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SUSTAINABLE PUBLIC PROCUREMENT

GREEN PUBLIC PROCUREMENT TECHNICAL GUIDELINES AND SPECIFICATIONS FOR ENERGY-EFFICIENT AIR CONDITIONERS

One planet procure with care

U4E UN environment programme United for Efficiency

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Green Public Procurement Technical Guidelines and Specifications for Energy Efficient Air Conditioners

PORTABLE AIR CONDITIONERS, SPLIT CONDITIONERS, WINDOW AIR CONDITIONERS, DUCTED AIR CONDITIONERS

November 2021

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

AE	Annual energy consumption
APF	Annual performance factor
CSPF	Cooling seasonal performance factor
EC	Energy cost
EE	Energy efficiency
EOF	End of life
EPR	Extended producer responsibility
EER	Energy efficiency ratio
GDP	Gross domestic product
GEF	Global environment facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
HSPF	Heating seasonal performance factor
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LCC	Life cycle cost
MC	Maintenance cost
MEPS	Minimum Energy Performance Standards
ODP	Ozone depletion potential
OECD	Organization for Economic Co-operation and Development
SEER	Seasonal energy efficiency ratio
SPP	Sustainable Public Procurement
TD	Transmission and distribution losses
UNEP	United Nations Environment Programme
U4E	United for Efficiency
WEEE	Waste Electrical and Electronic Equipment

1. FOREWORD

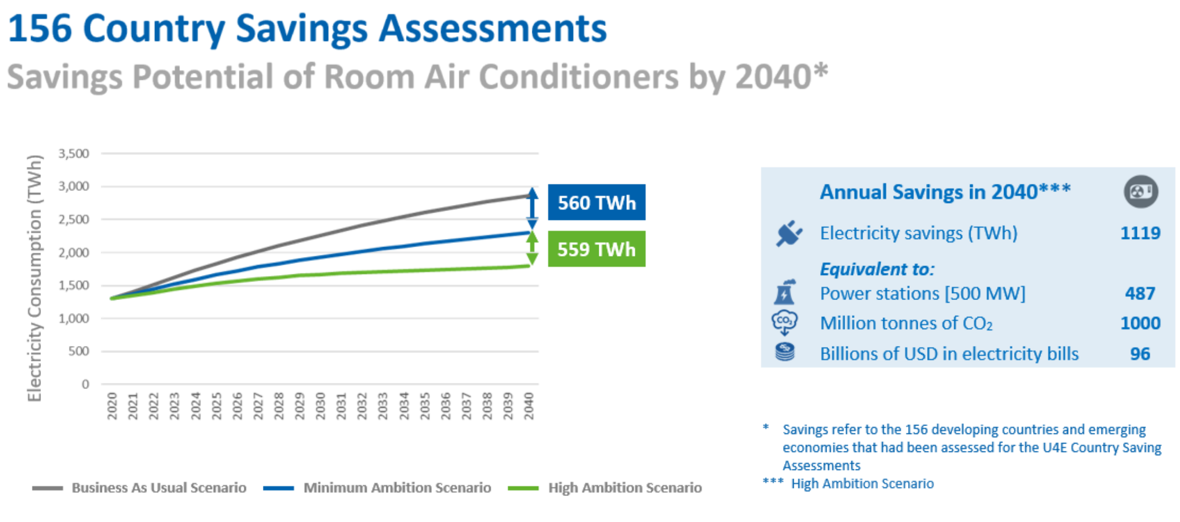
The Public Sector stands out in its capacity to exert enormous purchasing power, representing 12% of GDP in OECD countries and up to 30% in developing countries. This demonstrates the considerable potential for public procurement to be leveraged as a means to drive a Nation's economy to a greener and more sustainable one.
Public procurement refers to the purchase made by governments, state and semi-state-owned enterprises for goods, services and works. As public procurement accounts for a substantial portion of the taxpayers' money, governments are expected to carry it out efficiently and with high standards of conduct in order to ensure high quality service delivery and to safeguard the public interest[1]. Furthermore, Sustainable Public Procurement (SPP), or Green Public Procurement as it is often also called, allows governments to serve as an exemplary model and send strong market signals so as to achieve multiple benefits such as the reduction of greenhouse gas (GHG) emissions, improved energy security and economic competitiveness, resource efficiency or circularity.

SPP practices have the ability to transform markets by leveraging the power of public purchases to drive markets towards sustainability, reducing governments' environmental footprint and contributing significantly therefore to the achievement of considerable GHG emissions reduction while at the same leading to significant financial savings for state and semi-state entities due to much lower energy consumption. Stimulating SPP can help gear government spending towards sustainability but also can foster private sector and consumer behaviour change, enabling the overall transition to a green, sustainable economy. By sustainably procuring energy-efficient products and services, governments and public authorities in general can also impact their countries´ Nationally Determined Contributions (NDC´s) in different ways and intensity, as well as contributing towards achieving the following SDGs: n° 7 "Affordable and Clean Energy", n° 12 "Responsible Consumption and Production" and n°13 "Climate Action".

Therefore, as a side effect of SPP, markets can be ready to implement more stringent minimum energy performance standards (MEPS) and eco-design requirements for all appliances entering the market (e.g., the use of low GWP refrigerants), leading to more energy savings and reducing the environmental impact. Figure 1 shows the energy consumption and potential energy saving across 156 nations for room air conditioners considering minimum and high ambition scenarios for minimum energy performance standards (MEPS). Considering only air conditioners [and excluding the additional savings available from occupancy/load controls], if high ambition MEPS are implemented in 2020, the expected annual energy savings for 2040 are more than $ 100 Billion per year compared to the base case scenario, and equivalent to the annual output of 500 large power plants of 500 MW each. The benefits from modern air conditioner controls and building occupancy controls can further provide the same again in consumer savings, as well as providing better peak power demand management/reliability and large power network cost savings.

[1] *https://www.oecd.org/gov/public-procurement/*

Figure 1: Energy consumption and potential energy saving across 156 nations for room air conditioners considering minimum and high ambition scenarios for minimum energy performance standards



Source: U4E country assessments

Currently, SPP is not sufficiently embedded in sectoral policies and overarching sustainable development strategies, resulting in a lack of market readiness and response capacity from governments to purchase sustainable and green products and service alternatives. The relatively poor performance of SPP leads in turn to the insufficient leveraging of public procurement which results in:

- Limited market transformation,
- High environmental and social footprints of state actors, and
- Insufficient mitigation of climate change and limited impact on other sustainability objectives.

Against this background, the United Nations Environment Programme United for Efficiency (U4E) initiative, has developed a series of Sustainable Procurement Guidelines to provide a set of technical specifications for countries to develop their requirements for procuring higher energy efficient products and thus, complement and strengthen their market transformation processes to much more eco-efficient lighting, appliances and equipment. If countries focus on the main electrical products, which are usually procured in large numbers by state and semi-state entities, instigate and accelerate the market penetration of higher performance, positive impact electrical products such as lighting, appliances (refrigerators and room air conditioners) and equipment (electric motors and power distribution transformers), products that together represent more than one third of global energy consumption. This guide includes a step-by-step approach on how to apply sustainability and current best technical procurement criteria for the selected products in accordance with best international regulatory, social and environmental practices and introduces the rationale to be adopted by procurement practitioners when selecting among a set of products.

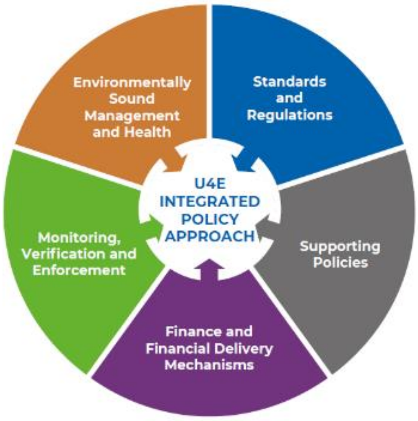
U4E Sustainable Public Procurement Guidelines are a key strategic instrument intended for public procurers, technical personnel and related officers in the expectation that these recommendations are integrated in their day-to-day procurement activities. They are also intended to address policymaker decisions related to Public Procurement Policy development to support their SPP implementation in the many relevant public institutions, as well to as address those interested in raising awareness of the significant opportunities with climate-friendly and energy-efficient purchases. This Sustainable Public Procurement Guideline is a supplement to the U4E Model Regulation Guidelines and other already available international tools, standards guidelines and reports from the U4E portfolio.

ABOUT UNITED FOR EFFICIENCY

U4E (*united4efficiency.org/*) is a global initiative led by UNEP, supported by leading companies and organizations with a shared interest in transforming markets for lighting, appliances and equipment, by encouraging countries to implement an integrated policy approach to energy-efficient products so as to bring about a lasting, sustainable and cost-effective market transformation.

The approach focuses on the end-user market and targets the five main components of the value chain for an energy-efficient market:

1. **Standards and regulations.**
2. **Supporting policies, including education, information, and training.**
3. **Market monitoring, verification and enforcement.**
4. **Finance and financial delivery mechanisms, including incentives and public procurement.**
5. **Environmentally sound management and health.**



U4E provides countries with tailored technical support through their in-house international experts and specialized partners, to get the most out of countries´ electricity by accelerating the widespread adoption of energy-efficient products, allowing monetary savings on consumer electricity bills, helping businesses to thrive through greater productivity, enabling power utilities to meet growing demands for electricity and assisting governments in reaching their economic and environmental ambitions. Currently the initiative is present in more than 30 countries worldwide. Based on each country's circumstances, U4E works with any of the following products: Lighting, Refrigerators, Room Air Conditioners, Electric Motors and Distribution Power Transformers – the five products that together consume over half of the world's electricity. Such support is available at three levels: Global, Regional and National; providing tools and resources and supporting multiple stakeholders on international best practices, regional policy roadmaps and harmonization process recommendations through guidelines and publications, such as energy efficiency Policy Guides, Global Model Regulations Guidelines, Model Public Procurement Specifications and Financing Guidelines. In addition, the initiative provides capacity building and education, policy tools and technical resources which include Country Savings Assessments completed for more than 155 countries showing the significant available financial, environmental, energy, and societal benefits that are possible with a full transition to more energy-efficient electrical products. This growing suite of tools and resources equips policymakers to understand the significant opportunities and the steps needed to start transforming their markets to eco-efficient appliances and equipment.

