

Topten ACT Criteria Paper

Air conditioners

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Anette Michel

Bush Energie GmbH

anette.michel@topten.eu



Topten ACT aims at transforming the European market of energy-using products towards higher energy efficiency.

Topten ACT identifies the top energy-efficient products in 16 European countries, and makes this information available to consumers and large buyers on tailored national websites. The most energy efficient models in different product categories (such as household appliances, lighting, office equipment, consumer electronics, cars) are presented with comprehensive product information based on official labels and standardized declarations. Topten works with manufacturers and thus increases both market offer and consumer demand of high energy efficiency products. Topten is strictly neutral and independent from manufacturers and retailers, its selection criteria are always published online.

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More information and access to all national websites on the European site: www.topten.eu

WP2 European Product Analysis , Task 2.1 Determining energy efficiency criteria, D 2.1 Periodic Criteria Papers (first set)

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1. Topten.eu: Air conditioners (ACs) - current selection criteria and products selected

Topten.eu selection criteria:

- Monosplit $\leq 4\text{kW}$: A+++ / A++ (cooling / heating efficiency)
- Monosplit $> 4\text{kW}$: A++ / A+
- Multisplit: A++ / A+
- Single and double ducts: A++ / A+

Numbers of air conditioner models currently on Topten.eu according to cooling/heating efficiency (last update: August 2015):

	A+++ / A+++	A+++ / A++	A++ / A++	A++ / A+	Total
Monosplit $< 3\text{kW}$	6	10	-	-	16
Monosplit 3-4 kW	4	6	-	-	10
Monosplit 4-5 kW			2	6	8
Monosplit 5-6 kW	1	-	3	19	23
Monosplit 6-7 kW	-	-		17	17
Monosplit 7-8 kW	-	-		7	7
Monosplit $> 8\text{kW}$	-	4		9	13
Multisplit	-	-	-	13	13
Single ducts	-	-	-	-	-
Double ducts	-	-	-	-	-
Total	11	20	5	58	107

Even though single and double ducts have a separate, less ambitious labelling scale (class A corresponds more or less to class F of split ACs), no model currently meets the Topten selection criteria.

There are 107 air conditioner models of 9 different brands on the Topten.eu product lists: Daikin, Fujitsu, Hitachi, LG, Mitsubishi Electric, Panasonic, Samsung, Stiebel Eltron, Toshiba. Most models reach a higher efficiency class for the cooling than the heating mode. And, unlike most other product categories, ACs with lower capacity reach higher efficiency values than those with higher capacity.

Nearly all Topten ACs use R-410A (Global warming potential (GWP): 1075) as refrigerant. Three models use R-32 instead, which has a GWP of 550.

2. Expected selection criteria in 2016

We will investigate how the selection criteria can be tightened in autumn 2015 and onwards. The difficulty is that we take the cooling capacity as a basis for structuring the selection criteria and product lists, because we think cooling is the main function of air conditioners. The energy label assumes many more hours of heating than cooling, therefore the efficiency and, even more so, capacity of the heating function have a much stronger impact on a model's declared energy consumption than the cooling function. Moving to the next heating efficiency class could clear the lists from models with lower heating capacity and lower overall energy consumption.

3. Technical background

The principle of ACs is based on the Carnot refrigerating cycle, as for all heat pumps. The heat pump consists of a refrigerant fluid circulating in the system of evaporator, compressor, condenser and expansion valve and thus transporting heat from inside to the outside of the room. Whenever it switches on, the compressor drives the cycle with electrical energy. ACs also have fans to improve the heat exchange.

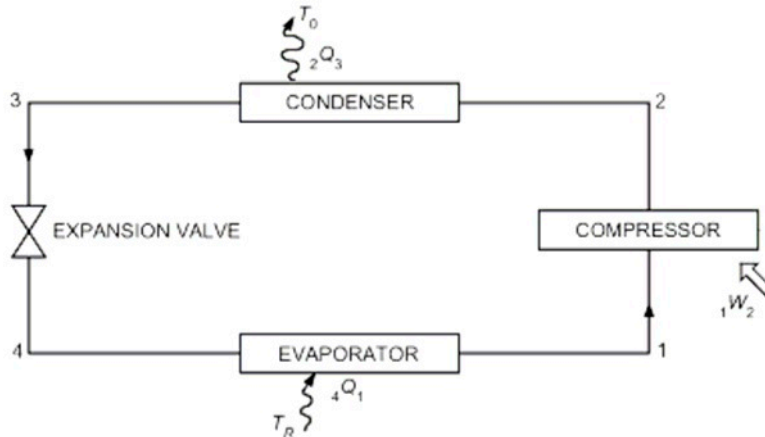


Fig 1: AC operating scheme (source: preparatory study from 2009).

