UN environment

SUPPLEMENT TO THE REFRIGERATORS POLICY GUIDE:
«ACCELERATING THE GLOBAL ADOPTION OF CLIMATE-FRIENDLY AND ENERGY-EFFICIENT REFRIGERATORS»

MODEL REGULATION GUIDELINES

SEPTEMBER 2019

CLIMATE-FRIENDLY AND ENERGY-EFFICIENT REFRIGERATORS

U4E United for Efficiency

KIGALI COOLING EFFICIENCY PROGRAM

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Foreword

The Model Regulation Guidelines supplement the United for Efficiency (U4E) Refrigerator Policy Guide, "Accelerating the Global Adoption of Climate-Friendly and Energy-Efficient Refrigerators."[1] It is voluntary guidance for governments in developing and emerging economies that are considering a regulatory or legislative framework that requires new refrigerating appliances to be energy-efficient and to use refrigerants with a lower global warming potential (GWP) than typical legacy refrigerants, and to ban the importation of used products.[2] It covers products commonly used in residential and light commercial applications. An accompanying Supporting Information Document includes the underlying rationale and methodologies.

Refrigerators are one of the first appliances sought by households as electricity becomes available and incomes rise. Ownership levels grow almost as fast as electrical grid connections. The projected stock of refrigerators in use in developing and emerging economies is expected to double from approximately 1 billion today to nearly 2 billion by 2030.[3] Refrigerating appliances, while only part of the overall cold chain that is needed to maintain proper conditions for food and medicines, are invaluable for the health and well-being of consumers. The key is expanding access to cooling while mitigating impacts on energy supplies, the environment and the planet.

Minimum Energy Performance Standards (MEPS) and energy labels, if well-designed and implemented, are some of the fastest and most effective approaches to transition markets toward more energy-efficient products. While a number of countries have MEPS and/or labels, many are outdated or unenforced. Inadequate MEPS and labels leave countries vulnerable as dumping grounds for products that cannot be sold elsewhere. Electricity consumption varies widely by type, size, age, and maintenance of the unit. Household refrigerating appliances in some unregulated markets have been found to consume over 1,000 kilowatt hours of electricity (kWh) per year, whereas some of the best consume around one-fourth as much.[4] Such savings have profound impacts on the cost to own and operate these devices.

Refrigerating appliances require electricity and a refrigerant to operate. When electricity comes from fossil fuel power plants – which is the case for nearly 75 per cent of the electricity in non-OECD countries – greenhouse gasses and air pollution are emitted. Many refrigerants have a global warming potential that is well over 1,000 times as potent as an equivalent molecule of carbon dioxide. Fortunately, technologies are widely available to improve energy efficiency and to use refrigerants with a lower global warming potential.

Under the Kigali Amendment to the Montreal Protocol, countries will phase-down hydrofluorcarbons (HFCs) by over 80 per cent over the next 30 years. The climate benefits are

[1] Policy Guide is available at https://united4efficiency.org/resources/accelerating-global-adoption-energy-efficient-refrigerators
[2] Such as Hydrochlorofluorocarbons and hydrofluorocarbons
[3] Policy Guide p. 20
[4] Policy Guide p. 14

significantly enhanced by improving energy efficiency while phasing down HFCs. U4E co-organised capacity building "Twinning" workshops for senior energy and environment officials from nearly 130 countries in 2018 and again in 2019 on sustainable cooling solutions. Many attendees expressed concerns about setting disjointed policies that only address efficiency or refrigerants and requested guidance on MEPS and labels that address both topics.

U4E consulted dozens of experts from various sectors and regions to assess best practices and new developments. The aim has been to balance ambitious energy performance and refrigerant requirements while limiting adverse impacts on the upfront costs and availability of products. Further evaluations (e.g. market assessments, and consumer, utility and manufacturer impact analyses) are needed before pursuing such guidance. The contents were developed assuming interested countries would put them into effect in approximately 2023, but the timing and text should be adjusted to whenever and however is most appropriate. While commonly-used standards are referenced, countries may be familiar with others that work well for their context.

