D3.3 - Topten HACKS Criteria Paper

Air conditioners

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HACKS coordinator: ADEME – www.ademe.fr

European portal www.topten.eu/hacks

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About HACKS

The objective of the Heating and Cooling Knowhow and Solutions (HACKS) project is to achieve market transformation for heating and cooling (HAC) appliances and improve comfort and health of European citizens.

Across the EU almost half of all buildings have individual boilers that were installed before 1992 with efficiency of 60% or less. The expected energy savings from a speedy replacement are immense.

To achieve this goal, 17 HACKS partners in 15 countries are working together, thanks to the financial support of the European Horizon 2020 programme.

After scanning market actors, current policies and most commonly used products in each country, starting from April 2020 the HACKS partners will implement involvement campaigns to raise awareness of the economic and environmental benefits brought by good HAC products and solutions:

- HACKS will motivate households equipped with old and inefficient devices – boilers, water heaters, air conditioners, certain types of boilers and stoves, etc. – to replace them with new super efficient equipment.
- In each country, partners will set-up dedicated on-line platforms to assist consumers in their purchasing process. The platforms will propose: tools to assess households' needs and provide customised information; best product lists with technical specifications; direct links to suppliers of most efficient products; and advice on how to use and maintain equipment.
- For those households who need to improve their situation because they feel too hot, too cold, or too humid but who cannot invest in new equipment or can avoid getting equipped, HACKS will propose simple and low costs solutions. It is possible to reduce energy consumption and energy bills while improving winter and summer comfort, air quality and health conditions through the installation of shading devices, thermostats, water saving taps and showerheads, etc.

Beyond households, HACKS will target all relevant stakeholders (“multipliers”) that participate in the decision-making process of consumers by setting up strategic partnerships to facilitate the purchase of energy efficient appliances. HACKS places a strong emphasis on installers but also retailers and consumer organisations because of their proximity to consumers, their capacity to involve them and bring them guidance on energy efficient equipment.

More information on the HACKS project can be found on https://www.topten.eu/hacks.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 845231.

Executive summary

The document provides an overview on energy efficient air conditioners under 12 kW, the regulations that govern these products and the market development in the European Union. It presents the selection criteria of energy efficient air conditioners of Topten platforms throughout Europe. The energy efficiency selection criteria for each Topten platform are explained as well as the method to gather data to set up a national product list and the type of information to be collected.

Best available technologies are air conditioners with a variable speed compressor and with low global warming potential refrigerants. Today the energy efficiency metrics used for split units are different than the one used for single and double duct air conditioners. This makes the comparison of product efficiency across different types of air conditioners not possible.

Finally, the paper also includes information that can be integrated in consumer recommendations on purchase, maintenance and use of an air conditioner.

With these criteria papers the intention is to be able to identify and select the most energy efficient models available on the market. The primary objective is to help partners on their territory for their Topten and HACKS website, but the technical content may also support anyone willing to find good products from an environmental point of view.

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1 Topten selection criteria for air conditioners

1.1 Topten.eu: Air conditioners - current selection criteria and products selected

Within the HACKS project, in January 2020, Topten tightened its selection criteria for energy efficiency but also introduced criteria for refrigerants.

Currently (February 2022) the selection criteria on Topten.eu are the following:

- Minimum energy efficiency class:
  - Monosplit ≤ 4kW: A+++/A+++ (cooling / heating efficiency)
  - Monosplit > 4kW: A++/A++
  - Multisplit: A++/A++
- The product must contain a lower-GWP refrigerants which has a GWP that is less than 700[1].

In February 2022 there were 84 models on Topten.eu.

Table 1: Models on Topten.eu according to their rated capacity and energy class – February 2022

	A+++/A+++	A+++/A++	A++/A+++	A++/A++	Total
Monosplit ≤ 3kW	17				17
Monosplit 3 ≤ 4 kW	11				11
Monosplit 4 ≤ 5 kW	1	2	5	15	23
Monosplit 5 ≤ 6 kW	0	0	0	1	1
Monosplit 6 ≤ 7 kW	0	0	4	2	6
Multisplit	0	18	0	8	26
Total	29	20	9	26	**84**

Source: Topten.eu

In the current Energy Label regulation for air conditioners, the energy class scale for split air conditioners is more stringent than the one for single and double duct air conditioners (class A corresponds more or less to class F of split ACs).

Still today, no single and double duct air conditioners meet the Topten selection criteria.

There are 84 air conditioner models of 8 different manufacturers on the Topten.eu product lists: Daikin, Fujitsu, Hitachi, LG, Mitsubishi Electric, Panasonic, Samsung, Toshiba.

1.2 National selection criteria

Most national Topten platforms display product lists of air conditioners (in 10 countries). Only the more Northern countries currently do not list them (i.e UK, Sweden, Norway, and Luxemburg). The national selection criteria are the same used by Topten.eu with the exception of Spain and Austria. Their criteria are slightly stricter in that they list only models with efficiency classes (cooling/heating) A+++/A+++.

[1] R32 is referred as a lower GWP refrigerant, not a low-GWP refrigerant. Low-GWP refrigerants are natural refrigerants such as R290 or R744.

1.3 Expected Topten selection criteria at the HACKS project end in fall 2022

Based on the market developments in 2020 and 2021, Topten will likely keep the current selection criteria for multi-split devices and larger split appliances with > 4kW cooling capacity.

However, small split appliances with ≤ 4kW for cooling have already reached the highest class for cooling and heating functions (A+++/A+++). All truly efficient devices on the market meet those criteria for over a year now and it is not possible for these products to differentiate each other. For this reason, Topten will assess whether the criteria can be further strengthened, based on the SEER (SEER A+++ limit is 8.5).

