq R < 1.75$	$1.75 \leq R$
Freezers	$1.00 \leq R < 1.25$	$1.25 \leq R < 1.50$	$1.50 \leq R < 1.75$	$1.75 \leq R$

3.3 Functional Performance

a. The temperature inside the fresh food compartment of the refrigerating appliance shall be adjustable to +4°C, as described in Botswana IEC 62552-3.
b. The temperature inside the freezer compartment of the refrigerating appliance shall be adjustable between -6°C and -18°C, as described Botswana IEC 62552-3.
c. A four-star compartment must be qualified with the minimum freezing capacity requirements of Clause 8 of Botswana IEC 62552-2.
d. Refrigerating appliances shall be tested at an AC voltage and frequency, as described in Botswana IEC 62552-1.
e. Refrigerating appliances shall operate appropriately with the rated voltage with surge protection +/- 15%.
f. Refrigerating appliances which, according to the manufacturer's instructions, can be used in ambient temperatures below +16°C and have a winter switch, shall have this winter switch automatically activated or de-activated according to the need to maintain the frozen compartment at the correct temperature.

3.4 Refrigerant and Foam Blowing Agent

Refrigerants and foam-blowing agents used in refrigerating appliances shall comply with requirements on their ozone depletion potential (ODP) and global warming potential (GWP) over a 100-year time horizon according to the limitations listed in Table 6.

Table 6. Requirements for Refrigerant and Foam-Blowing Agent Characteristics (numbers shown are upper limits)

Product Class	GWP	ODP

All types	20	0

Products using hydrocarbon (HC) refrigerants shall comply with Botswana IEC 60335-2-24:2020, or a subsequent revision, or a nationally modified edition of Botswana IEC 60335-2-24.

3.5 Product Information

The original equipment manufacturer shall provide a label to the importer, product retailer, or installer before the product enters the market.

The label shall indicate:

1) Model name / number;
2) Type of unit;
3) Country where the product was manufactured.
4) Volume of the different compartments and an indication of whether they are frost-free;
5) Rated performance grade;
6) Yearly energy consumption in kWh at ambient temperature in °C or °F;
7) Reference ambient temperature[s] used in performance rating;
8) Refrigerant and foam-blowing designation in accordance with ISO 817 or ASHRAE 34, including ODP and GWP.

All representations of energy performance shall indicate that the performance rating is an indicative value, and not representative of actual annual energy consumption in all situations.

The label shall be affixed on the product in a location that is readily visible for the consumer.

Products that meet the higher performance grade requirements per Clause 3 of this document are eligible for [TBD by Botswana].

5. Declaration of Conformity

Compliance with the requirements of Clause 3 and any additional optional claims shall be demonstrated in the Conformity Assessment Report (CAR), which:

1) demonstrates that the product model fulfils the requirements of this standard;
2) provides any other information required to be present in the technical documentation file; and
3) specifies the reference setting and conditions in which the product complies with this standard.

The measured storage temperatures of fresh food compartment, frozen food compartment, freezer compartment, other compartments, where applicable, shall comply with the requirements of Table 2 of Botswana IEC 62552-2.

The measured storage volume for each of the compartments shall not be less than the rated storage volume by more than 3% or 1 litre, whichever is the greater value. Where the volumes of fresh food compartment and cellar compartment are adjustable relative to one another by the user, this requirement applies when the cellar compartment is adjusted to its minimum volume.

The measured energy consumption (kWh/24h) in the energy consumption test shall not be greater than the rated energy consumption by more than 10%.

6. Market Surveillance

BERA, the entity implementing this standard shall develop a program to check compliance with this standard and surveil the market for noncompliance. The program should include details on sample size, lab accreditation requirements (ISO/IEC 17025 certified), and a challenge process that manufacturers can utilize if the initial testing of their product is found to be out of compliance.

BERA will be responsible for enforcement activities that include potential assessment of penalties for non-compliant products in the country. The authority shall establish written policies that clearly spell out its authority, procedures, and penalties. All testing done for compliance and market surveillance testing purposes shall be done using the measurement and calculation methods set out in this standard.