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PLEASE VISIT **united4efficiency.org**

2. SCOPE OF THESE GUIDELINES

This guideline applies to air-to-air air conditioners (including reversible units) powered by electric mains. This includes:

a) Portable air conditioners,
b) Split air conditioners, such as single and multi-split,
c) Window air conditioners, and
d) Ducted air conditioners.

THESE GUIDELINES DO NOT APPLY TO:

a) Chillers (air-water or water-water),
b) Comfort fans, or
c) Air-to-air rooftop air conditioners (packaged).

THE MAIN ENVIRONMENTAL, ECONOMIC AND SOCIAL PROCUREMENT CRITERIA INCLUDED FOR THE APPLIANCES IN THE SCOPE ARE:

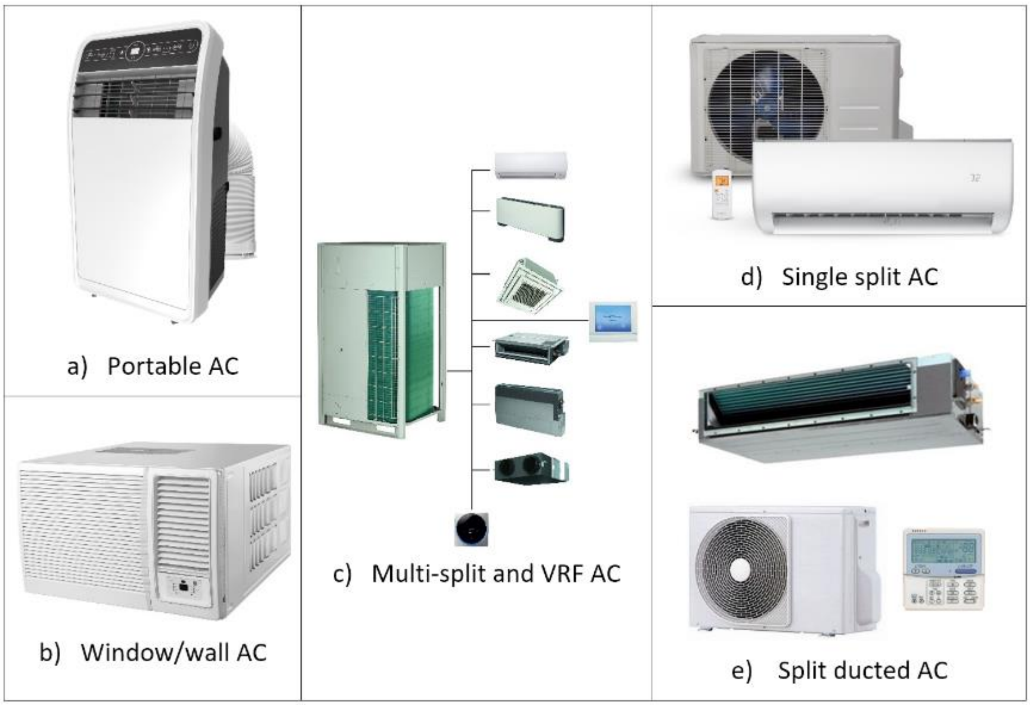
1. Energy consumption,
2. Refrigerant,
3. Sound power level,
4. Product durability (reparability),
5. Environmental sound management, and
6. Social criteria.

In some cases, the U4E Model Regulation[2], or other regulations and programmes are used as reference to set recommendations on SPP criteria. Nevertheless, due to the diversity of situations, such as test standards, energy efficiency regulations, market conditions, etc., each country will need to adapt the guideline criteria to its own needs. Furthermore, while some parameters might be used as a minimum requirement, others can be applied as award parameters that will influence the acquisition decision.

This guideline gives recommendations on the technical requirements to be considered during the SPP process and presents a methodology to calculate the life cycle costs and equivalent CO_2 emissions (Annex 3). This guideline is accompanied by an Excel spreadsheet tool to help tenderers to make more informed decisions when comparing between different bids.

[2] *U4E's Model Regulation Guidelines for Refrigerators, published in September 2019.* *https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-refrigerating-appliances/*

Figure 2: Types of air conditioners included in the scope



3. TERMS AND DEFINITIONS

A. AFFIDAVIT: A written statement, in this case from the manufacturer or supplier of the air conditioning appliance, declaring that the product being offered meets a specific (or all) requirement(s) in the tender.

B. BID: An offer or proposal for goods and/or services submitted in response to the (sustainable) procurement request from the relevant government entity.

C. COST:

End of life cost: Refers to the cost of the correct management of the product when it reaches its end of life, in accordance with legal requirements. For products coming under an extended producer responsibility (EPR) policy scheme, the producer [3] is responsible for the required end of life management and this cost can include requirements related to recycling and/or preparation for reuse. Usually, the appliance producer or supplier charges this cost to its client as part of the initial price of the product.

External cost: Refers to the social cost related to the GHG (greenhouse gas) emissions, i.e., the effects of climate change. For example, increased flooding and storms, the spread of disease, sea level rise, increased food insecurity, etc. This value is usually expressed in USD per tonne of equivalent carbon dioxide pollution released into the atmosphere. Even though the GHG emitted by one country has an affect globally, there is no consensus yet for this value or range (see Annex 3, Life Cycle Costs and Emissions, for more information).

Initial cost: Refers to the price of the product at the moment of acquisition. In some cases, parts of other types of cost may be included in the initial price, e.g., the end-of-life cost.

Maintenance cost: Refers to the cost of repair and maintenance of the appliance. In some cases, it can be contracted with the supplier of the technology on a monthly/yearly basis.

Operational cost: Refers to the cost of operation, mainly the cost of electricity used by the appliances.

D. DUCTED AIR CONDITIONER: Means an air conditioner where the cooled air (or heated air) is transported through ducts to the target areas (e.g., rooms).

E. EMISSIONS:

Direct emissions: Emissions caused by the refrigerants when they are released into the atmosphere.

Indirect emissions: Emissions caused in the power plants to produce the electricity that is used to run the refrigerating appliances.

[3] *Producer means any person who, irrespective of the selling technique used, puts on the market the product (manufacturer, retailer or importer).*

F. **MINIMUM ENERGY PERFORMANCE STANDARD (MEPS):** The minimum energy performance standard refers to the minimum energy efficiency level required to enter a product into the market. These standards relate to all products entering into the market, hence, the requirements for SPP should be more stringent than MEPS.

G. **MODEL REGULATION GUIDELINES:** Refers to the U4E guidelines used to support economies in the implementation or update of MEPS.

H. **TENDER:** Document issued by the government requesting offers for goods or services. This document contains the specifications and minimum requirements to be met. For example, the sustainability requirements suggested in this guideline.

I. **SPLIT AIR CONDITIONER:** A type of air conditioner or heat pump that is comprised of an indoor unit and an outdoor unit.

J. **MULTI-SPLIT AIR CONDITIONER:** A type of air conditioner or heat pump that is comprised of several indoor units working with one outdoor unit.

K. **WINDOW AIR CONDITIONER:** A self-contained air conditioner (all components in one unit) that is usually installed through the wall or window.

L. **PORTABLE AIR CONDITIONER:** A self-contained air conditioner (all components in one unit) that is not a fixture in a specific location and not incorporated in the building structure or building finishing.

4. AIR CONDITIONER PROCUREMENT CRITERIA

This chapter describes the main parameters that should be considered during the SPP of the air conditioners defined in Chapter 2. Apart from the considerations included in these guidelines, the products should also comply with all other product specific requirements and certifications in place, such as MEPS, energy efficiency labels, safety standards, hazardous substance and heavy metal restrictions, etc.

4.1 ENERGY CONSUMPTION

The lower the energy consumption, the lower the operational costs and the lower the indirect pollution emissions. For air conditioning, three main factors define their energy consumption:

- **Building efficiency:** The efficiency of the building in terms of type of construction, size, materials, etc. will affect the energy needed to cool a given space. The lower the cooling demand, the lower the energy needed for cooling and thus, the smaller the cooling equipment capacity needed will be.
- **Appliance efficiency:** The higher the efficiency of the appliance, the lower the energy consumption for a given cooling demand.
- **Efficient use:** User behaviour plays a critical role in reducing cooling demand. For instance, a more efficient use of the equipment can be made by closing windows and doors to avoid excess hot air infiltration, by setting the target temperature to save energy but still maintaining it at comfort levels (around 25.5ºC), and by setting controls to allow higher temperatures (or switch off) for periods without human presence/need for space cooling.

Although this guideline is about purchasing green air conditioners, it is important to also keep in mind the importance of building energy efficiency; reducing the cooling demand whenever possible and prioritizing natural cooling (e.g., by using better building envelope insulation levels and blinds to reduce excess solar radiation).

Manufacturers shall declare the appliance energy consumption under the test method applied locally. Therefore, all the products submitted to the tender should be tested with the test standard applicable in each country.