2 Technical background

2.1 Scope

An air conditioner is essentially an air-to-air heat pump that extracts heat from the inside air and expels it outside using a working fluid (refrigerant) that absorbs the heat and releases it when under different temperature and pressure conditions.

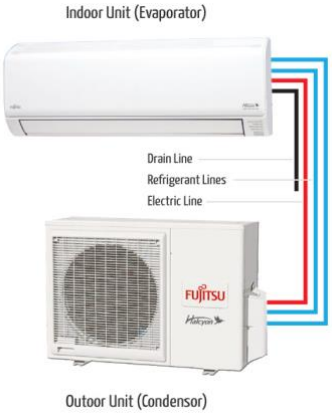
Based on 2016 data, 96% of air conditioners are “reversible”, i.e. they can also be used to heat the inside space. This means that the thermodynamic can either remove heat from the inside and bring it outside or it can absorb heat from the outside space and bring it into the room.

All air conditioners function according to the same principles. There exist however different types of air conditioners.

2.1.1 Ductless split air conditioners

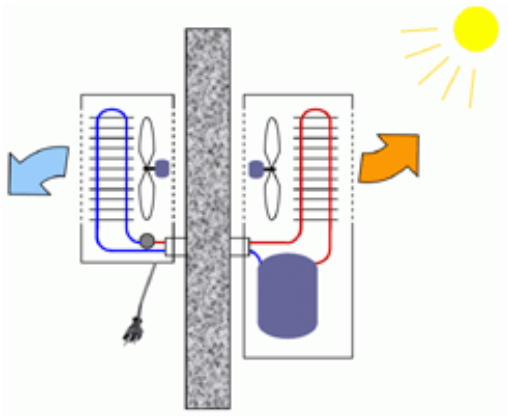
Split air conditioners are fixedly installed and are composed of two parts: an indoor and an outdoor unit. The two units are connected by a tube containing the refrigerant. In this system, there is no transfer of air from the outside to the inside. These products are ductless: The air inside the room is “recycled” and cooled as it goes through the inside unit. While it is cooled, the air conditioners also dehumidify the air for more thermal comfort. The humidity is evacuated through the drain line.

Figure 1: Inside and outside units of a split device



Source: Fujitsu.com

Figure 2: Schematic representation of a split unit. The blue tank is the compressor that is place in the outside unit.



Source : Topten.ch

In larger installations, several indoor units can be connected to one outdoor unit. This complex installation is known as a multi-split air conditioner.

Mobile splits air conditioners are portable and have movable indoor and outdoor units that are connected by the refrigerant tube. To install these devices, the user needs to put the outside unit through a slit door or window and close the gaps to avoid outside air from coming in.

Figure 3: Mobile split air conditioners

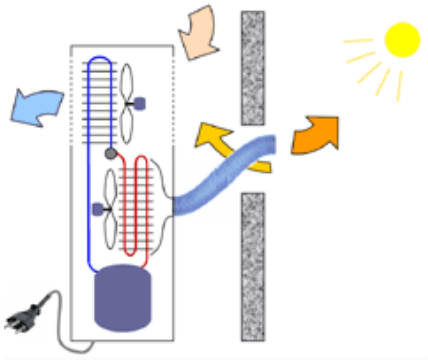
Source: amazon.co.uk

2.1.2 Single duct

Single ducts consist of one single portable unit placed freely in the room. The entire cooling cycle takes place in the same unit inside the room. The hot air is expelled through a duct towards the outside. The duct has to be placed through an open window or an open door. Because of the tube expelling air outside of the room, the air is replaced by warm air that is drawn into the room from gaps around the open window (similar to the mobile split air conditioners) or from other rooms in the house. To limit the entry of warm air into the room, window insulation packages exist. However, their effect is limited.

The overall cooling effect of these devices is low, and they basically just serve to cool locally.

Figure 4: Structure and installation of a single duct air conditioner



Source: Topten.ch

Figure 5: Single duct air conditionner

Source: fust.ch

Figure 6: Window insulation system for a single duct air conditioner

Source: hornbach.ch

It is important to keep in mind that the products always have a duct attached to them that goes towards the outside. In many marketing materials, the duct is not shown in the photo and the device seems to be a smaller than what it actually is.

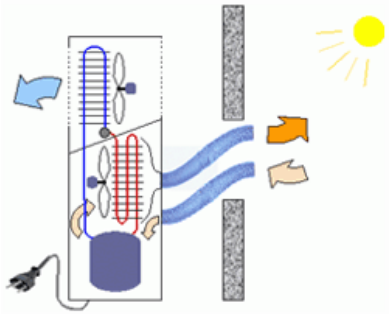
Figure 7: Advertisement for portable single duct unit. The duct is missing on the photo and the product needs to be placed near a window for the heat to be expulsed outdoors.

Source: goodwinecoolers.com

2.1.3 Double duct air conditioners

Double ducts also consist of one single unit but have separate ducts for air intake and exhaust. Double ducts can be portable and placed next to a window or they can be mounted to the wall. Because all components are placed in one unit that is on the inside, double duct air conditioners are louder than split units. Similarly, to the portable single duct unit, the device itself generates heat and releases into the room: it creates heat that it subsequently needs to remove.

Figure 8: Schematic representation of double duct air conditioner



Source: Topten.ch

Figure 9: Double duct air conditioner installation

Source: learn.compactappliance.com

2.1.4 Through-the-window air conditioners

Through-the-window air conditioners (also known as compact or through-the-wall AC) are widespread in the USA but occur rarely in Europe. They are too compact to be efficient and need to be fixed through an open window. They are also only adapted for vertical sliding windows (single-hung).