Each country has unique characteristics. This guidance is intended as a starting point to inform regulatory considerations rather than a final template to adopt. Regulatory processes should be undertaken transparently and with sufficient time to address local circumstances (e.g., availability and prices of products, income levels, utility tariffs, etc.). It is typically led by an energy ministry with the support of a national standards body and conducted in consultation with many experts from the public and private sectors, and civil society.[5] The National Ozone Unit (often in the environment ministry) should be closely involved in this process.

Countries committed to market transformation and prepared to invest in the requisite market assessment, impact analyses, stakeholder consultations, monitoring, verification, enforcement, awareness raising, and beyond should strongly consider mandatory MEPS and labels. Neighboring countries should align where practicable to reduce complexity and compliance costs for manufacturers and alleviate some of the challenges of oversight and enforcement for officials. Consistent approaches across countries helps yield economies of scale for efficient products that save consumers money on electricity bills, reduce air pollution, mitigate greenhouse gas emissions, and enable greater electrical grid stability.[6] U4E hopes this guidance is helpful with unlocking the many benefits of energy-efficient and climate-friendly cooling.

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[5] See figure 2.9 on page 60 of the Report on the Issues Related to Energy Efficiency while Phasing Down HFCs for an overview of a typical regulatory process, available at http://conf.montreal-protocol.org/meeting/mop/mop30/presession/Background-Documents/TEAP_DecisionXXIX-10_Task_Force_EE_September2018.pdf

[6] For an approximation of the electricity and greenhouse gas impacts of adopting the model regulation guidance, see the U4E Country Savings Assessments at https://united4efficiency.org/countries/country-assessments

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Acronyms

AEC	Annual Energy Consumption
AV	Adjusted Volume
CAR	Conformity Assessment Report
EC	Energy Consumption
GWP	Global Warming Potential
HC	Hydrocarbon
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
K	Volume Adjustment Factor
kWh	Kilowatt-hour
L	Liters
ODP	Ozone Depletion Potential
U4E	United for Efficiency
Wh	Watt-hour

Article 1. Scope of Covered products

1.1 Scope

This regulation 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 regulation 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.

Article 2. Terms & Definitions

Definitions of the relevant terms in this document are listed, below. Unless otherwise specified, these definitions are harmonized with those in 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 Article 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 IEC 62552-2:2015.

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*.

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.

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.

Article 3. Requirements

Refrigerating appliances falling within the scope of Article 1 shall meet the energy efficiency requirements of Article 3. The importation of used refrigerating appliances is prohibited.

3.1 Test Methods and Energy Use Calculation

Compliance with the energy efficiency requirements shall be tested according to IEC 62552:2015, *Household refrigerating appliances – Characteristics and test methods* (IEC 62552).[7] 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.

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.

[7] Energy consumption is determined, according to IEC 62552: 2015, from measurements taken when tested as specified at 16°C and at 32°C. Energy consumption can be measured at 32°C only (or 16°C only) if the reference ambient temperature defined by the regulation is 32°C (or 16°C, respectively). Using 16°C or 32°C as reference ambient temperatures is, however, not recommended as this defeats the purpose of IEC 62552 having two test temperatures. While IEC 62552 methods are primary references, countries might consider others that fulfil the same objective and maintain the energy efficiency requirements.

Annual Energy Consumption (AEC), as calculated per Equation 1[8], shall be less than or equal to Maximum Annual Energy Consumption (AEC_{Max}), as calculated per Table 2.

Equation 1. 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 2 and rounded to nearest integer.

Equation 2. $EC_T = \boldsymbol{a} \times EC_{16} + \boldsymbol{b} \times EC_{32}$ in Wh per day

where EC_{16} is energy consumption measured at ambient temperature 16°C and EC_{32} is energy consumption measured at ambient temperature 32°C, in accordance with IEC 62552-3: 2015.

If the typical temperature where refrigerating appliances are used in the country is not known, the reference ambient temperature of 24 °C and coefficients *a* and *b* from Table 1 can be used for Equation 2.

Table 1. Reference Ambient Temperature and Coefficients a and b for Equation 2

Reference Ambient 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 3

Equation 3. $\boldsymbol{Adjusted\ Volume\ (AV)} = \sum_{i=1}^{n}(\boldsymbol{V_i} \times \boldsymbol{K_i} \times \boldsymbol{F_i})$

where:

- V_i: Volume in *i*th compartment

[8] Some reginal standards add load processing efficiency or auxiliary energy consumption to set the annual maximum energy consumption requirements. IEC 62552: 2015 specifies test methods for load processing efficiency and energy consumption of specified auxiliaries.