7. Revision

This harmonized standard shall undergo a systematic review once every five years after approval in accordance with the SADC harmonization procedures. In further revisions, if R values higher than 1 are chosen to determine a stringent requirement in maximum annual energy consumption, the equations in Table 2 do not need to be revised.

Annex 1: Supplemental Information

Supplemental information to the accompanying standard above

1. An Example of Energy Consumption Calculation for Refrigerator

The default refrigerating appliance is a refrigerator with a fresh food compartment only.

Step 1: Adjusted Volume

At reference ambient temperature 24°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	92	$\frac{24-4}{24-4} = 1.00$	$(92 \times 1.00) = 92$
Frozen food storage	-	-	

Step 2: Energy Consumption

Measurement temperature	℃	16		32	
Temperature control settings	(Graduated dial)	5.5	5.0	5.9	5.7
Temperature in fresh food compartment	℃	3.3	5.1	3.7	4.9
Energy consumption per 24h	kWh/24h	0.259	0.223	0.874	0.785
Energy consumption by interpolation*	kWh/24h	0.245		0.852	
Daily energy consumption at 24°C ($E_{daily,24}$)	kWh/24h	$0.245 \times 0.5 + 0.852 \times 0.5 = 0.549$			
Annual energy consumption at 24°C (AEC_{24})	kWh/y	200			

* Multiple tests using different temperature control settings can be conducted to obtain values of energy consumption measurement and multiples values for interpolation calculation to estimate the energy consumption for a point where the fresh food compartment is at exactly +4°C. Reference IEC 62552: 2015, part 3, Annex I (Worked examples of energy consumption calculations), section I.3.2.2 (Single compartment example) for detailed calculation methodology.

Step 3: Energy Consumption Index – R

Reference temperature	24°C
AV (L)	92
$E_{daily,24}$ (kWh/d)	0.549
AEC (kWh/y)	$0.549 \times 365 = 200$
R	$\frac{0.163 \times 92 + 102}{200} = 0.58$

The energy consumption of this model exceeds the maximum annual energy consumption requirements, i.e., R<1, and hence the model does not meet the energy performance requirement.

2. An Example of Energy Consumption Calculation for Refrigerator-Freezer

A given refrigerating appliance is a frost-free (automatic defrost) refrigerator–freezer with a fresh food compartment and a freezer compartment.

Step 1: Adjusted Volume

At reference ambient temperature 24°C

	Measured volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	137	$\frac{24-4}{24-4}=1.00$	$137\times1.00+63\times2.1\times1.1=283$
Frozen food storage	63	$\frac{24-(-18)}{24-4}=2.10$	

Step 2: Energy Consumption

Measurement temperature	℃	16		32	
Temperature control settings	(Graduated dial)	5.0	4.1	4.9	4.6
Temperature in fresh food compartment	℃	3.6	4.1	3.7	4.9
Temperature in frozen food compartment	℃	-20.9	-19.3	-21.6	-20.4
Energy consumption per 24h	kWh/24h	0.475	0.432	0.739	0.679
Energy consumption by interpolation*	kWh/24h	0.441		0.724	
Daily energy consumption at 24°C ($E_{daily,24}$)	kWh/24h	$0.441\times0.5+0.724\times0.5=0.583$			
Annual energy consumption at 24°C (AEC_{24})	kWh/y	213			

* Multiple tests using different temperature control settings can be conducted to obtain values of energy consumption measurement and multiples values for interpolation calculation to estimate the energy consumption for a point where the fresh food compartment is at exactly +4°C. Reference IEC 62552: 2015, part 3, Annex I (Worked examples of energy consumption calculations).

Step 3: Energy Consumption Index – R

Reference Temperature	24°C
AV (L)	283
$E_{daily,24}$ (kWh/d)	0.583
AEC (kWh/y)	$0.583\times365=213$
R	$\frac{0.222\times283+161}{213}=1.05$

The energy consumption of this model does not exceed the maximum annual energy consumption requirements, i.e., R>1, and hence the model meets the energy performance requirement.

3. An Example of Energy Consumption Calculation for Freezer

A given refrigerating appliance is a frost-free (automatic defrost) freezer with a freezer compartment only.