The following sub-sections will provide details on the parameters that influence air conditioner energy consumption and that should be considered when preparing the tender for purchasing them:

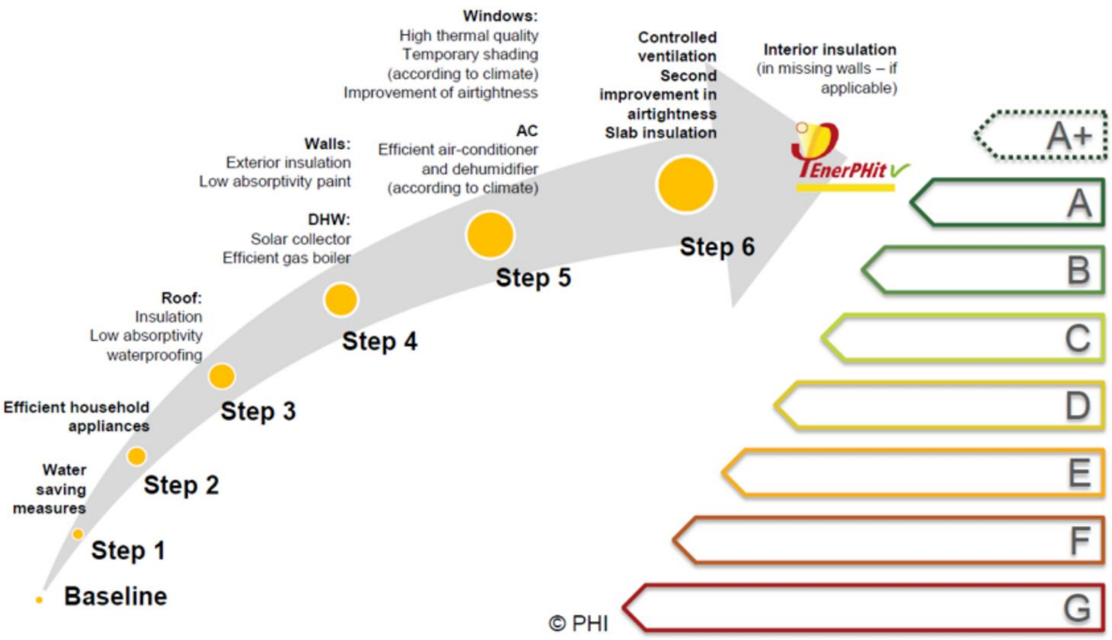
- Type and size [capacity] of air conditioner.
- Energy efficiency requirements.
- Variable (inverter) vs. fix speed compressors.
- Special controls to save energy.
- Reversible units.

The information needed to verify these requirements can be found in the energy label, which usually includes the energy consumption, capacity and energy efficiency level. Information for other parameters, such as inverter compressors, can be obtained from the air conditioner technical information (manuals) and/or from a manufacturer/supplier affidavit.

4.1.1 Type and size of air conditioner

The type and size of air conditioner depends on the application. Oversized air conditioners will result in higher energy consumption and thus, the capacity of the appliance should be carefully selected according to the cooling demand needed. The cooling demand depends on different factors, such as the building envelope, the type of windows and doors, the orientation of the building, the type of climate of the country/region, the room size that needs to be cooled, the type of activity inside the building. If this information is not available, consulting the relevant building regulations and/or an independent expert on energy or cooling appliances is recommended to calculate the needed cooling capacity. Furthermore, the expert can identify other energy efficiency measures that can be applied to the building to reduce cooling demand, such as those shown in Figure 3 below.

Figure 3: Step-by-step implementation of energy efficiency measures in existing housing in Mexico



Source: NAMA Vivienda Existente; Authors: Passive House Institute, IzN Friedrichsdorf, GOPA Consultants; Review and supervision: CONAVI, Infonavit, GiZ

Caution should be taken when specifying certain types of air conditioner. For instance, portable air conditioners usually have a higher energy consumption level, but this might not be shown on the energy efficiency label and related metrics as they use different [4] equations and test methods to define their energy efficiency. Hence, the declared energy efficiency of a portable air conditioner might not be comparable with other types of air conditioners (e.g., split air conditioners), and they are not recommended for SPP (unless it is required by the application).

Window (or through-the-wall) air conditioners need special attention when being installed in the building. If they are not installed correctly, there can be significant losses to the ambient environment, and the air conditioner will consume more electricity than expected. Furthermore, some country´s regulations use differing[5] energy efficiency labels and metrics to define energy efficiency levels for window air conditioners, making it difficult to compare fairly between other types of air conditioners (such as split air conditioners). This would not be the case if the same representative energy efficiency metric and test standards are used for all types.

4.1.2 Energy efficiency requirements

The energy efficiency requirements for appliances should be updated frequently to account for improvements in the market, so that only the higher efficiency air conditioners are targeted during the SPP process. SPP energy efficiency requirements should target products that are above the average efficiency in the market if they want to incentivize the cooling products industry to accelerate the transition to more sustainable technologies. It is recommended that tenders set the energy limits to target around the 20% most efficient air conditioners in the market.

More efficient products can also be targeted and justified with the life cycle cost analysis (LCC) method, which will account for the initial costs, operational costs and external costs due to CO_2 emissions, hence, the higher the energy consumption, the higher the operational costs and emissions (see Annex 3, Life Cycle Costs and Emissions, for more information).

The energy efficiency of an air conditioner will depend on the outdoor conditions over the year. Depending on local regulations, the energy efficiency metrics employed may account for seasonal variations or not. Typical terms[6] for seasonal cooling efficiencies are the ISO cooling seasonal performance factor (CSPF) or the seasonal energy efficiency ratio (SEER). The typical term for one point cooling efficiency is the energy efficiency ratio (EER). Furthermore, some countries use both

[4] Main discussion on laboratory test for portable air conditioners is how to account with the impact of duct heat losses and infiltration on the unit performance, as well as to use a seasonal metric to account with actual ambient changes in the portable unit, as in this case the whole unit is placed inside the building and heat interaction with the outdoor will depend on the unit type.

[5] The seasonal efficiency captures the benefits of a variable speed compressor over the entire season/year, making it a fairer comparison with fixed speed compressors if their efficiency is also calculated with the seasonal method.

[6] Other terms might be used in different countries. They might be comparable or not depending on the test Standards and the climatic conditions used for the energy efficiency calculation in each country. Two countries using the same term for the energy efficiency metrics does not guarantee that they are comparable if they use different test methods and/or climatic conditions.

seasonal and one-point efficiencies depending on the type of equipment (variable or fixed speed compressors). Seasonal performance metrics are usually preferred[7] for comparing all air conditioner types independently of the type of climate, and independently of whether they are fixed or variable speed.

It is important to notice that seasonal efficiencies (CSPF or SEER) cannot be compared directly to single condition efficiencies (EER). Furthermore, since seasonal efficiencies depend on the type of climate used for the calculation (and other parameters in the test standard), they should be calculated on the same basis to be comparable, i.e., all products should declare efficiencies according to the local regulation[8].

If there are energy efficiency labels in place, using one energy efficiency class as the minimum requirement might be a simple and effective way to set out the SPP requirements. It is recommended that the target efficiency classes represent around the 20% most efficient models in the market.

As an example, Figure 4 shows the evolution of the energy efficiency classes distribution for refrigerators (this example still holds for air conditioners) in Europe with the actual label (A+++ to G before 2021) and with the new label projected from 2021 until 2030 (A to G from 2021). In this case, for the new label, the efficiency Class D or higher is expected to have a share of around 30% of the market in 2021, while Class C or higher will share around 5% of the market. Therefore, targeting Class D or higher (Class A, Class B and Class C) could be the SPP requirement for 2021. Taking a minimum efficiency as Class C or higher as a mandatory requirement could be too ambitious, leaving the tender without any bid, or with higher life cycle cost.

Nevertheless, the number of energy efficient models is expected to increase in the future. For example, the models in Class A to Class C are expected to represent around 30% of the market in 2023. Therefore, the requirement could be increased to Class C or higher in 2023. Then, the requirement can be updated again to Class B or higher in 2025, and to Class A in 2028. Therefore, the energy efficiency requirements for SPP should be updated periodically. This must be considered when setting the legal basis to avoid administrative barriers when updating the minimum efficiency requirements in the future. Otherwise, the requirements might become obsolete in a few years.

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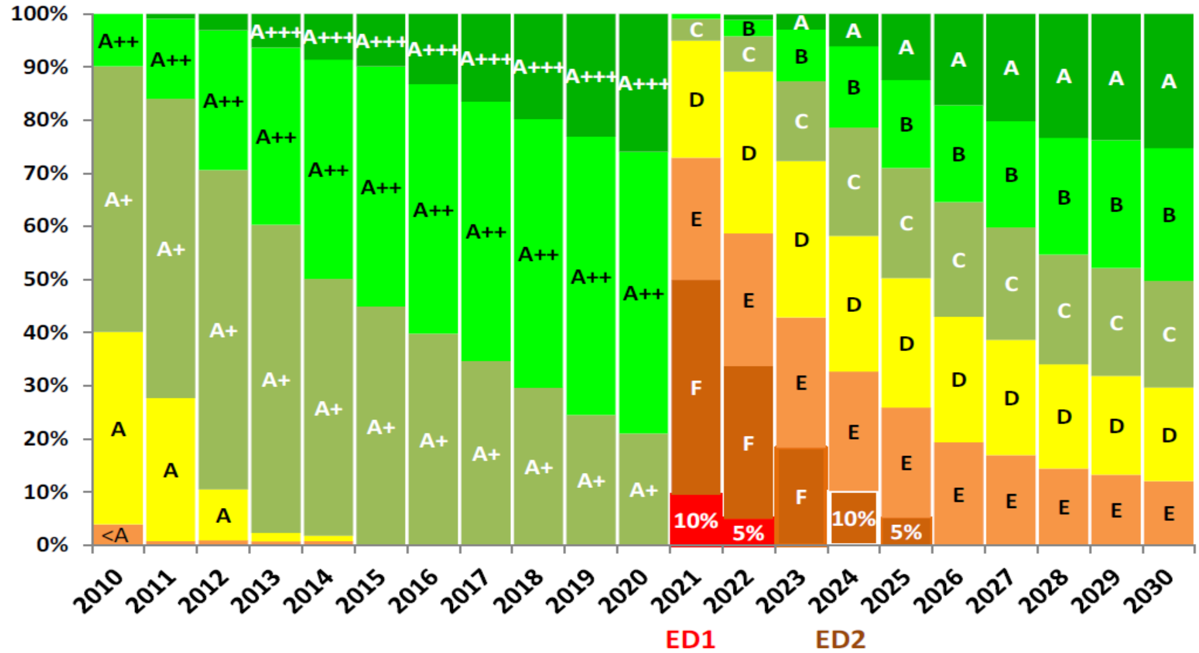
[7] *If EER values are used to classify air conditioner energy efficiency in the country, considering the migration to seasonal energy performance factors is recommended. In the meantime, the EER values can be used to define SPP requirements in the same way as the seasonal performance values.*

[8] *ISO has an approved CSPF calculation tool according to ISO 16358-1:2013/AMD 1:2019. This tool can be used by policy makers and technical experts that need to calculate the CSPF, and/or compare the CSPF value at different climates. The tool is available at:* *https://standards.iso.org/iso/16358/-1/ed-1/en/amd/1/*

Figure 4: Label energy efficiency market distribution projected until 2030 for refrigerators



Source: Draft new labelling EU regulation [1]

The same logic used in the previous example to set the SPP efficiency requirement on the European label (Class A to Class G) can be applied with any other types of comparative label. For instance, the 5-star label in India, or the percentage of savings label in Mexico. The most important aspect is to know the efficiency distribution in the market to set an ambitious, but realistic target, for SPP.