- K_i is volume adjustment factor, as calculated per Equation 4 and rounded to two decimal places, and Fi is frost adjustment factor.

Equation 4. $K = \frac{T_1 - T_c}{T_1 - T_2}$

T_1 is reference ambient temperature selected by the country, T_2 is temperature of fresh-food compartment (4°C), and T_c is temperature of the individual compartment concerned.[9]

F=1.1 for frost-free (automatic defrost) is applied only to frozen food compartments, otherwise *F*=1.0.

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.

A reference ambient temperature can be selected to be lower or greater than 24°C, if appropriate for the country. Tables 4 and 5 show optional references ambient temperatures, and associated requirements. For another ambient temperature, interpolation or extrapolation is performed to obtain an optimum estimate of the daily energy consumption.

Table 3. Optional Reference Ambient Temperatures and Coefficients a and b for Equation 2

Reference Ambient Temperature (°C)	a	b
20	0.75	0.25
32	0	1.0

Table 4. Maximum Annual Energy Consumption (AEC_{Max}) for Optional Reference Temperatures

Reference Temperature	Product Category	AEC_{Max} (kWh/year)
20°C	Refrigerators	0.134×AV+84
	Refrigerator-Freezers	0.188×AV+137
	Freezers	0.175×AV+161
32°C	Refrigerators	0.220×AV+137
	Refrigerator-Freezers	0.288×AV+210
	Freezers	0.268×AV+247

[9] See annex 1 for examples of the Energy Consumption Calculation, and annex 2 for examples of the Volume Adjustment Factor (K) Calculation

For a product to meet the high efficiency grade, the performance shall be calculated per equation 5, rounded to two decimal places, and it shall meet the requirements in Table 9.

Equation 5. $$R = \frac{AEC_{Max}}{AEC}$$

3.3 Functional Performance

The temperature inside the fresh food compartment of the refrigerating appliance shall be adjustable to +4°C, as described in IEC 62552-3: 2015.

The temperature inside the frozen food compartment of the refrigerating appliance shall be adjustable between -6°C and -18°C, as described IEC 62552-3: 2015.

A four-star compartment must be qualified with the minimum freezing capacity requirements of Clause 8 of IEC 62552-2:2015.

Refrigerating appliances shall be tested at an AC voltage and frequency, as described in IEC 62552-1: 2015.

Refrigerating appliances shall operate appropriately with the rated voltage with surge protection +/- 15%.

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[10]

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 7.

Table 5. Requirements for Refrigerant and Foam-Blowing Agent Characteristics (numbers shown are upper limits)

Product Class	GWP	ODP
All types	20	0

[10] Countries may wish to vary the date by which these requirements come into effect based on the availability and cost of viable refrigerant gasses, which may not coincide with the availability and cost of meeting the energy-efficiency requirements.

Products using hydrocarbon (HC) refrigerants shall comply with IEC 60335-2-24:2010/AMD:2017, or a subsequent revision, or a nationally-modified edition of IEC 60335-2-24.

Table 6. Refrigerant Charge Size Limits for Hydrocarbons (HCs)

Product Class	Maximum Charge
All types (domestic refrigeration)	0.15 kg

3.5 Product Information

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

The label shall indicate:

1) Model name / serial number;
2) Type of unit [refrigerator, refrigerator-freezer, or freezer];
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 based on the measurement according to [test standard name], 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.

Article 4. Entry into Force

This regulation shall enter into force no earlier than [date] and at least [six months/1 year] after adoption.

Article 5. Declaration of Conformity

Compliance with the requirements of Article 3 and any additional optional claims shall be demonstrated in the CAR, which:

1) demonstrates that the product model fulfils the requirements of this regulation;
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 regulation.