Step 1: Adjusted Volume

At reference ambient temperature 24°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	-	–	$(295 \times 2.10) \times 1.1 = 681$
Frozen food storage	295	$\frac{24-(-18)}{24-4} = 2.10$	

Step 2: Annual Energy Consumption

Measurement temperature	℃	16		32	
Temperature control settings	(Graduated dial)	3.7	3.4	3.5	3.0
Temperature in fresh food compartment	℃	-	-	-	-
Temperature in frozen food compartment	℃	-18.7	-17.8	-18.4	-17.7
Energy consumption per 24h	kWh/24h	0.691	0.665	1.330	1.294
Energy consumption by interpolation*	kWh/24h	0.671		1.309	
Daily energy consumption at 24°C ($E_{daily,24}$)	kWh/24h	$0.671 \times 0.5 + 1.309 \times 0.5 = 0.990$			
Annual energy consumption at 24°C (AEC_{24})	kWh/y	361			

* Multiple tests using different temperature control settings can be conducted to obtain values of energy consumption measurement and multiples values for interpolation calculation to estimate the energy consumption for a point where the freezer compartment is at exactly -18°C. Reference IEC 62552: 2015, part 3, Annex I (Worked examples of energy consumption calculations), section I.3.2.2 (Single compartment example) for detailed calculation methodology.

Step 3: Energy Consumption Index – R

Reference temperature	24°C
AV (L)	681
$E_{daily,24}$ (kWh/d)	0.990
AEC (kWh/y)	$0.990 \times 365 = 361$
R	$\frac{0.206 \times 681 + 190}{361} = 0.91$

The energy consumption of this model exceeds the maximum annual energy consumption requirements, i.e., R<1, and hence the model does not meet the energy performance requirement.

4. A Comparison of Product Categories and Energy Use Calculation

Energy efficiency standards and labels (S&L) are based on energy consumption values obtained from test standards. While the standard for measuring refrigerator energy consumption is broadly similar across countries, a number of factors can result in variations in energy consumption values (i.e., Wh/day or kWh/year) across countries, in particular due to different specifications for ambient temperature, compartments' internal temperature and additional features in the test procedure. Accordingly, product categories of refrigerating appliances vary based on market characteristics and regulatory perspectives. The differences in test conditions and/or use of the test results lead to different energy consumption values, which makes it difficult to compare across regions. Table 1 shows examples of product categories defined in national standards in Africa.

Table 1. Product categories of refrigerating appliances in select economies

	Draft MEPS, Rwanda	South Africa	Kenya
Reference test standard	IEC 62552: 2015	IEC 62552: 2007	IEC 62552: 2015
Reference ambient temperature	24°C	25°C	32°C for MEPS; 28°C for labels
Product category	Refrigerator	1. Household refrigerators, without low temperature compartments 2. Household refrigerators/chillers, with compartments at 5°C or 10°C, or both 3. Household refrigerators, with no star low temperature compartments 4. Household refrigerators, with 1-star frozen food compartments 5. Household refrigerators, with 2-star frozen food compartments 6. Household refrigerators, with 3-star frozen food compartments	1 Refrigerator without a low temperature compartment, automatic defrost 2 Refrigerator without a low temperature compartment, automatic defrost 3 Refrigerator with or without an ice making compartment, includes a short-term frozen food compartment, manual defrost
	Refrigerator-Freezer	7. Household refrigerators/freezers, with low temperature compartments	4 Refrigerator-freezer, fresh food compartment is cyclic defrost, freezer is manual defrost 5B Refrigerator-freezer, both compartments automatic defrost, bottom mounted freezer 5S Refrigerator-freezer, both compartments automatic defrost, side by side 5T Refrigerator-freezer, both compartments automatic defrost, top mounted freezer
	Freezer	8 Upright freezers 9 Chest freezers	6C Chest freezer, all defrost types 6U Vertical freezer, manual defrost 7 Vertical freezer, manual defrost

While Kenya's energy-efficiency standard for refrigerating appliances is based on test methods of IEC 62552: 2015, it defines two methods for calculating daily energy consumption, one for MEPS (E_{daily}_MEPS) and the other for labels (E_{daily}_Label). While the E_{daily}_MEPS is based on 32°C, the projected annual energy consumption (PAEC) is calculated for 28°C based on E_{daily}_Label (measured at 16°C and 32°C), adjusted defrost energy consumption, and load processing energy consumption. PAEC tends to be greater than E_{daily}_MEPS. Energy consumption that appears on the product labels in Kenya is comparative energy consumption (CEC), a nominal average energy consumption based on PAEC, so it is necessary to take into consideration the difference between Kenya's CEC and the energy use calculation in the draft standard. Table 2 shows an example of energy use calculations for one sample product under Kenya's standard and the draft regional standard.