If the label is obsolete, i.e., where more than 30% of the models are in the top energy efficiency class, a more stringent energy efficiency level should be required to effectively target the most efficient models in the market. Hence, requirements can be specified with an energy efficiency limit that does not coincide necessarily with the limit of one of the label´s energy efficiency classes.

Furthermore, energy efficiency might depend on the capacity of the unit. This is sometimes considered in the minimum energy performance standards (MEPS) requirements, but not in the energy efficiency label. In this sense, different energy efficiency SPP requirements can be applied for different capacities, even if they do not coincide with the label levels.

If there is no appropriate market data available, international benchmarks can be used to set the minimum requirements for energy efficiency. In this case, it is recommended to use the higher energy performance levels indicated in the U4E Model Regulations Guidelines for Air Conditioners, which indicates the high efficiency products that are available[9] in the global market.

[9] Some countries with a low energy efficient air conditioner market might have few, or no, models which meet the U4E high performance level. In this case, the requirements may need to be adjusted, or the import of products that meet these requirements could be considered.

As an example of international energy efficiency requirement benchmarks, Table 1 shows the minimum ISO CSPF high efficiency levels considered by the U4E Model Regulation Guidelines in two different climates and for different capacity ranges (and the adjusted requirement for capacities above 16 kW). Please refer to the U4E Model Regulation [2] for other climates. The U4E Model Regulation Guidelines are intended for window and single split air conditioners. Nevertheless, if the same seasonal characteristics and test conditions are used to calculate[10] the CSPF for other types[11] of air-to-air air conditioners, such as multi-split, the U4E efficiency levels can be used also for these types of air conditioners (excluding portable air conditioners).

The U4E Model Regulation Guidelines also contain energy efficiency levels for reversible air conditioners, which uses the annual performance factor (APF) metric.

Table 1: High efficiency level based on U4E model regulation guidelines for different climates

High efficiency levels for cooling mode (CSPF)		
Capacity Range	**Climate 3C[(a)]**	**Climate 0B[(b)]**
0 to 4.5 kW	7.9	5.9
4.5 to 9.5 kW	7.5	5.6
9.5 to 16 kW	7.0	5.3
> 16 kW[(c)]	6.1	4.6

a) Climate Warm Marine (3C) according to U4E Model Regulation Guidelines [2]

b) Climate Extremely Hot-Dry (0B) according to U4E Model Regulation Guidelines [2]

c) The U4E Model Regulation Guidelines do not include requirements for air conditioners with cooling capacities above 16 kW. To set requirements for these capacities, the recommended values in U4E for capacities between 9.5 kW and 16 kW can be multiplied by the factor 0.872 (capacity-efficiency degradations based on EU regulations [3], [4])

Following the example of Table 1, the U4E Model Regulation Guidelines[12] high efficiency level recommendations can be used to set the SPP requirements on energy efficiency for different climates (the U4E Model Regulation Guidelines give recommendations for 17 different climates). Nevertheless, market information is important to effectively target the most efficient products in the market and to update the requirements in the future. Furthermore, one should note that the local energy efficiency rating would only be comparable to the U4E Model Regulation

[10] *For instance, the ISO 16358 [5] can be used to calculate the CSPF of different types of air conditioner, which might be combined with different test standards depending on the type (e.g., ISO 5151 [6], ISO 13253 [7] or ISO 15042 [8])*

[11] *The European regulations do not differentiate on MEPS for different types of air-to-air air conditioners (window, single split, multi-split, ducted, etc.) in the same capacity range, except for portable air conditioners.*

[12] *Available at: https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/*

Guidelines if the same[13] test standard and energy efficiency equations and climate tables are used.

If the high efficiency levels from the U4E Model Regulation Guidelines shown in Table 1 are too ambitious to be implemented as SPP requirements in a certain market, the intermediate-efficiency levels can be used as a temporary requirement until the market is ready to use more stringent ones. Table 2 shows the minimum ISO CSPF intermediate-efficiency levels considered by the U4E Model Regulation Guidelines in two different climates and for different capacity ranges (and the adjusted requirement for capacities above 16 kW). Please refer to the U4E Model Regulation [2] for other climates.

Table 2: Intermediate efficiency level based on U4E Model Regulation guidelines for different climates

Intermediate efficiency levels for cooling mode (CSPF)		
Capacity Range	**Climate 3C[(a)]**	**Climate 0B[(b)]**
0 to 4.5 kW	7.0	5.3
4.5 to 9.5 kW	6.3	4.8
9.5 to 16 kW	5.8	4.5
> 16 kW[(c)]	5.1	3.9

a) *Climate Warm Marine (3C) according to U4E Model Regulation Guidelines [2]*
b) *Climate Extremely Hot-Dry (0B) according to U4E Model Regulation Guidelines [2]*
c) *The U4E Model Regulation Guidelines do not include requirements for air conditioners with cooling capacities above 16 kW. To set requirements for these capacities, the recommended values in U4E for capacities between 9.5 kW and 16 kW can be multiplied by the factor 0.872 (capacity-efficiency degradations based on EU regulations [3], [4])*

Finally, some countries use specific higher energy performance endorsement labels [independent certification labels], which can only be used by the more efficient products in the market, e.g., energy star in USA, or PROCEL in Brazil. Independent endorsement labels or certification are an easy way to identify the more efficient products in the market. Nevertheless, it is recommended that the requirements of the endorsement label/certification are checked to ensure that they are not obsolete and that they effectively target the most efficient products in the market (around the top 20%). Otherwise, these labels will need to be updated before they can be used as a reference in the SPP process.

4.1.3 Variable (inverter) vs. fixed speed compressors

Air conditioners with variable speed compressors (inverter units) can adjust their cooling capacity when there are variations in outdoor conditions, which results in greater energy efficiency compared to the same unit working at single speed.

[13] It is not guaranteed that the temperature-hour distribution used for the different countries in the *CSPF calculation for the U4E Model Regulation is the same used in the actual country regulations. Therefore, before adopting the U4E Model Regulation high efficiency level requirements [2], the compatibility of the CSPF calculation should be checked.*

If the local regulation uses the EER (based on only one outdoor condition), either for fixed speed, or for all air conditioners, the inclusion of only inverter units for the SPP process as a requirement is recommended. This is because these EER metrics do not allow for a fair overall seasonal performance comparison between variable and fixed speed air conditioners.

Nevertheless, if local regulations use a seasonal energy efficiency ratio for all air conditioners, these metrics can be used to fairly compare variable and fixed speed air conditioners, so using a minimum seasonal performance requirement for energy efficiency should be sufficient, and fixed speed air conditioners do not need to be excluded from the tender.

4.1.4 Occupancy and temperature limiting controls

Occupancy controls

Occupancy controls, which are used to detect the presence of a person in order to automatically turn the cooling on and off, can lead to a greater than 50 % energy saving in some spaces.

As these detectors can significantly reduce energy consumption, they should be considered for inclusion in the specifications wherever possible and relevant. Presence detection is carried out through infrared detection or motion detection. Some detectors are now embedded in the air conditioning appliance or system as standard or can be as an option. The occupancy controls can automatically shut off the equipment during unoccupied hours.

The advantage of modern room air conditioners with built-in occupancy control, is their ability to employ presence sensing to easily save energy by using air conditioning only when and where it is needed, and without the need to carefully place separate detectors and to design the wiring or wireless system to control the right group of air conditioners.

Note: Placement of sensors is a complex topic, and it is recommended that further information and guidance be requested from manufacturers/suppliers to help ensure appropriate operation for the task/environment.

Temperature limiting controls

Room temperature limiting controls, which are used to automatically reduce or turn the cooling off, can lead to a greater than 25 % energy saving in some spaces. Temperature limiting controls have setpoint stops, which are accessible only to authorized personnel, such that room occupants cannot adjust the setpoints outside of the normal comfort range for the location (typically by not more than ±3°C (±5°F)).

As temperature setpoint limiting controls can significantly reduce energy consumption they should be considered for inclusion in the specifications wherever possible and relevant. Some temperature limiting controls are now embedded in the air conditioning appliance or system as standard or can be as an option.

The advantage of modern room air conditioners with built-in temperature limiting controls, is their ability to employ setpoint limits to easily save energy by using air conditioning only when it is needed. Similar timed or network connected 'smart' controls can be used to reduce or turn off the air conditioning in order to limit peak electrical demand. Other controls such as soft start and delayed start can also support power network reliability. These can be important considerations for many global regions and can be included as a requirement for SPP.