Figure 10: Out-of-the-window air conditioner

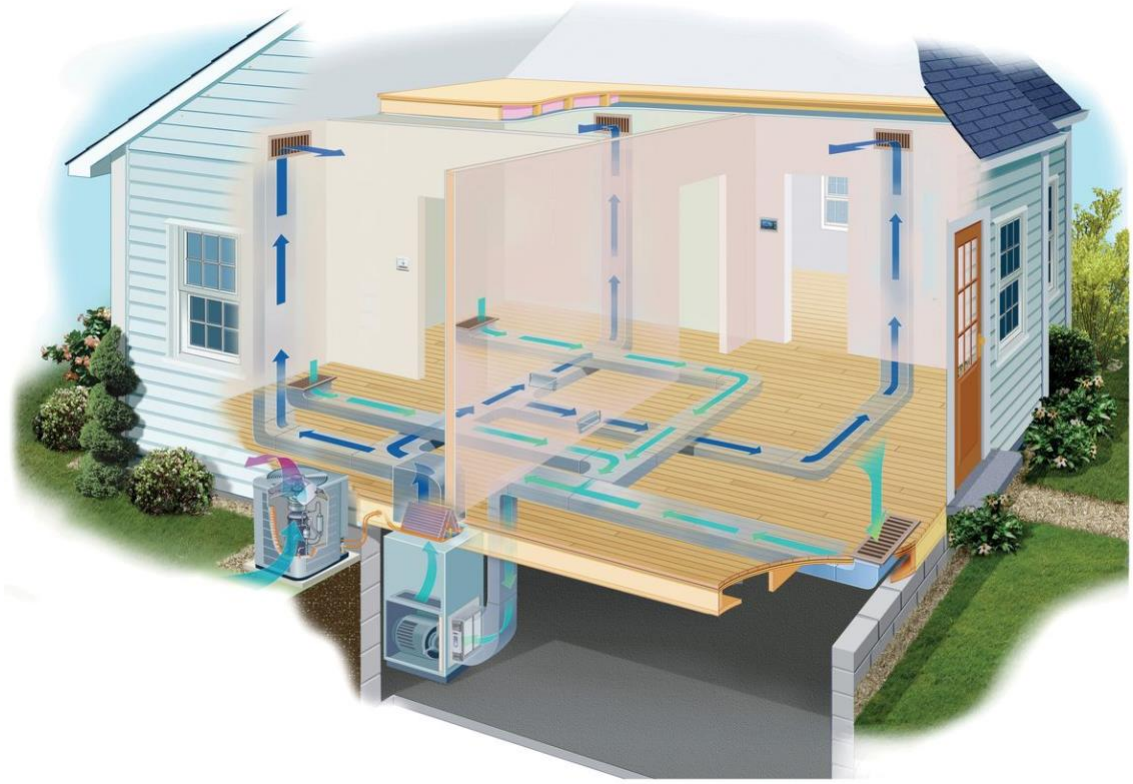
Both sides of the unit are closed off with a partition that allows the heat to enter the room.

Source: lowes.com

2.1.5 Ducted systems

Ducted systems are not in the scope of the Topten lists. In a ducted system, the cool air is transported through ducts in different rooms and comes out through vents. These systems are found in buildings with a central cooling system such as in hotels. The installation of this cooling systems requires a complete building overhaul or is installed directly in new builds.

Figure 11: Example of a ducted air conditioning system



Source: thisoldhouse.com

2.1.6 Air conditioning technology comparison

Each air conditioner that is in the scope of the HACKS project has its own pros and cons. A summary is presented in Table 2.

Table 2: Pros and cons of air conditioner technologies

Air conditioner type	Pros	Cons
Split system	+ high energy efficiency + high effectiveness + quiet	- relatively expensive investment - needs to be fixed and drilling in the wall is required - installation by a third-party - cannot be moved according to the needs of the user
Single duct and double duct	+ cheap + easily purchased in the store + immediate installation	- energy consuming - noisy - infiltration of hot air - the product releases heat into the room

2.2 Technical description

All air conditioners are constituted of four main components: the compressor to pump the heat-laden refrigerant through the system, the condenser to reject the heat from the system to the outside, the evaporator to absorb heat into the system and the expansion valve to control the flow of the refrigerant. These 4 components are found in all products that rely on a thermodynamic cycle (refrigerators and heat pumps).

The refrigerant flows through the cycle and changes from a liquid and gaseous state through the absorption and release of heat. The refrigerant is in a closed system and the cycle repeats itself continuously. The cycle is accomplished by maintaining a pressure difference between the high pressure and low-pressure sides of the system.

2.2.1 Technical Terms

The following terms are the most important and are needed to understand the current regulation. More terms can be found in section 7.

Rated Capacity

The size of an air conditioner is determined by its rated capacity output in kW. This value however does not correspond to the actual energy consumption. The rated capacity of the air conditioner is determined by various factors such as the size of the room and the heat load. The room size as sole criteria for estimating the rated capacity does not work in all cases. A poorly insulated room with large windows will require a higher rated capacity to satisfy the needed cooling load.

Table 3: Example of air conditioner rated capacity estimate according to the size of the room

	Small room	Medium room	Large room
Room size (m^2)	10-20 m^2	20-40 m^2	40-60 m^2
Minimum required kW	2.8 kW	4.2 kW	5.6 kW

Source: www.appliancesonline.com.au

Energy Efficiency Ratio (EER)

The energy efficiency ratio (EER) of a particular cooling device is the ratio of output cooling energy (in W) to input electrical energy (in W) while working at full load. An air conditioner with a 2.5 kW rated capacity and an EER of 10.6 will consume at full load approximatively 235 W. The higher the EER, the more efficient the product.