Table 2. Energy use calculations in Kenya and the draft regional standard

Measurement temperature	℃	32		16	
Temperature in fresh food compartment	℃	4.65	3.16	4.77	2.62
Temperature in freezer food compartment	℃	-19.72	-17.08	-19.6	-17.68
Steady state power	W	55.53	53.40	24.52	24.19
Incremental energy for defrost	Wh	123.13	125.91	149.69	133.11
Defrost interval	h	26.4	26.4	52.8	52.8
Energy consumption per 24h (E_{daily}_MEPS)	kWh/24h	1.442	1.389	0.670	0.632
Energy consumption by interpolation[a] (E_{daily}_MEPS)	kWh/24h	1.407		0.645	
Annual energy consumption at 32°C (AEC_{32})	kWh/y	$1.407 \times 365 = 514$			
Projected MEPS energy consumption (PMEC) for Kenya	kWh/y	$AEC_{32} + 8.76 \times W_{heater}$[b] $= 514$			
Daily energy consumption at 24°C ($E_{daily,24}$) for Draft Regional Standard	kWh/24h	$1.407 \times 0.5 + 0.645 \times 0.5 = 1.026$			
Annual energy consumption at 24°C (AEC_{24}) For Draft Regional Standard	kWh/y	375			
For Kenya labels					
Incremental energy for defrost (for label)	Wh	233.95	239.23	284.41	252.91
Energy consumption per 24h (E_{daily}_Label)	kWh/24h	1.542	1.492	0.732	0.686
Energy consumption by interpolation[a] (E_{daily}_Label)	kWh/24h	1.512		0.695	
Number of days in operation per year	days	259		106	
Load processing efficiency	W/W	0.98		2.5	
Projected AEC (PAEC) at 28°C[c]	kWh/y	541			
Comparative energy consumption (CEC)[d]	kWh/y	580			

[a] Multiple tests using different temperature control settings can be conducted to obtain values of energy consumption measurement and multiples values for interpolation calculation to estimate the energy consumption for a point where the fresh food compartment is at exactly +4°C. Reference IEC 62552: 2015, part 3, Annex I (Worked examples of energy consumption calculations).

[b] W_{heater} is the average power in watts of any ambient controlled anti-condensation heater. $W_{heater} = 0$ above.

[c] $= 259 \times E_{daily,32-label} + 106 \times E_{daily,16} + W_{heater} \times 8.76 + \frac{V_{frozen} \times 0.091 + V_{unfrozen} \times 0.274}{Load\ processing\ efficiency}$, where V_{frozen} is the total volume of all frozen compartments and $V_{unfrozen}$is the total volume of all unfrozen compartments.