4.1.5 Reversible units – space cooling and heating in one unit

In countries where space heating is also needed, the use of reversible units is recommended unless a more efficient separate heating system is used. In general, a reversible unit will heat more efficiently compared to other conventional heaters, such as an electrical resistance heater, even at low temperatures, and the price of reversible units might only differ by about some 10% more compared to cooling units. Nevertheless, each case needs to be analysed separately. For instance, even in countries where there might be a period of the year with cold nights, the building might be unoccupied during night time, so heating might not be needed in this case. On the other hand, in colder climates, if the air conditioner unit is selected according to the cooling demand, the heating capacity of the reversible unit might not be able to cover the whole heating demand over the year, requiring a backup system, or the use of a specifically dedicated separate heat pump.

Energy efficiency in the heating mode is measured separately from the cooling mode, but it can be combined with the cooling efficiency to give only one efficiency level for both cooling and heating. Furthermore, as in the cooling mode, the heating efficiency can be based on a unique ambient temperature, or on a seasonal efficiency basis with the changes of ambient temperatures during the year. The one ambient temperature heating efficiency metric is usually known as the coefficient of performance (COP), while the seasonal energy efficiency metric is usually known as the seasonal coefficient of performance (SCOP) [heating seasonal performance factor (HSPF) is also used] respectively, while the combined heating and cooling energy efficiency uses the APF metric. The same air conditioner will give different energy efficiency results depending on the metrics that were used for its calculation and the reference climate table. Therefore, when developing the requirements of minimum energy efficiency levels for the heating mode, it is important to consider the metrics and climate used to declare the energy efficiency in the specific country.

The U4E Model Regulation Guidelines[14] give recommendations on the high seasonal energy efficiency level of reversible units in 17 different climates (energy efficiency of the combined cooling and heating mode, i.e., the APF metric).

As an example of energy saving potential, if a seasonal energy performance factor in heating mode of 4 is required as a minimum efficiency for SPP (a SCOP of 3.8 are the MEPS used in the European Union in the average European climate for example), the reversible unit will use one quarter (1/4) of the energy that would be used by an electrical resistance heater (the maximum efficiency of the electrical resistance heater is one) for the climate in which the seasonal efficiency was calculated.

[14] *The U4E Model Regulation can be downloaded at https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners/*

4.2 REFRIGERANT

4.2.1 Type of refrigerant

The requirements for the refrigerant will depend on size and type of air conditioner. Table 3 shows the recommended values in terms of ozone depleting potential (ODP) and global warming potential (GWP). The ODP should always be 0.

In some countries, small split air conditioners (below 6 kW) are available which operate with natural refrigerants (R290). If this is the case in the country or market in question, a GWP ≤150 should be used as the limit for small air conditioners. Otherwise, using natural refrigerants can be specified as an award criterion to incentivize manufacturers/suppliers to produce or import these air conditioners, and use the 750 GWP level as a mandatory maximum limit.

When comparing two air conditioner models, if a model is using a low GWP refrigerant (e.g., R290), it might lead to less total emissions during the whole life cycle compared to a model with a higher GWP refrigerant (e.g., R32) even if the latter has slightly higher energy efficiency. In these cases, it is good to compare the total emissions to make a final decision (see Annex 3). This guideline is accompanied by an Excel spreadsheet tool to help tenderers to make more informed decisions when comparing between different bids.

For air conditioners up to 16 kW, refrigerants with a GWP ≤750 are already common in many countries (typically R32). This limit is the recommendation given in the U4E Model Regulation Guidelines. For air conditioners above 16 kW, the ODP = 0 should be used as a requirement, and a GWP of ≤750 can be used as an award criterion.

Table 3: GWP and ODP requirements depending on type and size of air conditioner

Type of AC	GWP limit	ODP limit
Portable AC	≤150	0
Other ACs < 6 kW	≤750 (or ≤150 if available)	0
6 kW < other ACs < 16 kW	≤750	0
Other ACs > 16 kW	Award criteria with reference ≤750	0

(Based on U4E Model Regulation Guidelines [2])

The new synthetic unsaturated HFCs, known as HFOs, can also have zero ODP and low GWP. Nevertheless, they may still have unknown degradation pathways, be flammable and/or have toxicity implications and yield dangerous decomposition products when they burn. Therefore, it is recommended that if natural refrigerants are available[15], these are preferred over the HFOs.

[15] *For more information about "The availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact" check the European report:* https://eurovent.eu/sites/default/files/field/file/GEN%20-%201160.03%20-%20EU%20report%20refrigerants%20split%20air%20conditioners.pdf

The information needed to verify these requirements can be found in the air conditioner technical information, manuals, identification plate and from manufacturer/ supplier affidavits.

4.2.2 Refrigerant leaks

Refrigerant leaks depend on the type of air conditioner and how well the overall installation is carried out, as well as the ongoing maintenance of the appliance. For instance, an average residential air conditioner might leak at an annual rate of 5% of its total refrigerant charge, leading to 60% of the total charge remaining at the end of its lifespan (considering a current typical lifespan of 12 years).

Refrigerant leaks will lead to direct emissions as the refrigerant is released to the atmosphere and will also decrease the energy efficiency of the system, increasing energy consumption and the related indirect emissions (each air conditioner has an optimal refrigerant charge). If the leak is big and refrigerant is not refilled, the air conditioner might stop working. If the air conditioner is refilled but the leak is not repaired properly, the total amount of refrigerant released to the atmosphere during the lifespan of the product might be several times greater than the initial refrigerant charge for systems with high leak rates.

Therefore, it is important to check with the supplier (or company in charge of installation and maintenance) that the installation and maintenance works will be carried out according to the manufacturer's instructions and best international practices to minimise refrigerant leaks, with procedures to find and repair the leak, which might include periodic revisions with a clear schedule. Furthermore, technicians should be qualified and using the proper equipment, for instance, electronic leak detectors and system analyzers. These requirements can be demonstrated by the supplier by presenting the certificates and/or from supplier affidavits.

Annex A3.2 gives guidance on how to calculate the equivalent CO_2 emissions during the whole life cycle of the appliance, including the direct emissions due to refrigerant leaks.

4.3 SOUND POWER LEVEL

The recommended sound power limits are shown in Table 4. These values are based on the new EU eco-design regulation for air conditioners below 12 kW for all air conditioners entering into the market. The requirements for outdoor units above 12 kW might be set as award criteria instead of a minimum requirement depending on where the unit will be installed.

If there are local regulations in place with more stringent sound power level requirements, these should be followed.

The information required to verify the sound level of an air conditioner can be obtained from the air conditioner technical information (manuals) and/or from a manufacturer/ supplier affidavit, and sometimes is also included in the energy label.

Table 4: Sound power level requirement depending on type and size of air conditioner

Type of AC	Indoor unit (dB)	Outdoor unit (dB)
Portable AC	≤65	-
Other ACs < 6 kW	≤60	≤65
6 kW < other ACs < 12 kW	≤65	≤70
Other AC's > 12 kW	≤65	Award criteria if ≤70

(Based on EU Regulation [3])

4.4 SAFETY REQUIREMENTS

All products shall conform to the national requirements for quality, safety [16] and performance.

Furthermore, the installers and technicians engaged for repair services (and when contracting maintenance works) should be suitably qualified and certified according to the national rules considering the product type and the refrigerant used.

The information needed to verify these requirements can be obtained from a manufacturer/supplier affidavit.

4.5 PRODUCT DURABILITY (REPARABILITY)

The typical lifespan of an air conditioner is around 12 years, varying depending on the country, user, type, and size. In any case, to ensure that the air conditioner works efficiently during its lifespan, the manufacturer/supplier needs to meet several reparability requirements, such as providing for the availability of spare parts (see Section 4.5.1) and ready access to repair and maintenance information (see Section 4.5.2). Eco-design measures and manufacturing quality requirements for higher performance products aim to extend the useful service lifetime, increasing the economic and environmental benefits at the same time.

The reparability requirements presented in this section are based on the new[17] European eco-design requirements for 2022 [3]. Therefore, if these are not a requirement yet for air conditioners in the application country, they could be included as a requirement for SPP.

For contracts that include the maintenance of the appliances, these should ensure that air conditioners are repaired and maintained to work efficiently during the lifespan of the product.

These requirements can be verified by the manuals and manufacturer/supplier affidavit.

[16] *The most common international safety standards for air conditioners is IEC 60335-2-40 [9]*

[17] *The final version of this regulation has not been published yet. The new regulation will substitute the current regulation EU 206/2012.*

4.5.1 Availability of spare parts

The manufacturer/supplier should guarantee the supply of essential spare parts, including at least:

- Compressors.
- Heat exchangers.
- Printed circuit boards.
- Fan motors.

The spare parts shall be delivered in a reasonable period of time from the date of order (e.g., maximum 15 working days) and they shall be offered even when the model is no longer in the market, ideally during the lifespan of the product (at least 7 years after placing the last unit of the model on the market).

In addition, the manufacturer/supplier shall ensure that these spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance.

4.5.2 Access to repair and maintenance information

Apart from making available the spare parts listed above, if requested by qualified [18] professional repairers, the manufacturer/ supplier shall provide access to the following appliance repair and maintenance information:

- Qualification requirements of maintenance personnel.
- The unequivocal appliance identification.
- A disassembly map or exploded view.
- Technical manual of instructions for repair.
- List of necessary repair and test equipment.
- Component and diagnosis information (such as minimum and maximum theoretical values for measurements).
- Wiring and connection diagrams.
- Diagnostic fault and error codes (including manufacturer-specific codes, where applicable).
- Data records of reported failure incidents stored on the appliance (where applicable).
- Instructions for installation of relevant software and firmware including reset software.
- Information on how to access data records of reported failure incidents stored on the product (where applicable).
- Access to professional repair, such as internet web pages, addresses, contact details.
- Relevant information for ordering spare parts.
- The minimum period during which spare parts necessary for the repair of the appliance are available.