Coefficient of Performance (COP)

The COP is the same efficiency metric as the EER the only difference being that it applies to the heating mode. The higher the COP, the more efficient the product.

Seasonal Energy Efficiency Rating (SEER)

The SEER is a metric rating the energy efficiency of the air conditioner in cooling mode by taking part-load operation of the air conditioner into account. Air conditioner with variable drive speed compressors (also known as the inverter technology), have the ability to work at part-load. This indicator considers the different cooling needs during the year and thus include part load operation of air conditioners. The energy consumption is measured at four different outdoor temperatures at different part loads. The measurements are extrapolated to a wide range of outdoor temperature values. The higher the SEER, the more efficient the product.

Seasonal Coefficient of Performance (SCOP)

The SCOP or the Heating Seasonal Performance Factor it the same metric as the SEER to rate the energy efficiency rating in the heating mode. The higher the SCOP the more efficient the product.

2.2.2 Refrigeration cycle

The refrigerant cycle is the basis of any air conditioner. Understanding its basic principles is useful when engaging into technical conversations on the topic.

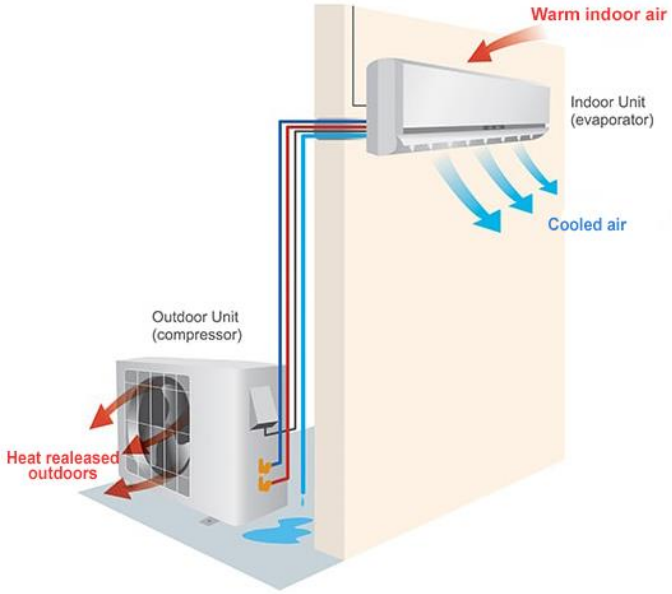
Summary of the refrigeration cycle

The refrigerant is the working fluid of the air conditioner. It operates in a closed cycle and follows through these subsequent steps:

This refrigerant comes into the compressor as a low-pressure gas, it is compressed and then moves out of the compressor as a high-pressure gas. The gas then flows to the condenser. Here the gas condenses to a liquid and gives off its heat to the outside air. The fan ventilates the condenser coils to increase the flow of air on the condenser, making the heat exchange more efficient.

Figure 12: Illustration of the refrigeration cycle for a split system.

During this process the inside air is cooled by the heat removal process of the air conditioner.



Source: https://www.firstservice.org/

The liquid then moves to the expansion valve still as a high pressure gas. This valve restricts the flow of the fluid and lowers its pressure as it leaves the expansion valve. The low-pressure liquid then moves to the evaporator, where heat from the inside air is absorbed and changes it from a liquid to a gas.

As the gas circulates through the evaporator, it starts absorbing heat from the immediate environment (the inside room). The liquid slowly transforms to gas as more and more heat is absorbed. The temperature of the air surrounding the evaporator drops and the fan in the inside unit blows the air into the room.

When the refrigerant leaves the evaporator, it is a hot low-pressure gas that moves to the compressor where the entire cycle is repeated.

This process continues until the air on the inside air reaches the desired temperature. When the thermostat senses that the interior temperature is at the desired level, it shuts the air conditioner off. When the room heats up again, the thermostat turns the air conditioner back on until the preferred ambient temperature is achieved again.

2.2.3 Refrigerants

Refrigerants are compounds that can absorb from and eject heat into the environment. The first generation of refrigerants are known as the Chlorofluorocarbons (CFCs). These compounds have a high ozone depleting potential (ODP), a high global warming potential (GWP) and are in a great part responsible for the depletion of the ozone layer. Hydrochlorofluorocarbons (HCFCs) are less damaging to the ozone than CFCs. Through binding agreements of the Montreal Protocol, they are being phased out globally. Hydrofluorocarbons (HFCs), which include R410A and R134 do not damage the ozone, however they still have a high global warming potential (2088 and 1975 respectively).

The Parties of the Montreal Protocol adopted the Kigali Amendment that calls for a phase-down of HFC gases. The European Union is contributing to this phase-down with its F-Gas regulation (No 517/2014).

R410A and R134 are commonly found in air conditioners in Europe. R32 with a GWP of 675 is a more recent refrigerant that has been on the market for several years and which is gaining market share in Europe. Natural refrigerants such as propane (R290) can be used but are not allowed on the market because of safety concerns. The amount of refrigerant needed for one split unit surpasses the maximum allowed amount that are prescribed in safety standards.

2.3 Best available technology

An efficient air conditioner is the sum of efficient components. The largest contributor to the energy efficiency of the air conditioner is the compressor.