There are 'cooling only', 'heating only' ACs and reversible ACs than have both a cooling and heating function. Today most split ACs are reversible.

Air conditioner types:



Outdoor- and indoor unit



Mobile split

Split air conditioners consist of an indoor- and an outdoor unit, fixedly installed. The condenser including the compressor is located in the outdoor unit, not delivering any waste heat indoors. Several indoor units can be connected to one outdoor unit – resulting in a **multi-split** air conditioner. **Mobile split** air conditioners have a portable indoor unit containing the compressor, which leads to less efficiency (possibly mobile split ACs have been phased out by the tier 2 Ecodesign). Air conditioners that are neither a double duct nor a single duct are called **room air-conditioners (RAC)** by the EU regulations.



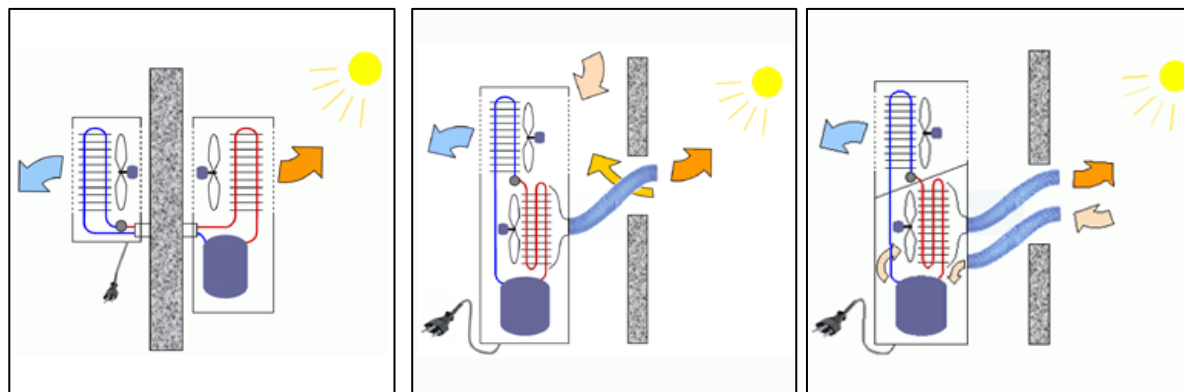
Single ducts consist of one single unit placed freely in the room. The air is expelled through a duct, which requires a window to be open. Warm air is drawn into the room, as the condenser is cooled with air taken from the room – the cooling effect is small and only local.



Double ducts also consist of one single unit, but have separate ducts for air intake and exhaust. Either double ducts are moveable and placed next to a window, or the ducts are mounted into the wall.



Through-the-window air conditioners (also: compact or through-the-wall AC) are widespread in the USA, but of no importance in Europe. They are too compact to be efficient and need an opening in the insulation.



Location of compressor ('box'), condenser (red) and evaporator (blue) and flow of hot and cold air in split ACs, single ducts and double ducts.

Split variable speed (inverter) air conditioners are today's best available technology (BAT). Variable speed drives allow the compressor to run at part load and adjust the actual cooling / heating capacity to the temperature change that is needed. Fixed-speed ACs on the other hand can only run at full load (100% of their cooling / heating capacity), they reach a specific temperature by switching on and off. Part load operation is much more efficient than switching on and off.

For most outdoor and indoor units a lot of possible combinations exist. Many manufacturers provide an online tool which creates all relevant Label declarations (examples can be found in the link section below).

4. Policy measures, standards and labels

The labelling and Ecodesign regulations from 2011 cover all electric air conditioners with a rated cooling capacity up to 12 kW. ACs that use a heat transfer medium other than air in either the condenser or evaporator are exempted. The regulations are expected to lead to savings between 11 and 16 TWh in 2020.

Energy Label: different schemes for different technologies

The first air conditioner Energy Label was in place from 2003 until 2012 (Directive 2002/31/EC). By 2008, most of the sold models were in class A (GfK/Attali/Bush for Defra, 2009). The current Energy Label, based on regulations No. 626/2011 has classes up to A+++ and is compulsory since January 2013.

For reversible ACs (ACs that can cool and heat) the new Energy Label rates both the efficiency of the cooling and of the heating function. The efficiency and energy consumption of the heating function can be declared for three different climate zones. The assumed cooling and heating hours per year and the part load ratios depend on the climate zone. The Label itself provides a lot of information (see below for definitions):

- energy efficiency class(es)
- capacity for cooling / heating (kW)
- energy efficiency (called SEER / SCOP or, for single and double ducts, called EER/COP)
- annual (or hourly for single and double ducts) energy consumption cooling / heating
- sound power level of outdoor and indoor units.

Manufacturers must additionally declare On the product Fiche the name and GWP of the refrigerant.