Moreover, the manufacturer/supplier shall give information to all users about the instructions for the correct installation and maintenance, including cleaning the air conditioner.

4.5.3 Warranty

A minimum warranty period for the air conditioner of one year after the date of purchase is recommended. Other parts of the equipment might be guaranteed for at least 3 years (e.g., the main components such as the compressor, heat exchanger, control board, thermostat, fan, motor, controls, etc.). A complete functional parts warranty period of three years could be reasonably required. This warranty should cover all the main operational components, including the controls.

[18] *In order to give access to repair and maintenance information, the professional must have the technical competence to repair the air conditioner and comply with the applicable regulations for repairers of electrical equipment in the country of application.*

4.6 ENVIRONMENTALLY SOUND MANAGEMENT

The SPP acquisitions should minimize the adverse effects that may result from end of life of the product, i.e., waste, with a strong emphasis on reduction, reuse, and recycling.

Some countries already have a take back programme that ensures the correct environmental disposal of the air conditioner at the end of life, for instance through extended producer responsibility (EPR) policies [19]. In any case, the manufacturer/supplier should be responsible for the sustainable management of waste at the end of the useful life of the equipment (Waste Electrical and Electronic Equipment – WEEE), including the refrigerant of the system.

The European eco-design regulation requires that all air conditioner appliances are designed in such a way that the maximum portion of materials can be removed with the use of commonly available tools in order to facilitate material recovery (for re-use) and recycling, while avoiding pollution. Therefore, if this is not a requirement yet for all air conditioners in the relevant market, it might be included as a requirement for SPP.

To reduce the solid waste generated by packaging, the packaging shall be the minimum possible to facilitate handling the equipment and it should be recyclable or reusable. Purchasers are also encouraged to prefer packaging with at least one of the following characteristics:

- Does not contain styrene (e.g., Styrofoam, EPS, polystyrene).
- Maximizes post-consumer recycled content.
- Minimizes the contents of lead, cadmium, mercury and hexavalent chromium, with a goal of less than 100 ppm (0.01%) in total content.
- Packaging remains the property of the supplier and not the recipient.

These requirements can be difficult to verify. A manufacturer/supplier affidavit can be used for this purpose as further described below.

The generation of waste also arises when purchasing new air conditioner units in order to replace old ones. This must be taken into account during any relevant procurement process. This includes:

- The old devices that are replaced.
- The new air conditioners, which will become waste at the end of their useful life.
- The shipment containers and packaging in which the new appliances are sent.

Old air conditioners must be managed correctly and if there is a suitable local recycling plant available, it should be the first preferred management option. During the development of the procurement documentation, current relevant environmental legislation should be the main factor to be considered.

The entity responsible for the management of the old devices varies depending on the legislation. If the current applicable legislation provides for an EPR regime that includes the relevant air conditioner, the buyer entity should require that the seller/supplier be part of an appropriate environmentally sound

[19] *National Producer Responsibility Schemes Under the EU F-Gas Regulations;* [EIA-Briefing-Note-National-Producer-Responsibility-Schemes-FINAL.pdf (eia-international.org)]

management (ESM) system and that this system guarantees the correct management of the replaced devices. If the relevant air conditioners are not included in any extended producer responsibility scheme, the buyer can request that the tender criteria include that the selling/supplying company is responsible for the collection and environmentally sound management of the replaced units. In all other cases, the buyer must take care of the air conditioner end of service life management themselves.

If the buyer chooses to pass on the responsibility of the management of the used appliances to the seller/supplier (as an additional condition of the contract), some aspects must be included in the request for a proposal to the selling/suppling companies, mainly:

- The minimum requirements for the withdrawal of the relevant used products and their subsequent management.
- The obligation to show verifiable/proven documentation from the seller that proves that the removed devices are being managed correctly, including the gases the air conditioner contained, and that the company in charge of the used/waste product management is an authorized operator.

The minimum proven documents that should be requested, to assess the tracking of the discarded devices, are the certificates of the recycling plants that have received the electrical and electronic equipment waste and the certificate of the plant in charge of the gases management. It is recommended that the disbursement of the final contract payment should depend upon receiving all the necessary environmentally sound management documentation.

Alternatively, the buyer can choose to manage the waste through a waste manager that is legally authorized and who has the capacity to manage cooling appliances correctly, and can guarantee the adequate removal and treatment of the gases and the oil contained in the appliance. Once the gases and oil are extracted, they can be recycled or destroyed, depending on the type of gas. The rest of the materials that make up the equipment (mainly metals and plastics) should also be recycled.

If the buyer decides to compel the seller to manage the old appliances, this should be included in the tender conditions. At a minimum, the following aspects should be considered:

- Explaining the minimum requirements for the withdrawal of the spent products from service/storage and their subsequent management.
- Requiring verifiable/proven documentation from the seller that proves that the removed air conditioners are being managed correctly, as well as the gases they contain, and that the company in charge of the used/waste product management is an authorized operator.
- If an EPR scheme exists, the seller should present a certificate which proves that the seller or the legal manufacturer of the air conditioner has joined a collection and recycling system organization.
- Issue of a document that certifies that the collection of the air conditioner has been completed by an authorized waste manager.
- Issue of a certificate proving that the air conditioner has been delivered to the treatment plant and the authorization certificate of the plant to treat air conditioner appliances.

- Issue of a certificate proving the adequate destruction of the gases in the air conditioner.

In particular, the gas destruction certificate may take a few weeks to be received, as gases are not usually destroyed in the treatment plant, but by a specialized third party. **It is recommended that the disbursement of the final contract payment be dependent upon receiving all the necessary environmentally sound management documentation**.

Air conditioners contain gases in the refrigeration circuit mixed with oil. In the past, these gases used to be a group of synthetic gases called chlorofluorocarbons (CFCs), but the use of CFCs was progressively banned by the Montreal Protocol (1987), as they destroy the protective ozone layer. CFCs were soon replaced by other synthetic gases, first by hydrochlorofluorocarbons (HCFCs) which are less harmful for the ozone layer (and still used in some countries); and later by hydrofluorocarbons (HFCs), that have little impact on the ozone layer.

The evolution of the replacement of refrigerant gases has been uneven over the world, and different approaches have been taken by European and American industries for example. In any case, the most important points to take into account are:

- Gases used in the refrigeration circuit of air conditioners can be different depending on the age of the appliance and the place where it was built. The reality is that the vast majority of the air conditioners that become waste today across the world, have gases that damage the ozone layer and have an important GWP.
- Improper management of an air conditioner can break the cooling circuit and thus the gases can be released into the atmosphere and the oil can contaminate the soil.

For these reasons it is important to guarantee the right end-of-life treatment of air conditioners.

Another point to consider is that older air conditioners can include components classified as hazardous waste, like capacitors with PCB or mercury containing switches. This aspect should also receive adequate recycling treatment. Once properly treated, air conditioners contain metals and plastics that can be sold, but the value of these recovered materials might not be sufficient to pay for the full end of life treatment costs.

Regarding the packaging of the new air conditioners, this must be separated and sent to a recycler. If an EPR system is established for these packaging materials, then it should be managed by the entity supplying the appliances. If it is not, the best option is to deliver the packaging waste directly to the local waste management facility or paper/cardboard recycler.

Summary of the ESM considerations to take into account:

1. The entity that acquires the air conditioner must know, before calling the tender, if the relevant waste management legislation incorporates an EPR scheme for the type of waste generated at the time of the acquisition of the new appliances, specifically:
    - If the seller/supplier of the air conditioning appliance has an obligation to take responsibility for the management and recycling of the old devices;
    - The same for the packaging generated.

If there is an obligation, it will be the management system to which the seller/supplier is attached for the aforementioned products that will be responsible for their collection and recycling / treatment. However, the buyer must verify that there are no exceptions in relation to equipment installed before the entry into force of the legislation.

2. If an EPR scheme has not been locally implemented, or does not affect the relevant air conditioner, the responsibility for the collection and recycling/management of said products lies with the buyer of the new air conditioners, as the final holder of the waste. However, the buyer can request appropriate agreement(s) with the manufacturer/seller/supplier for the management of the waste, but the conditions of this agreement must be included in the bidding rules for the acquisition of the new cooling products.

3. During the tendering process, inclusion of provision for the submission and verification of bidder certificates on appropriate EPR scheme membership and separate additional certification stating the destination of the gases in order to guarantee their correct disposal is recommended.

4.7 SOCIAL CRITERIA

Social criteria can be included in the SPP tender. The bidder must provide evidence that it complies with national and international decent work standards, if possible, throughout the production and service chain.

Possible ways of verification are a manufacturer/supplier affidavit or with certification to local and international standards on labour laws.

REFERENCES

[1] Draft new EU regulation: Commission Delegated Regulation supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of refrigerating appliances and repealing Commission Delegated Regulation (EU) No 1060/2010. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=pi_com:Ares(2018)5145999, last accessed in August 2021.

[2] U4E Model Regulation Guidelines for Energy-efficient and Climate-friendly Air Conditioners. Available at https://united4efficiency.org/resources/model-regulation-guidelines-for-energy-efficient-and-climate-friendly-air-conditioners, last accessed in March 2021.

[3] Draft new EU regulation: Commission Delegated Regulation to Implementing Directive 2009/125/EC of the European Parliament and of the Council repealing Regulation (EU) No 206/2012 with regard to ecodesign requirements for air conditioners and comfort fans. Available at https://www.eceee.org/ecodesign/products/airco-ventilation/, last accessed in August 2021.

[4] COMMISSION Regulation (EU) 2016/2281 of 30 November 2016 implementing Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products, with regard to ecodesign requirements for air heating products, cooling products, high temperature process chillers and fan coil units. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R2281&from=EN, last accessed in August 2021.

[5] ISO 16358:2013, Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors – Parts 1 to 3.

[6] ISO 5151:2017, Non-ducted air conditioners and heat pumps — Testing and rating for performance.