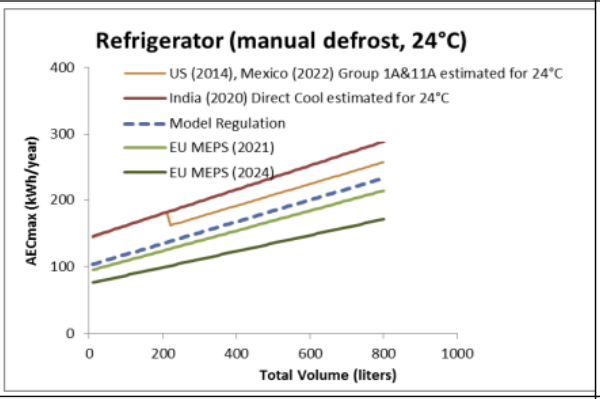
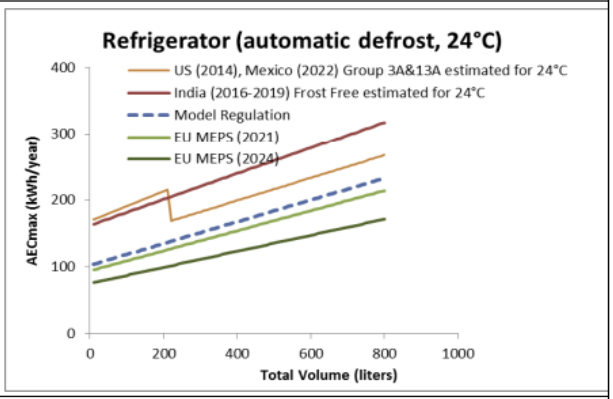
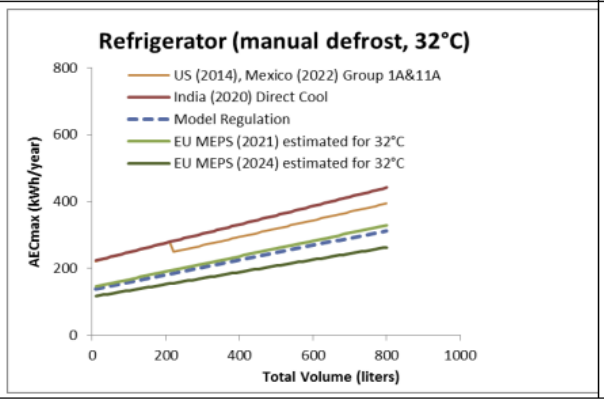
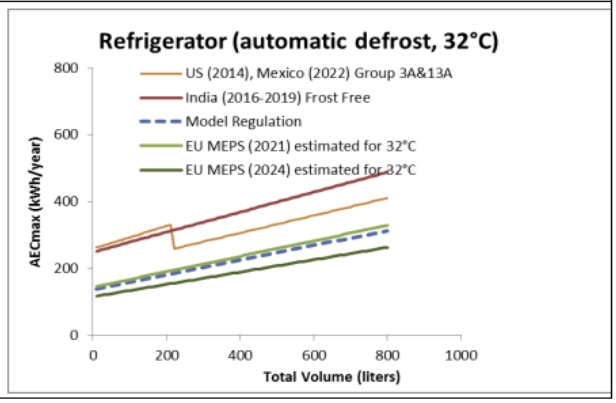
[d] The CEC for the appliance model is determined from the values of PAEC for the units tested. The CEC and normalized volume (Vnorm) are then used to calculate the base energy consumption (BEC), which is the nominal energy consumption of a model of a given group and total adjusted volume with a star rating index (SRI) of 1.00, and the star rating.

5. Trends in Energy Efficiency Standards

The maximum energy consumption requirements for refrigerator-freezers to be effective in 2025 are roughly comparable with those from the current U.S. (effective in 2014), Mexico (effective in 2022), and the current EU standards (effective in 2021). These requirements are expected to be cost-effective in many countries, mainly because the U.S. and EU set such requirements according to robust technical and economic analyses, and these are large markets that influence the cost and availability of such products more broadly. Setting requirements that are consistent with the expected market transition in major emerging economies that have robust policies provides an important policy signal to manufacturers that also sell to those markets with outdated, under-enforced, or no mandatory MEPS and labels. A common or comparable set of requirements will help manufacturers prepare to offer products that can be sold more broadly, with an aim to unlock greater economies of scale so that energy-efficient solutions are more widely accessible. Combining the transition toward higher efficiency with the transition toward lower-GWP refrigerants would allow the industry to exploit synergies in redesigning equipment and retooling manufacturing lines to pursue both opportunities simultaneously. The 2023 requirements are less stringent by 25% than the 2025 requirements. It would be beneficial for the countries to have the MEPS rolled out in a phased manner, improving the policy process and infrastructure.

Tables 7, 8, and 9 illustrate comparisons of the **Model Regulation Guidelines**, which are exactly the same as the **Botswana Minimum Energy Performance Standards**, with select standards for reference temperatures of 24°C and 32°C.