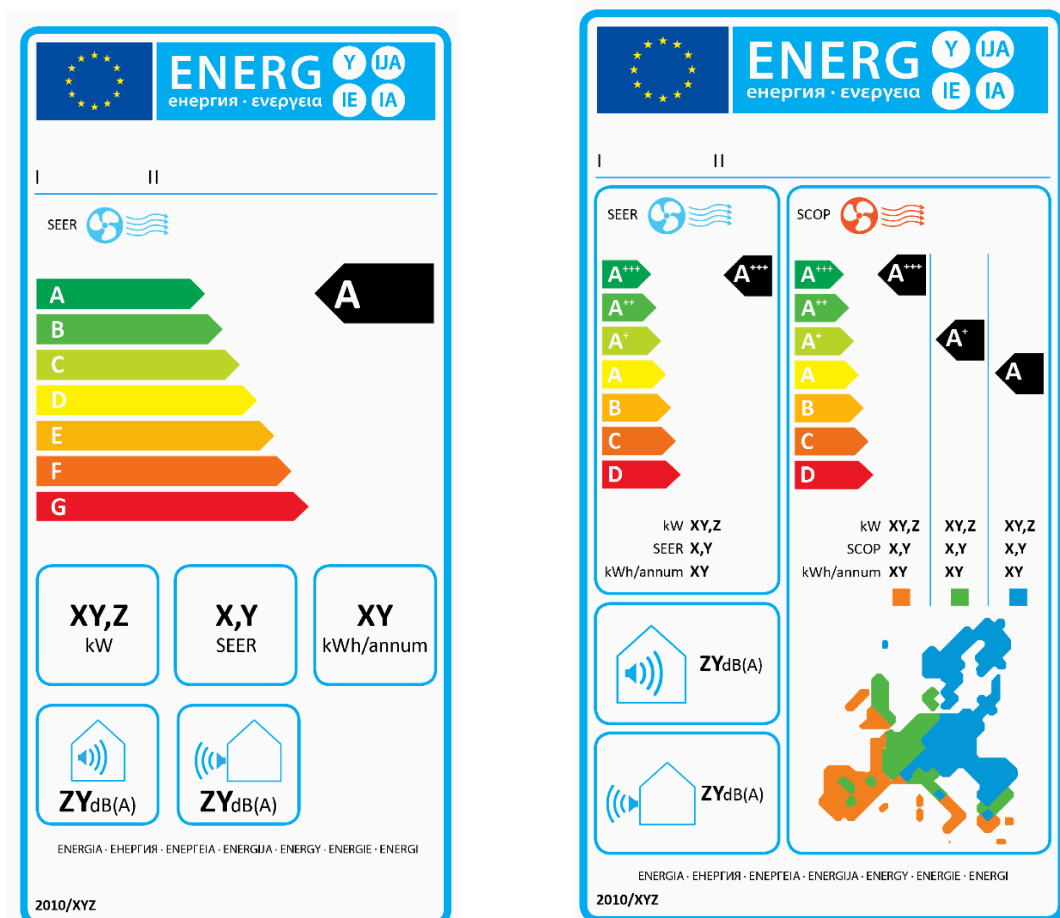


Fig. 1 + 2: Current energy label for split cooling only and for reversible room air conditioner. The Label for single and double ducts looks again different.

The Energy Label's classification scheme distinguishes between room air conditioners, single and double ducts. Class A for single and double ducts (EER = 2.6) corresponds to class F for room air conditioners (SEER = 2.6), which has been banned from the market in 2013. The table below shows the classification scheme, with classes that have been (partly) banned by the Ecodesign regulation in grey.

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

	Room 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

partly banned
banned

Box: What is the difference between SEER and EER / SCOP and COP?

The Energy Label and Ecodesign requirements for room air conditioners are based on **Seasonal** efficiency indicators (**Seasonal Energy Efficiency Ratio (SEER)** for cooling, **Seasonal Coefficient of Performance (SCOP)** or Heating Seasonal Performance Factor (HSPF) for heating). These indicators do consider the different cooling or heating needs during the year and thus include part load operation of air conditioners. The efficiency is measured at four different outdoor temperatures and the respective loads. The measured efficiency is then interpolated to a wide range of outdoor temperature values, and the SEER / SCOP calculation formula defines the number of hours for each temperature over the year and integrates the respective efficiency values. Seasonal efficiency indicators do account for the efficiency gains by variable speed (inverter) drives' ability to work at part load. In Europe the SEER and SCOP are applied for room air conditioners since the introduction of the current Energy Label in 2013. The European measurement standard has been revised (EN 14511:2011) and amended with a part load measurement standard (EN 14825:2012) at the same time when the new Label was designed. It was not known what values would be reached according to the new test standard – a difficult precondition for designing an Energy Label with appropriate classes. A test of an efficient Chinese air conditioner by Topten in 2011 implied that the top class of the new Label would already be met (EEDAL paper, 2011). The old energy label for air conditioners referred to the **Energy Efficiency Ratio (EER)**, cooling function) and **Coefficient Of Performance (COP)**, heating function) to express the energy efficiency of all air conditioners. These indicators are measured at full load operation only. EER and COP are still applied for single and double ducts.