[7] ISO 13253:2017, Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance.

[8] ISO 15042:2017/AMD 1:2020, Multiple split-system air conditioners and air-to-air heat pumps — Testing and rating for performance — Amendment 1.

[9] IEC 60335-2-40:2018, Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers.

[10] European Commission, (2018). Preparatory/ Review of Regulation 206/2012 and 626/2011 Air conditioners and comfort fans, FINAL REPORT. Available at https://www.applia-europe.eu/images/Library/Review_Study_on_Airco_05-2018.pdf, last accessed in August 2021.

[11] Muller Nicholas Z., Robert Mendelsohn, and William Nordhaus, (2011). "Environmental Accounting for Pollution in the United States Economy". *American Economic Review*, 101 (5): 1649-75.

[12] ISSO 26000:2010, Guidance on social responsibility. Available at https://www.iso.org/obp/ui#iso:std:iso:26000:ed-1:v1:en, last accessed in August 2021.

Annex 1

Summary - Criteria for Air Conditioners

Criteria	Parameter	Recommendation for SPP	Section
Energy consumption	Type and size	Avoid portable ACs if possible and chose the size according to the cooling demand (oversized ACs consume more energy).	4.1.1
	Energy efficiency	Target the efficiency class corresponding to the 20% most energy efficient models in the market.	4.1.2
	Speed compressors	Prioritize variable speed compressors (inverter).	4.1.3
	Occupancy and temperature limiting controls	Include embedded occupancy and temperature limiting controls in the specifications wherever possible and relevant. Include peak power load management and connected 'smart' controls in the specifications where relevant.	4.1.4
	Reversible units	Use reversible units if heating is needed and where no other more efficient heating system is in place.	4.1.5
Refrigerants	ODP	ODP = 0	4.2
	GWP	Prioritize natural refrigerants (different GWP limits apply depending on size and type as per Table 3).	
	Leaks	Installation and maintenance requirements to minimize refrigerant leaks	
Sound power	Maximum db	60 dB (indoor) and 65 (outdoor) when <6kW 65 dB (indoor) and 70 (outdoor) when >6kW	4.3
Safety	Product and installation	The product shall meet all local safety requirements and technicians for installation and maintenance should be qualified for the specific products.	4.4
Product durability	Spare parts	The manufacturer/supplier should ensure availability of spare parts, even when the model is no longer in the market.	4.5.1
	Information	The manufacturer/supplier should make available the repair and maintenance information.	4.5.2
	Warranty	A complete warranty for a minimum of one (1) year and three (3) years for all the main operational components.	4.5.3
Environmentally sound management	Dismantling	Facilitate material recovery (for re-use) and recycling while avoiding pollution	4.6
	Take back requirements	Manufacturer/supplier should ensure the correct environmental disposal of the air conditioner at the end of life.	4.6
	Packaging	Minimum possible to facilitate handling the equipment and it should be recyclable.	4.6
Social criteria	Decent work	Complies with national and international decent work standards.	4.7

Annex 2

SPP Excel Spreadsheet Tool

This SPP guideline is accompanied by an SPP Excel spreadsheet tool [20], which provides information about the maximum energy consumption requirements for the sustainable public procurement process and calculates the impact of a given bid: cost and emissions.

Figure 5 shows the "Country Input" tab, where the user should input the characteristics of the region/project, such as energy price, real discount rate, emissions factor for the electricity generated, lifespan of products, etc. If the user does not input information for a certain parameter, a default value is automatically used. For those parameters that are expected to be constant in all tenders, it is recommended that the cell is locked after the policymakers have introduced the correct value, so it cannot be changed by other users, e.g., for the climate and requirements on energy efficiency.

Figure 5: SPP Excel spreadsheet tool for air conditioners: "Country Input" tab

Introduce the specific data for your country or project in the yellow cells. If no data is introduced, the default value will be used.

Yellow cells are expected to be filled by the user, while the blue ones are expected to be adjusted by the country and blocked, so a normal user cannot change it accidentally

Parameter	Country	Default	Comments about the parameter	Values that will be used
Real electricity price [USD]		0.16	The real electricity price refers to the real cost for the government for each kWh consumed. If the electricity is subsided, the real price should account for the cost in the electricity bill + the subsided part	0.16
Select Temperature-Hour distribution from the droplist.		Group 1	Group 1 climate is being used as default, please select the climate that corresponds to your country. The U4E requirements depend on the selected climate. More information about Temperature-bin hours can be found in Climate zones Tab.	Group 1
Select the Efficiency level requirement from the droplist		High Efficiency U4E	The default U4E refers to the High Energy Efficiency levels of the U4E model regulations. To use different values, the "user input" should be selected in the drop-list, and the advisor/legislator has to introduce the local SPP requirements in the Tab "MEPS&EE".	High Efficiency U4E
Annual leakage rate		5%	Corresponds to the annual leakage rate in % of the refrigerant charge, accounting leaks during operation and maintained. The default value of 5% corresponds to the assumptions taken by W. Goetzler et.al., 2016, in "The Future of Air Conditioning for Buildings". Values might vary depending on country practices.	5%
Refrigerant lost at end of life		15%	Corresponds to leakage rate in % of the refrigerant charge at the end of life, e.g., refrigerant that is not treated correctly. The default value of 15% corresponds to the assumptions taken by W. Goetzler et.al., 2016, in "The Future of Air Conditioning for Buildings". Values might vary depending on country practices.	15%
GWP requirement		750	GWP refers to the Greenhouse Warming Potential of the refrigerant being used. A GWP<750 is the requirement used as a default value. This is the value recommended by the U4E model regulation for window and split air conditioners up to 16 kW. In some cases, more stringent values can be used. For portable AC, the recommended value is GWP<150.	750
Real Discount Rate [%]		4%	Accounts for the cost of opportunity to invest in energy efficiency. For public procurement this value is usually lower than for the private sector.	4%
Real Energy Escalation Rate [%]		4%	Accounts for future increase of electricity prices.	4%
Real Discount Rate for Energy [%]	0%	0%	The Real Discount Rate for Energy takes into consideration the Real Discount Rate and the Real Energy Escalation Rate: Real Discount rate for Energy = Real discount rate - Real energy price escalation (all corrected with inflation)	0%
Emissions per energy use [kg CO2/kWh]		0.5	CO2-eq emissions of the national electricity mix. This might differ from country to country. Typical values are between 0.5 to 1 kg of equivalent CO2 per kWh produced	0.5
Energy transport and distribution losses [%]		8.25%	Used to calculate the total kWh produced in the power plant. Default value is the world average (source: world bank)	8.25%
GHG cost [USD/Tonne of CO2]		27	This accounts for the external costs due to the GHG emissions. The default value (27 USD) corresponds to the one used by Muller et al. (2011) for the US economy [in 2020 $ and Upper Range]. Different values can be applied in different countries.	27
Lifespan of the product		12	This lifespan value might differ from country to country and type of product. Ecodesigned products can have a significantly longer lifetime due to higher energy and durability performance requirements, improved product repariability and spare part availability requirements (e.g. a 7 year parts availability requirement, post model replacement date).	12
Emissions for manufacturing and distribution [kg CO2]		500.00	The default corresponds to the Preliminary Study to update the European Regulation 206/2012. This corresponds to a typical product with 7.1 kW of capacity. The value can be adjusted if the procured air conditioner is very different in size.	500.00

Figure 6 shows the "Cost and Emissions" Tab. At the top of the window, the type of metric can be selected (CSPF for cooling only, or APF for reversible units). Then, other characteristics such as capacity, efficiency, consumption, expected saving from special controls (10% of savings in this example), or type of refrigerant can be introduced. The tool

[20] *The SPP Excel spreadsheet tool can be downloaded at United for Efficiency´s website at: https://united4efficiency.org/resources/sustainable-public-procurement-excel-spreadsheet-tool/*

shows the minimum efficiency requirements (based on the U4E high efficiency levels [2], or user input, as selected by the user previously). The tool then calculates operational emissions and costs, life cycle cost analysis and total emissions (also considering the refrigerants being used).

This allows the results from different models (i.e., different bids) to be compared in the tool to help the buyer take more informed decisions.

For instance, Bid 1 in Figure 6 passes the minimum efficiency and refrigerant requirements, while Bid 2 does not. Furthermore, the spreadsheet demonstrates that even though each air conditioners in Bid 1 is 100 USD more expensive (10,000 USD in total) than those in Bid 2, the total life cycle cost for the 100 units is 51,564 USD less compared to the more inefficient Bid 2. From the emissions point of view, Bid 1 will result in a more than 400 tonnes of equivalent CO_2 reduction compared to Bid 2.

Figure 6: SPP Excel spreadsheet tool for air conditioners: "Cost and Emissions" tab – comparison of new units

Bid code	Number of units	Capacity per unit [kW]	Energy efficiency for cooling CSPF [kWh/kWh]	Minimum energy efficiency requirement	Meets Energy requirements?	Unitary Cooling Seasonal Energy Consumption (CSEC) in kWh per year	Special controls to reduce energy consumption? [Yes/No]	Expected savings for special controls in %
1	100	3.50	8.60	8.00	YES	800	Yes	10%
2	100	3.50	7.00	8.00	NO	982	No	
					-			
					-			
					-			
					-			
					-			
					-			

						The costs and environmental impact are considered for procured amount of refrigerators and for their total lifespan		
GWP for refrigerant	Refrigerant charge per unit (kg)	Meets fluid requirements?	Total price of the bid [USD]	Total operational cost (for all life of product) [USD]	Total External cost for CO2 emissions [USD]	Total Life Cycle Cost [USD]	Total indirect emissions (energy use) in kg CO2eq	Indirect + Direct (Refrigerants) emissions in kg CO2eq
675	1.0	YES	60,000	138,240	14,080	212,320	470,845	521,470
2,088	1.5	NO	50,000	188,544	23,681	262,225	642,180	877,080
		-						
		-						
		-						
		-						
		-						
		-						

Finally, if the new appliances are intended to replace older appliances which are still functional (i.e., early replacement), the tool can be used to calculate the payback period from the economic and environmental perspective compared with the new appliances. Figure 7 shows the necessary input for the old appliances. With the expectancy of years left for the old equipment, the tool also calculates the balance cost and emissions from the replacement, which might be positive or negative depending on the situation.