Table 7: Comparison of Model Regulation Guidelines (Botswana Minimum Energy Performance Standards) with select – refrigerators[1]

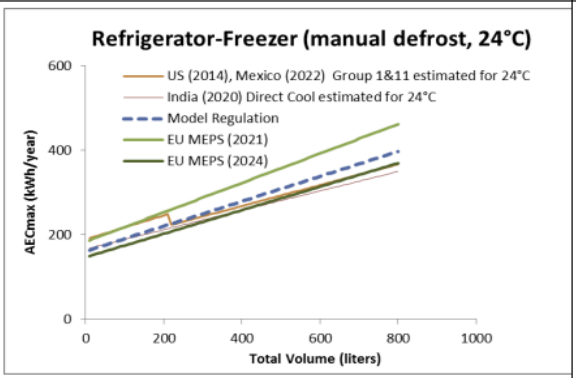
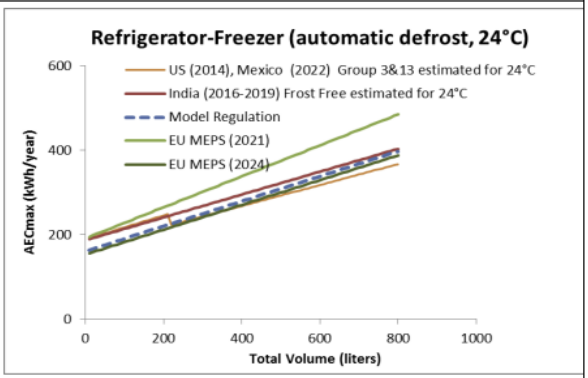
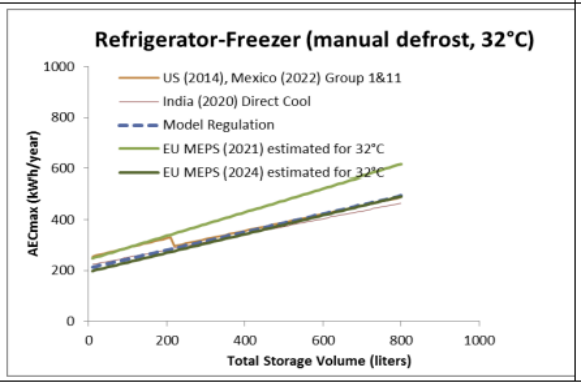
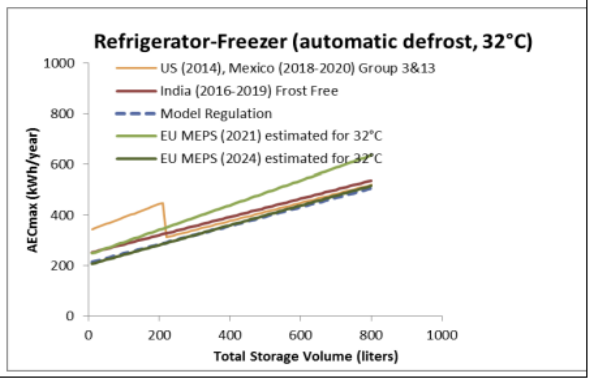
Ref. Temp.	Maximum Annual Energy Consumption (AECmax, kWh/year) in Refrigerators	
	Manual Defrost	Automatic Defrost
24°C		
32°C		

Notes:

1. For refrigerators, energy consumption at 24°C according to the Indian and Mexican standards is assumed to be less by 35 per cent than the energy consumption at 32°C. Energy consumption at 32°C according to the EU standard is assumed to be greater by 35 per cent than the energy consumption at 24°C.
2. Based on refrigerators with fresh food compartment only.