Ecodesign regulation: tier 2 requirements in force

Since January 2014 tier 2 of the Ecodesign regulation No 206/2012 applies. Requirements are staged depending on type, capacity and the GWP of the refrigerant. Models with a refrigerant with a GWP < 150 can have a 10% lower efficiency.

Table 2: Tier 2 energy efficiency requirements, applying since January 2014

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

Additionally ACs must not use more than 0.5W when in Off, 0.5W (no display) / 1W (with display) when in Standby mode, and power management must switch AC automatically into standby mode when it's not used. Since 2013 noise emissions must not exceed 60dB(A) (indoor < 6kW), 65 dB(A) (outdoor ≤ 6kW and indoor > 6kW) or 70 dB(A) (outdoor > 6kW). Information requirements cover a long list of technical information.

4.1. Market analysis

The air conditioners market in the EU is growing. In 2005, 4.9 million units were sold across the EU-27. By 2020, sales are expected to double to close to 10 million units per year. The stock is estimated to grow from over 40 million units today to 110 million units by 2020. Annually an additional cooling capacity of around 12.6 GW is installed in EU houses (Riviere et al., 2009).

Total annual electricity consumption by air conditioners in Europe was estimated at around 30 TWh in 2005. By 2020 electricity consumption was expected to increase to around 73 TWh annually without any measures (business as usual) (EC, 2012). The Ecodesign regulation and the new Energy Label are expected to lead to savings of around 11 - 16 TWh annually by 2020 (regulations / impact assessment) – less than 50% of the expected increase in electricity consumption.

5. FAQ

What air conditioner should I buy?

First of all, try not to have to buy an AC at all. In climate-moderate countries it is usually possible to keep rooms sufficiently cool with alternative, less energy-consuming measures:

- **Shading:** shade the windows as soon as the sun's reaching them. A good shade should be bright and on the outside of the window. Also it should be possible to let in enough light in order not to need to switch on electric lighting (spare 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 you don't need.
- **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 you can't renounce on an air conditioner, then resist buying a cheap single or double duct and choose a split model, which needs to be installed fixedly. 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).

6. References and links

Useful links

Topten.eu air conditioner product lists:

http://www.topten.eu/english/building_components/air_conditioners/monosplit-3kw.html
http://www.topten.eu/english/building_components/air_conditioners/monosplit-3-4kw.html
http://www.topten.eu/english/building_components/air_conditioners/monosplit-4-5-kw.html
http://www.topten.eu/english/building_components/air_conditioners/monosplit-5-6-kw.html
http://www.topten.eu/english/building_components/air_conditioners/monosplit-6-7-kw.html
http://www.topten.eu/english/building_components/air_conditioners/monosplit-7-8-kw.html
http://www.topten.eu/english/building_components/air_conditioners/Monosplit-8kW.html
http://www.topten.eu/english/building_components/air_conditioners/Multi-split.html

Topten.eu air conditioner selection criteria:

http://www.topten.eu/english/criteria/selection_criteria_air_conditioners.html&fromid=

Policy recommendations:

<http://www.topten.eu/?page=policy-recommendations-room-air-conditioners&fromid=>

Examples of 'energy Label calculators' provided by manufacturers:

<http://erp.mitsubishielectric.eu/erp/doclist/lot-10>
http://ecodesign.toshiba-airconditioning.eu/en/energy-efficiency-lot10?set_language=en
<http://www.samsung.com/ch/business/system-air-conditioner/energylabel>

References

Commission Regulation No 626/2011 on the energy labelling of air conditioners: new energy label, compulsory since 1 January 2013:

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:178:0001:0072:EN:PDF>

Amendment regarding Online Energy Labels: Regulation No. 518/2014

<http://www.topten.eu/uploads/File/Online-Energy-Labels-518:2014-EN.pdf>

European Commission, Energy Labelling of Domestic Appliances: Commission Directive 2002/31/EC of 22 March 2002 with regard to energy labelling of household air-conditioners (old energy label):

http://www.topten.ch/uploads/images/download-files/Commission_air-conditioners_2002_31.pdf

The measurement standard EN 14511 for air conditioners has been revised in 2011 and amended with EN 14825/2012 to include measurement at part load conditions and calculation of seasonal performance by the European Committee for standardisation CEN:

<http://www.cen.eu/Pages/default.aspx>

EEDAL paper from Topten with results from an international test of an energy-efficient AC (2011): http://www.topten.eu/uploads/File/023_Annette_Michel_final_paper_S.pdf