In this example, the replacement of 100 old air conditioners (with an average consumption of 1,300 kWh per year) with 100 new air conditioners (Bid 1 from Figure 6) will save 17,120 USD and avoid more than 355 tonnes of equivalent CO_2 emissions. In this case, the environmental payback period is 0 years. This is because the benefits of the more environmentally friendly refrigerant in the new air conditioners are greater than the drawback of producing new air conditioners (in terms of CO_2 emissions).

Figure 7: Excel SPP Excel spreadsheet tool for air conditioners: "Cost and Emissions" tab – comparison for early replacement

Note: The table below can be used to calculate the Payback and balance cost and emissions due to early replacement. It considers the emissions of production and distribution of new appliances.

Compare with Bid code	Number of units	Energy efficiency for cooling [kWh/kWh]	Unitary energy Consumption in kWh per year	GWP for refrigerant	Refrigerant charge per unit (kg)	Discounted Payback Period Cost (years)	Payback Period for CO2 emissions (years)	Expected years left for old appliance	Balance cost for early replacement [USD]	Balance emissions for early replacement [kg CO2 eq]
1	100	4	1,300	2,088	1.5	6.5	0.0	4	-17,120	-294,039
						If the number is negative, or shows an error, the Payback is never reached			The early replacement will save money	The early replacement reduces emissions

Annex 3

Life Cycle Costs and Emissions

This section shows how life cycle costs and emissions can be calculated for air conditioning appliances. Life cycle costing (LCC) is a good tool to quantify the impact of a given bid and help the tenderer to choose between different alternatives that exceed the minimum requirements (see the SPP Excel spreadsheet tool in Annex 2).

A3.1 Economic impact

A3.1.1 Life cycle cost (LCC)

From the economic point of view, the entire cost during the life cycle of the product should be considered, and not only the acquisition cost. In this sense, the life cycle cost analysis can be calculated as per Equation 1 (EQ.1).

$$LCC = PP + N \cdot \sum_{n=1}^{L} \left(\frac{AE \cdot EC}{(1+r)^n} + MC \right) + EOL + \alpha \cdot E_{app} \qquad \textbf{EQ.1}$$

Where:

- PP is the initial cost of the SPP purchase for all appliances.
- AE is the annual energy consumption declared by the manufacturer in kWh.
- EC is the real cost of the energy in $/kWh.
- MC is the maintenance cost.
- EOL is the end-of-life cost (such as collection and recycling costs).
- L is the expected lifespan of the product (currently around 12 years for air conditioners).
- N is the number of appliances in the tender.
- r is the difference between the real discount rate and the real escalation rate of energy price. If the discount rate and escalation rate of energy price are similar, r≈1.

Since this guide is intended for public procurement, the real energy cost should be considered, i.e., the price of energy without governmental subsides. The maintenance costs might also be included in the contract (e.g., it might be included in the PP term). The cost related to the product disposal at the end of life is usually included in the price of the product, especially in those countries with EPR policies.

Some countries charge taxes to entities depending on their GHG emissions. Even without taxes, GHG emissions will affect other parts of the economy, involving costs for both public institutions and society. The external cost due to GHG emissions can be considered using the factor α ($/tonne of eq. CO_2) multiplied by the emissions due to energy consumption during the use phase and the type of refrigerants used (see Eapp in Section A3.2). According to Muller et al. (2011) [11], the external environmental cost[21] due to the emission of 1 tonne of equivalent CO_2 is up to 27 USD (based on average value for the US in 2020 $ @ $ 65 per tonne of carbon).

A3.1.2 Early replacement (cost)

A life cycle costing is useful in comparing the total cost between two alternatives. When an early replacement is considered, i.e., the replacement of existing equipment that has not yet reached the end of its life (still working properly), a cost balance can be used to calculate the worthiness of the replacement of the old inefficient unit by a new efficient appliance.

In this case, the savings will also depend on the consumption and the life expectancy of the old appliance, see Equation 2 (EQ.2).

$$\boldsymbol{balance\ cost} = \left(\frac{PP \cdot L_{exp}}{L} + N \cdot \sum_{n=1}^{L_{exp}} \frac{AE \cdot EC}{(1+r)^n}\right) - \left(N_{old} \cdot \sum_{n=1}^{L_{exp}} \frac{AE_{old} \cdot EC}{(1+r)^n}\right) \qquad \textbf{EQ.2}$$

The first term corresponds to the cost of the new appliance during the life expectation of the old equipment (Lexp), e.g., if the equipment is 10 years old, considering a lifespan[22] of 12 years, Lexp = 2 years. In this case, the initial price is normalized with the life expectation of the old equipment and the lifespan of the new equipment considered for the early replacement, as after two years the old equipment would be replied anyway. The operating cost of the new and old appliances are considered during the life expectation of the old equipment. AEold refers to the annual energy consumption of the old air conditioner in kWh.

The early replacement will lead to economical savings if the balance cost is negative, i.e., the cost of the old equipment is higher than cost of the new equipment.

A3.2 GHG emissions

A3.2.1 Emissions during use stage and refrigerants

Equation 3 (EQ.3) can be used to calculate the total emissions, the indirect emissions due to the energy use of the air conditioner during its lifetime and the direct emissions due to the use of refrigerant (Eapp in kg of equivalent CO_2).

$$E_{app} = N \cdot \left(\frac{AE}{1-TD} \cdot \beta \cdot L + \left(GWP_{ref} \cdot m_{ref} \cdot R_{EoF,ref}\right)\right) \qquad \textbf{EQ.3}$$

[21] *The external environmental cost might vary for different countries and the assumptions made to calculate the cost, e.g. if it considers or not the effect of emissions outside of the country.*
[22] *12 years is taken as a reference value in this example, but depending on the condition of the equipment, this number can be reduced or increased.*

Where:

- AE is the annual energy consumption in kWh.
- TD are the transmission and distribution losses.
- $\boldsymbol{\beta}$ is the indirect emission factor in equivalent CO_2 per kWh of consumed electricity (which will depend on the energy mix of the country or region).
- L is the expected lifespan of the product.
- N is the number of appliances in the tender.

For the refrigerant (ref):

- GWP is the global warming potential.
- m is the refrigerant charge in kg.
- $\boldsymbol{R_{EoF}}$ is the ratio of the refrigerant that will end up in the atmosphere (compared to mref) during maintenance operation, leakages, and after the disposal of the unit. This number will depend on the recycling practices of each country and might be higher than 1. For example, if we consider that 43% of the charge is lost during the lifetime (and refilled), and all refrigerant is released to the atmosphere at the end of life, $\boldsymbol{R_{EoF}}$ = 1.43

This calculation does not consider the emissions due to production and distribution because the equation is intended to compare two new options, but these terms will be considered in the early replacement calculations. Furthermore, if leaks are not repaired correctly, the lack of refrigerant might lead to a decrease on energy efficiency, increasing energy consumption and the related indirect emissions.

Most of the emissions (equivalent CO_2) of an air conditioner occurs during the usage stage due to energy use and due to refrigerant direct emissions depending on the refrigerant used and recycling practices.

The emission of ozone depletion substances is not included because it is a requirement for all new air conditioners to have an ODP = 0.

A3.2.2 Early replacement (emissions)

When early replacement is considered, i.e., the replacement of existing equipment that has not yet reached the end of its life (still working properly), a balance of emissions can be calculated in a similar way to that of costs in the previous section (see Equation 4 (EQ.4).

$$\boldsymbol{balance\ emissions = \frac{L_{exp}}{L}\left(N_{new}\cdot\lambda + \left[\frac{AE}{1-TD}\cdot\beta\cdot L\right]_{new} - \left[\frac{AE}{1-TD}\cdot\beta\cdot L\right]_{old}\right) + \left(\left[N\cdot GWP_{ref}\cdot m_{ref}\cdot R_{EoF,ref}\right]_{new} - \left[N\cdot GWP_{ref}\cdot m_{ref}\cdot R_{EoF,ref}\right]_{old}\right)} \quad \textbf{EQ.4}$$

In this equation, the emissions of the new appliances are compared to the emissions of the old appliances, if the balance is negative this means that the emissions of the old appliances would be higher than the emissions of the new appliances, for which the production and distribution impact is also introduced with the factor $\boldsymbol{\lambda}$ (in kg of CO_2 per unit). In this case, the emissions due to electricity consumption are considered only during the expectancy of life for the old equipment (Lexp), while $\boldsymbol{R_{EoF,ref}}$ represents the ratio of the (refrigerant lost during Lexp + lost at the end of life) compared to the total refrigerant mass ($\boldsymbol{m_{ref}}$).

A3.3 Power load

The power consumption of the air conditioner will depend on the ambient temperature; and the total power needed to run the air conditioners will also depend on the use profile (for instance, office building, residence, etc.). The pattern of use of the air conditioner will usually lead to certain hours of the day/year where the air conditioner draws more power (peak hours), which also might coincide with the total peak demand of electricity. The peak demand leads to oversized power plants. A more efficient product will reduce the power demand, helping to alleviate the peak power demand on power plants and reducing investments needed to increase power plant capacity in the future.

The estimated power demand of several appliances (N) can be calculated as per Equation 5 (EQ.5).

$$\boldsymbol{P = N \cdot \frac{Q_c}{EER}} \qquad \textbf{EQ.5}$$

EER is the energy efficiency of the unit at a certain ambient temperature, e.g., rated at 35ºC, and $\boldsymbol{Q_c}$ is the cooling capacity at the rated temperature (same as the EER).