[1] The U.S. standard has different requirements for products of less than 220 L

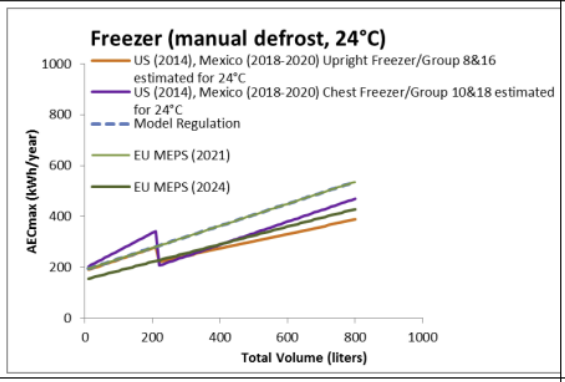
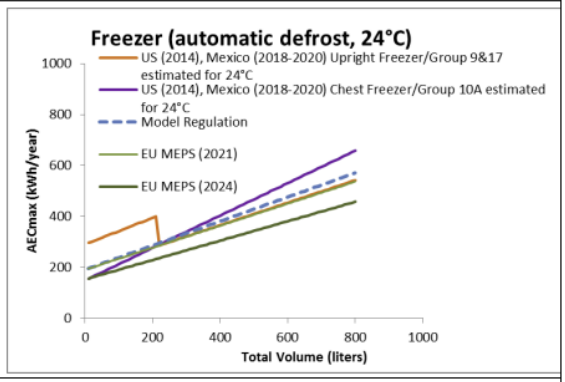
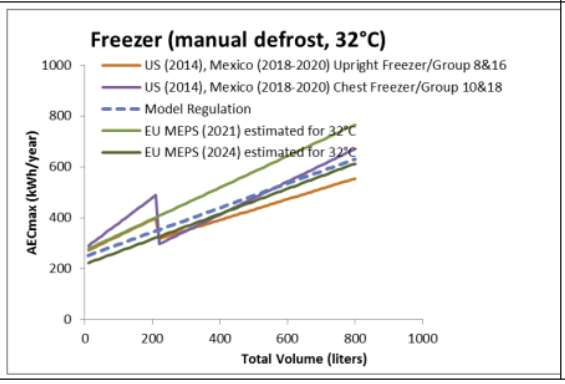
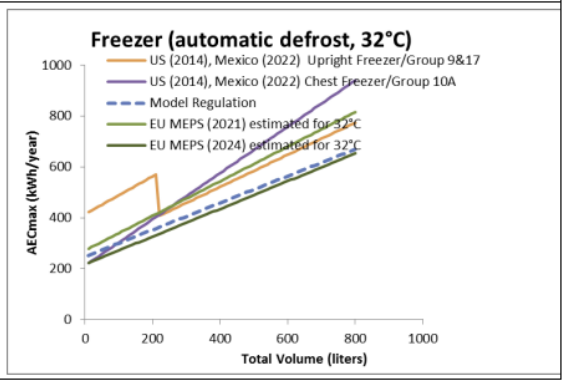
Table 8:Comparison of the Model Regulation Guidelines (Botswana Minimum Energy Performance Standards) with select standards – refrigerator freezers

Ref. Temp.	Maximum Annual Energy Consumption (kWh/year) in Refrigerator-Freezers	
	Manual Defrost	Automatic Defrost
24°C		
32°C		

Notes:

1. For refrigerator-freezers, energy consumption at 24°C according to the Indian and Mexican standards is assumed to be less by 25 per cent than the energy consumption at 32°C. Energy consumption at 32°C according to the EU standard is assumed to be greater by 25 per cent than the energy consumption at 24°C.
2. Based on two-door frost-free refrigerators with fresh food compartment volume accounting for 70 per cent of the total storage volume.

Table 9: Comparison of the Model Regulation Guidelines (Botswana Minimum Energy Performance Standards) with select standards – freezers

Ref. Temp.	Maximum Annual Energy Consumption (kWh/year) in Freezers	
	Manual Defrost	Automatic Defrost
24°C		
32°C		

Notes:

1. For freezers, energy consumption at 24°C according to the Indian and Mexican standards is assumed to be less by 30 per cent than the energy consumption at 32°C. Energy consumption at 32°C according to the EU standard is assumed to be greater by 20 per cent than the energy consumption at 24°C.
2. According to the U.S standard, there is a dimensionless correction factor of 0.7 for energy consumption in chest freezers and 0.85 for energy consumption in upright freezers. These correction factors are applied in the comparison.
3. As the automatic defrost type of freezers tends to need more energy than the manual defrost type, the Model Regulation Guidelines align the requirements further with the automatic defrost type.