Variable speed driver compressors (also known as the inverter technology) are today's best available technology (BAT). Variable speed drives allow the compressor to run at part load and adjust the energy consumption for the cooling / heating to what is actually needed. Because an inverter monitors and adjusts ambient temperature whenever needed, energy consumption drops by 30% compared to a traditional on/off system (non-inverter).

Figure 13: Fixed speed compressor (on/off)

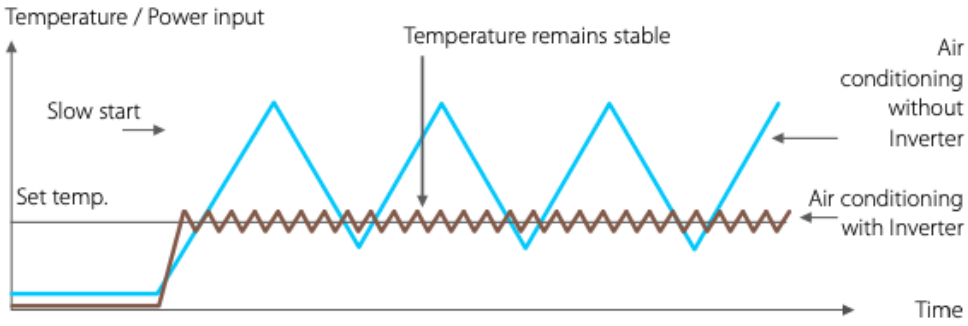
Source: Wikipedia

Figure 14: Variable speed drive compressor

Source: https://www.zerohvacr.com/

Fixed-speed compressors (on/off compressors) on the other hand can only run at full load (100% of their cooling / heating capacity), they reach the targeted temperature by switching on and off. Part load operation is much more efficient than switching on and off.

Figure 15: Operation difference in between compressors with or without inverters



Source: Daikin Europe

3 Policy measures, standards and labels

The regulation for air conditioners covers products that use the air as a medium for heat transfer. As opposed to the products covered in the regulation for space heaters that transfer the heat through tubes of water. Using this as the main differentiation point between the products, there is no overlap. The Energy Label and Ecodesign regulations from 2012 cover all electric air conditioners with a rated cooling capacity under 12 kW. The energy savings from the regulations are expected to reach between 11 and 16 TWh in 2020. Both regulations are currently being revised. A Consultation Forum took place in September 2019 and a second Consultation Forum took place in July 2021. The revision process has been quite delayed in the last year. One point of contention is having one unique label for all cooling products, where single duct products are to be listed on the same scale as split systems. There have also been calls for adapting the measurement method before the regulation is revised. If this were to be the case, the revision could be delayed by several years

Current relevant regulations

- Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans.
- Commission Delegated Regulation (EU) No 626/2011 of 4 May 2011 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners.
- Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 214 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006.

3.1 Ecodesign regulation

The latest tier of the Ecodesign regulation entered into force in January 2014. The regulation sets minimum performance criteria for energy efficiency, noise and standby levels. In the regulation, split units are treated differently than single and double duct units. Indeed, the requirements are more favorable for single and double duct units. The regulation also attempted to promote air conditioners with low-GWP refrigerants (GWP < 150) by allowing these models to be 10% less efficient. In practice, no manufacturer of split units made use of the bonus given to air conditioners with low-GWP refrigerants.

Table 4: Tier 2 energy efficiency requirements, as of January 2014

The energy efficiency metrics for single ducts and double ducts are the EER and COP while the metrics for split units are the SEER and SCOP.

	Split ACs		Double ducts		Single ducts	
Rated capacity and refrigerant	**SEER**	**SCOP**	**EER**	**COP**	**EER**	**COP**
< 6kW, GWP > 150	4.6	3.8	2.6	2.6	2.6	2.04
< 6kW, GWP < 150	4.14	3.42	2.34	2.34	2.34	1.84
6-12 kW, GWP > 150	4.3	3.8	2.6	2.6	2.6	2.04
6-12 kW, GWP < 150	3.87	3.42	2.34	2.34	2.34	1.84

Source: EU No. 206/2012

The F-Gas regulation also prescribes that as of January 2020, **portable room air conditioners** that contain a refrigerant with a GWP of 150 or more are to be banned from the market (Regulation 517/2014). A ban for single split air conditioners with less than 3 kg of refrigerants that have a GWP of 750 or more will enter into force in January 2025.

Air conditioners similarly to other products have low power modes requirements where the products shall not consume more than 0.5W in Off-mode, 0.5W (no display) / 1W (with display) in standby mode. The power management system must switch the device automatically into standby mode when it's not used. The Ecodesign regulation also sets noise requirements (see Table 5). Information requirements cover a long list of technical information that are required for the SEER and SCOP calculation but that do not provide a lot of information for users[2].

Table 5: Requirements for maximum sound power level

Rated capacity ≤ 6kW		**Rated capacity ≥ 6kW**	
Indoor sound power level in dB(A)	**Outdoor sound power level in dB(A)**	**Indoor sound power level in dB(A)**	**Outdoor sound power level in dB(A)**
60	65	65	70

Source: EU No. 206/2012

3.2 Energy Label: different schemes for different technologies

The current Energy Label is based on regulation No. 626/2011. The label is mandatory since 2013 and ranges today from A+++ to D.

The Energy Label rates the energy efficiency heating and cooling performance of all air conditioners. The label for split units however uses a different scale than the label for double and single duct units.

For double and single duct units, the full load performance is used to determine the energy efficiency class.