The CAR shall be submitted to [agency name] for review prior to making the product available for sale. If the CAR for the designated model is approved, which is confirmed by written correspondence from [agency name][11] and listing of the product on any applicable [product registration system], the model may be sold in the market. If a CAR is rejected, a written explanation will be provided to the submitter. All aspects identified in the written explanation shall be addressed in a revised CAR. Until the CAR is approved, the product is ineligible for sale in the market. The CAR is valid for the designated model for 24 months. An updated CAR or a notice of withdrawal shall be submitted to [agency name] at least 90 days prior to the change in specifications of or cancelation of production of the currently certified product.

Article 6. Market Surveillance

The designated authority implementing this regulation 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.[12] The program shall also consider specifying the tolerance for differences in annual energy consumption and volume between a product's certified rating and the measurements resulting from verification testing of that product.[13]

[Agency name] will be responsible for enforcement activities that include potential assessment of penalties for non-compliant products in the country. [Agency name] 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 regulation.

[11] Responsibilities are often split across various agencies, so list whichever are appropriate for each step.

[12] For further guidance on how to develop and implement compliance certification, market surveillance and enforcement programs please refer to the U4E Policy Guide. Additional stipulations regarding such protocols are often included in MEPS and labelling legislation / policy documents. Given the variance in approaches based on national context, a specific example is not provided in this guidance.

[13] For example, for a product to be in compliance under some existing regulations, the annual energy consumption determined via verification testing must be no more than 10% higher than the certified consumption level. In addition, the volume determined via verification testing must be within ±3% of the certified volume rating. These tolerance values can vary, and setting the specific values is part of each individual regulatory process.

Article 7. Revision

This regulation shall be strengthened by a simple administrative rulemaking based on an updated market assessment conducted on the cost and availability of new technologies once every five years after this regulation enters into force.

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 or Table 5 do not need to be revised. If R=1 indicates the requirement of maximum annual energy consumption, the equations in Table 2 or Table 5 need to be updated by adjusting the coefficients.

Annex 1. Examples of the Energy Consumption Calculation

A. Refrigerator

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

Step 1: Adjusted Volume

At reference ambient temperature 20°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	92	$\frac{20-4}{20-4} = 1.00$	$(92 \times 1.00) = 92$
Frozen food storage	-	-	

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	-	-	

At reference ambient temperature 32°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	92	$\frac{32-4}{32-4} = 1.00$	$(92 \times 1.00) = 92$
Frozen food storage	-	-	

Step 2: Annual Energy Consumption

Measurement temperature	°C	16		32	
Temperature control settings	(Graduated dial)	5.5	5.0	5.9	5.7
Temperature in fresh food compartment	°C	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 20°C (EC_{20})	kWh/24h	$0.245 \times 0.75 + 0.852 \times 0.25 = 0.397$			
Annual energy consumption at 20°C (AEC_{20})	kWh/y	145			
Daily energy consumption at 24°C (EC_{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	20°C	24°C	32°C
Volume (L)	Fresh food compartment (92)		
AV (L)	92	92	92
EC (kWh/d)	0.397	0.549	0.852
AEC (kWh/y)	$0.397\times 365 = 145$	$0.549\times 365 = 200$	$0.852\times 365 = 311$
R	$\frac{0.134 \times 92 + 84}{145} = 0.66$	$\frac{0.163 \times 92 + 102}{200} = 0.58$	$\frac{0.220 \times 92 + 137}{311} = 0.51$

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.

B. 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 20°C

	Measured volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	137	$\frac{20-4}{20-4} = 1.00$	$137 \times 1.00 + 63 \times 2.38 \times 1.1 = 302$
Frozen food storage	63	$\frac{20-(-18)}{20-4} = 2.38$	

At reference ambient temperature 24°C

	Measured volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	137	$\frac{24-4}{24-4} = 1.00$	$137 \times 1.00 + 63 \times 2.1 \times 1.1 = 283$
Frozen food storage	63	$\frac{24-(-18)}{24-4} = 2.10$	

At reference ambient temperature 32°C

	Measured volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	137	$\frac{32-4}{32-4} = 1.00$	$137 \times 1.00 + 63 \times 1.79 \times 1.1 = 261$
Frozen food storage	63	$\frac{32-(-18)}{32-4} = 1.79$	

<u>Step 2: Annual Energy Consumption</u>

Measurement temperature	°C	16		32	
Temperature control settings	(Graduated dial)	5.0	4.1	4.9	4.6
Temperature in fresh food compartment	°C	3.6	4.1	3.7	4.9
Temperature in frozen food compartment	°C	-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 20°C (EC_{20})	kWh/24h	$0.441 \times 0.75 + 0.724 \times 0.25 = 0.512$			
Annual energy consumption at 20°C (AEC_{20})	kWh/y	187			
Daily energy consumption at 24°C (EC_{24})	kWh/24h	$0.441 \times 0.5 + 0.724 \times 0.5 = 0.583$			
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).