For split units, the label is slightly more complicated. Because the energy efficiency metric is a seasonal metric, the label takes these climatic variations into account and thus the part-load performance of

[2] The information requirements show for each setpoint temperature the corresponding COP and EER in the different climate zones.

the product. For the heating mode, the label shows three energy efficiency class rating for the heating function according to three different climate zones. The climates of the cities of Helsinki, Strasbourg and Athens are used for the seasonal heating profile for the cold, moderate and warm climates respectively. The assumed heating hours per year and the part load ratios depend on the climate zone.

For the cooling mode, only one climatic profile is used on the label which corresponds to the seasonal temperature profile of the city of Strasbourg.

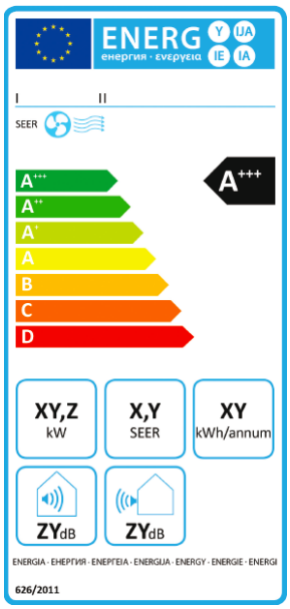
The Label provides the following information:

- Energy efficiency class(es)
- Rated capacity for cooling / heating (kW)
- Energy efficiency (SEER / SCOP for split air conditioners and EER/COP for single and double ducts)
- Annual energy consumption in cooling and/or heating mode for split units or hourly energy consumption for single and double ducts
- Sound power level of outdoor and indoor units.

The name and GWP value of the refrigerant must be declared on the product fiche. It is also declared on the unit.

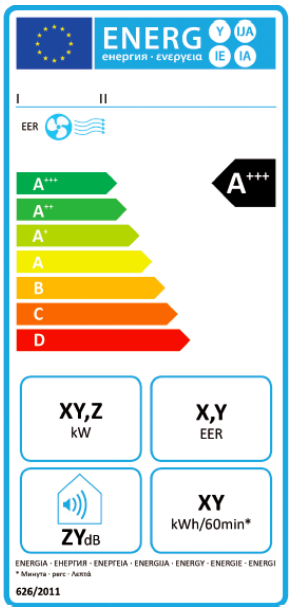
Figure 16: Energy label for non-reversible split unit air conditioners

These labels are quite rare because in Europe, most units are reversible.



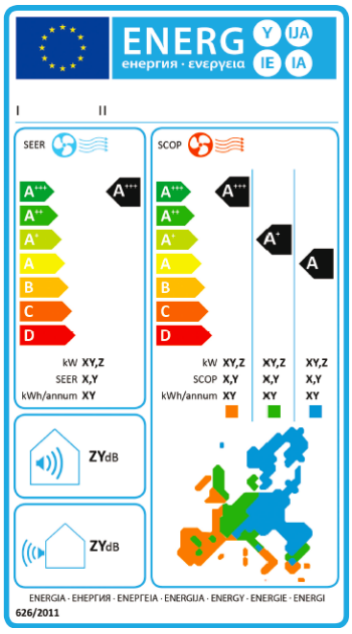
Source: EU No 626/2011

Figure 17: Energy label for non-reversible single and double duct air conditioners.



Source: EU No 626/2011

Figure 18 : Energy label for reversible split air conditioners showing the SEER and SCOP values and annual energy consumption



Source: EU No 626/2011

Figure 19: Energy label for reversible single duct and double duct air conditioners

The energy efficiency is based on the performance of the device at full capacity (EER and COP).

Source: EU No 626/2011

Single and double duct air conditioners are rated on different scales making the two energy labels impossible to compare. Indeed, an A+ single duct air conditioners is much less efficient than an A+ split air conditioner.

Table 6: Classification scheme of the Energy Label (as October 2015).

Some classes are partly banned because of the allowance given to air conditioner containing a refrigerant with a GWP of less than 150.

	Split air conditioners		**Double ducts**		**Single ducts**	
	SEER	**SCOP**	**EER**	**COP**	**EER**	**COP**
A+++	≥ 8.5	≥ 5.1	≥ 4.1	≥ 4.6	≥ 4.1	≥ 3.6
A++	≥ 6.1	≥ 4.6	≥ 3.6	≥ 4.1	≥ 3.6	≥ 3.1
A+	≥ 5.6	≥ 4.0	≥ 3.1	≥ 3.6	≥ 3.1	≥ 2.6
A	≥ 5.1	≥ 3.4	≥ 2.6	≥ 3.1	≥ 2.6	≥ 2.3
B	≥ 4.6	≥ 3.1	≥ 2.4	≥ 2.6	≥ 2.4	≥ 2.0
C	≥ 4.1	≥ 2.8	≥ 2.1	≥ 2.4	≥ 2.1	≥ 1.8
D	≥ 3.6	≥ 2.5	≥ 1.8	≥ 2.0	≥ 1.8	≥ 1.6
E	≥ 3.1	≥ 2.2	≥ 1.6	≥ 1.8	≥ 1.6	≥ 1.4
F	≥ 2.6	≥ 1.9	≥ 1.4	≥ 1.6	≥ 1.4	≥ 1.2
G	< 2.6	< 1.9	< 1.4	< 1.6	< 1.4	< 1.2
banned						
partly banned						

Source: EU No. 206/2012 and EU No 626/2011

The energy label shows for each the cooling mode and for the three heating mode, a certain amount of kWh per year. It is assumed for this calculation that the appliance operates for 350 hours in the

cooling mode and 1400, 1400 and 2100 hours for the cold, mild and warm climate respectively. Depending on what main heating system is in place (central heating and air conditioner as an add-on or main heating source), it is difficult to asses whether this number of hours reflects the real use conditions.

3.3 Policy recommendations for the revision

The draft Ecodesign and Energy Label regulation that was presented at the Consultation Forum in 2019 proposed to use the same metrics and ratings for all types air conditioners. Within the framework of HACKS, the policy recommendations of Topten are listed hereunder:

One label for all air conditioners

The merger of the energy labels for split and mobile appliances into one so that all products can be compared to one another. The current situation is very misleading to the consumer and unfairly favors inefficient mobile air conditioners.

Strong energy efficiency ecodesign requirements.

Based on the findings of the preparatory study, the minimum energy performance requirements can be further tightened. For the new regulation to have a strong impact on the market and avoid that products populate the top classes shortly after the entry into force of the regulation, Topten calls for tighter MEPS.

Promotion of low GWP refrigerants.

Although the F-Gas regulation has been into force for several years, there should be further measures in place to accelerate the phase-down of HFC refrigerants. A malus system that would penalise high GWP air conditioners should be considered.

Alignment of the measurement metric

The use of the seasonal metric for all types of air conditioners to better reflect real-life performance. The SEER and the SCOP are consolidated metrics that take into account a range of outdoor temperatures instead of working only at full load like the EER and COP.

4 Market analysis

The air conditioners market in the EU is growing. In 2015, 4.2 million units were sold across the EU-27 and in 2017, these increased to 5.8 million units. By 2030, sales are expected to reach 6.2 million units per year. Only a small part of the sales is for replacement of units, the rest being units installed for the first time. The stock is estimated to grow from over 46.1 million units today to 60 million units by 2030 (EC, 2018). Approximately 85% of the air conditioners sold are split units. Portable single and double duct units account for the remaining 15%. Out-of-the-window air conditioners do not have a significant market share in Europe and the share of mobile split units is also very small, as they have practically disappeared from the market.

The total annual electricity consumption of air conditioners in Europe was estimated at 28.5 TWh in 2015. By 2030 electricity consumption is expected to increase by 41% to approximately 40.2 TWh annually if no other measures are taken (business as usual) (EC, 2018).

5 How to gather data

When collecting data on air conditioners in the framework of the HACKS project, the energy efficiency classes of the product for heating and cooling mode are determined by the combination of the inside and outside unit. One outside unit can be compatible with several inside unit models and vice versa.

Topten.eu serves as reference for national Topten product lists.

National product lists should reflect market availability for each country. The following procedure is recommended for data gathering:

- Check what products are listed on Topten.eu
- Check which of those products are available in your country
- Check national products which are only available in your country to see if they comply with the selection criteria. Inform Topten.eu about them so they can be added to the topten.eu list.

For additional products it is recommended to ask local distributors for the available product combinations that are the most sold and most efficient.

The Eurovent database is also a source of information and helps to a certain degree facilitate the data gathering process.

In most technical datasheets, the energy efficiency classes for the mild climate are given. The energy classes for the colder and warmer climates are only visible on the energy label – hence it maybe more difficult to display this information even if it may be more representative.

5.1 Attributes

The attributes on Topten.eu are listed in the table below. Because the F-Gas will be limiting refrigerants above a GWP of 750 for products with more than 3kg, the amount of refrigerant could be added as a further refrigerant. Also, this information is useful as manufacturers are encouraged to develop air conditioners with low GWP air conditioners such as propane. In these cases, the amount of refrigerant is key because it conflicts with the existing safety standards for flammability.

Table 7: Attributes on Topten.eu for air conditioners – February 2022

Attribute	Example
Efficiency (cooling)	A+++
Efficiency (heating)	A+++
Electricity in 10 years	€143.00
Brand	Daikin
Indoor unit	FTXM-20M2V1B
Outdoor unit	RXM-20M3V1B9
Cooling capacity (kW)	2,0
Heating capacity (kW)	2,5
SCOP (heating)	5,1
SEER (cooling)	8,5
Energy cooling (kWh/year)	83
Energy heating (kWh/year)	632
Type of air conditioner	Split
Construction indoor unit	wall mounted

Noise level external (dB)	59
Noise level inside (dB)	57
Refrigerant	R32
GWP	675
Size indoor unit (WxDxH mm)	294x811x272
Size outdoor unit (WxDxH mm)	550x765x285
Number of indoor units	1

Source: Topten.eu

6 Input for Consumer Recommendations

What air conditioner should I buy?

Before buying an air conditioner, the user should try to see if by implementing other measures, the purchase of an air conditioner can be avoided. An unnecessary installation and use of an air conditioner will lead to substantial installation and operational costs. These methods will also impact how much the air conditioner is used in the first place as they all contribute to the reduction of the cooling load. In climate-moderate countries it is usually possible to keep rooms sufficiently cool with alternative, less energy-consuming measures:

- **Shading**: use proper shading for windows early in the day already. Once the sun reaches the windows, it is already too late to avoid the outside heat. A good shading system should be of a light colour and on the outside of the window. Also, it should allow let enough light in, in order not to need to switch on electric lighting (additional heat).
- **Airing**: air at night and in the early morning hours, if possible.
- **Avoid indoor waste heat**: buy energy-efficient appliances and switch off whatever is not needed.
- **Fan**: a fan lowers the experienced temperature by several degrees by creating a constant airflow. A fan uses much less electricity than an AC.

If all measures above are tried and it is still too warm, it is recommended to buy a split air conditioner instead of single or double duct models that are cheaper but less effective and consume very large amounts of energy. The split units are fixed and need to be installed by a professional installer. Only these achieve a true and lasting cooling effect, and they are much more energy-efficient than single and double ducts. Single and double ducts release waste heat to the room and need a window or wall opening, through which hot outdoor air enters into the room (the AC blowing air out of the room is creating low pressure in the room, so air from outside is compensating for this).