<u>Step 3: Energy Consumption Index – R</u>

Reference Temperature	20°C	24°C	32°C
Volume (L)	Fresh food compartment (137), Frozen food compartment (63)		
AV (L)	302	283	261
EC (kWh/d)	0.512	0.583	0.724
AEC (kWh/y)	$0.512 \times 365 = 187$	$0.583 \times 365 = 213$	$0.724 \times 365 = 264$
R	$\frac{0.188 \times 302 + 137}{187} = 1.06$	$\frac{0.222 \times 283 + 161}{213} = 1.05$	$\frac{0.288 \times 261 + 210}{264} = 1.08$

The energy consumption of this model exceeds the maximum annual energy consumption requirements, i.e., R>1, and hence the model meets the energy performance requirement.

1-C. 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 20°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	-	-	$(295 \times 2.38) \times 1.1 = 772$
Frozen food storage	295	$\frac{20-(-18)}{20-4} = 2.38$	

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	$\frac{24-(-18)}{24-4} = 2.10$	

At reference ambient temperature 32°C

	Volume (L)	Volume Adjustment Factor (K)	Adjusted Volume (L)
Fresh food storage	-	-	$(295 \times 1.79) \times 1.1 = 581$
Frozen food storage	295	$\frac{32-(-18)}{32-4} = 1.79$	

Step 2: Annual Energy Consumption

Measurement temperature	°C	16		32	
Temperature control settings	(Graduated dial)	3.7	3.4	3.5	3.0
Temperature in fresh food compartment	°C	-	-	-	-
Temperature in frozen food compartment	°C	-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 20°C (EC_{20})	kWh/24h	$0.671 \times 0.75 + 1.309 \times 0.25 = 0.831$			
Annual energy consumption at 20°C (AEC_{20})	kWh/y	303			
Daily energy consumption at 24°C (EC_{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	20°C	24°C	32°C
Volume (L)	Frozen food compartment (295)		
AV (L)	772	681	581
EC (kWh/d)	0.831	0.990	1.309
AEC (kWh/y)	$0.831\times 365 = 303$	$0.990\times 365 = 361$	$1.309\times 365 = 478$
R	$\frac{0.175 \times 772 + 161}{303} = 0.98$	$\frac{0.206 \times 681 + 190}{361} = 0.91$	$\frac{0.268 \times 581 + 247}{478} = 0.84$

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.

Annex 2. Examples of Volume Adjustment Factor (K) Calculation

Table 7. 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
T_1=20°C	K=1 (T_2=4°C)	T_c = -6°C	K=1.63
		T_c = -12°C	K=2.00
		T_c = -18°C	K=2.38
T_1=32°C	K=1 (T_2=4°C)	T_c = -6°C	K=1.36
		T_c = -12°C	K=1.57
		T_c = -18°C	K=1.79

Annex 3. Performance Grade Requirements

Labels indicating achievement of a higher performance grade may be applied to units that meet or exceed the levels specified in Article 3 during testing for compliance with the Article 3 requirements. Table 8 shows a possible scale for energy performance ratings for refrigerating appliances.

Table 8. Labeling Requirements for Refrigerating Appliances

Grade	Refrigerators	Refrigerator-Freezers	Freezers
High Efficiency	$R \geq 1.50$	$R \geq 1.50$	$R \geq 1.50$
Intermediate	$1.25 \leq R < 1.50$	$1.25 \leq R < 1.50$	$1.25 \leq R < 1.50$
Low Efficiency	$1.00 \leq R < 1.25$	$1.00 \leq R < 1.25$	$1.00 \leq R < 1.25$

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