What is the best way to cool the indoor areas?

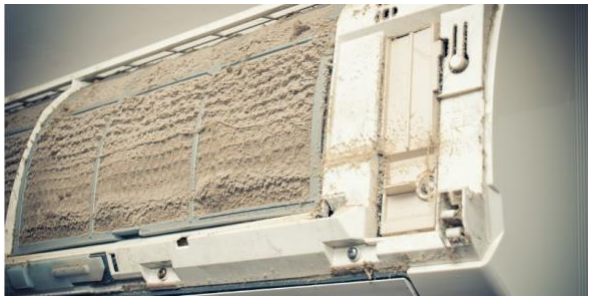
Once the air conditioner is on, it is important to make sure that all windows and doors are closed. If not, the warm outside air will simply enter and replace the cold air. To improve the cooling effect, it is useful to turn off any heat generating appliances. Split air conditioners work better in open floorplan indoor spaces[3] because the air can easily circulate across the room.

[3] Open rooms with very few walls that hinder the air flow.

Will the energy efficiency of my air conditioner will remain the same throughout its lifetime?

With time, if no actions are undertaken to maintain the device, its energy efficiency will drop. As the air conditioner is used, the filters and heat exchangers become filthy with dust. The dust prevents the efficient exchange of heat in the evaporator. This is why the filters need to be regularly cleaned and the device serviced. Servicing also makes sure that the device is checked for malfunctions or external damages. It can happen that the outside unit is damaged by rodents or weather. If the device leaks its refrigerant, the servicing will top-up the refrigerant in the device so that it functions at its best capacity.

Figure 20: Dusty filters of an inside unit



Source: climatecare.com

7 Terminology

Coefficient of Performance (COP)

The ratio of the heating capacity in Watts to the effective power input in Watts at given rating conditions.

Energy Efficiency Ratio (EER)

The ratio of the total cooling capacity to the effective power input to the device at given rating conditions.

Fixed Capacity Unit

The type of equipment that does not have the possibility to change its capacity.

Global warming potential (GWP)

The measure of how much 1 kg of the refrigerant applied in the vapour compression cycle is estimated to contribute to global warming, expressed in kg CO_2 equivalents over a 100-year time horizon.

Ozone Depletion Potential (ODP)

The 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”.

Seasonal coefficient of performance (SCOP)

The overall coefficient of performance of the unit, representative for the whole designated heating season (the value of SCOP pertains to a designated heating season), calculated as the reference annual heating demand divided by the annual electricity consumption for heating.

Seasonal energy efficiency ratio (SEER)

Overall energy efficiency ratio of the unit, representative for the whole cooling season, calculated as the Reference annual cooling demand divided by the annual electricity consumption for cooling.

Self-Contained Unit

A type of air conditioner or heat pump that consists of an encased assembly designed as a self-contained unit primarily for mounting in a window or through the wall or as a console ducted to the outdoors. It consists of compressor, heat exchangers and air handling system installed in one cabinet and is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone (conditioned space).

Single-duct Portable Air Conditioner

An encased assembly or assemblies designed primarily to provide delivery of conditioned air to an enclosed space, room or zone which takes its source of air for cooling the condenser from the conditioned space, and discharges this air through a duct to the outdoor space.

Split Unit (single)

A type of air conditioner or heat pump that is comprised of an indoor unit and outdoor unit, with the indoor unit mounted on floor or wall or ceiling. It consists of compressor, heat exchangers, fan motors and air handling system installed in two separate cabinets.

Ton of Refrigeration (RT)

Metric used in Anglo-Saxon countries but is often listed in product documentation. Used as a measure of cooling or heating capacity, one RT is the rate of heat transfer that results in the melting of 1 short ton of ice at 0°C in 24 hours.

Variable Speed Drive

A type of air conditioner or heat pump where the compressor can vary its capacity by two steps (2-stage), 3-4 steps (multi-stage), or five or more steps (true variable capacity).

8 References and links

8.1 Useful links

- Topten.eu product lists: https://www.topten.eu/private/products/air_conditioners
- Topten.eu selection criteria: https://www.topten.eu/private/selection-criteria/selection-criteria-air-conditioners
- Policy recommendations: https://www.topten.eu/private/adviser/policy-recommendations-room-air-conditioners
- Examples of 'energy Label calculators' provided by manufacturers:
  - Daikin Energy Label Generator: https://energylabel.daikin.eu/eu/en_US/lot10.html
  - Toshiba Energy Label Generator: http://ecodesign.toshiba-airconditioning.eu/en/energy-efficiency-lot10
  - Samsung: https://www.samsung.com/uk/business/system-air-conditioner/energylabel/
  - Mitsubishi Electric: http://erp.mitsubishielectric.eu/erp/1/doclist/lot-10

8.2 References

- European Commission (2009). Preparatory study on the environmental performance of residential room conditioning appliances (airco and ventilation).
- European Commission (2018). Review of Regulation 206/2012 and 626/2011: Air conditioners and comfort fans. Available on the eceee website
- Commission Regulation No 626/2011 on the energy labelling of air conditioners: new energy label, compulsory since 1 January 2013: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1581340062655&uri=CELEX:32011R0626
- Commission Regulation No 206/2012 with regard to ecodesign requirements for air conditioners and comfort fans: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1581340284593&uri=CELEX:32012R0206
- Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 214 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1581344480660&uri=CELEX:32014R0517