Service Contract to DGTREN

Preparatory study on the environmental performance of residential room conditioning appliances (airco and ventilation)

Contract TREN/D1/40-2005/LOT10/S07.56606

Air conditioners
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Definition of Product, Standards and Legislation

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Note : this report is about air conditioners only; ventilation and comfort fans are treated in other documents.

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1 Definition of product, standards and legislation

Introduction

As required by the MEEuP methodology, the report of task 1 is subdivided into 3 parts:
- MEEuP Part 1.1: Product category and performance assessment
- MEEuP Part 1.2: Test standards
- MEEuP Part 1.3: Existing legislation

Part 1.1: Product category and performance assessment
The exact wording of the lot 10 study[1] "Residential room conditioning appliances: airco and ventilation" opens to some interpretation regarding the products to be included in the study, that were already addressed in the introduction document to the lot 10 study. Main findings for the two categories of air conditioners, cooling only and reversible are reported.

Part 1.2: Test standards
This section is made of three categories for energy performance test standards, refrigerant and safety standards and noise test standards.

Part 1.3: Existing legislation
Legislation is separated within three main parts as required in the MEEuP methodology:
- Legislation and voluntary agreements at European level,
- Legislation at Member State Level
- Third country legislation

Third country legislation has been gathered by air conditioning economies abroad Europe.

[1] Contract TREN/D1/40-2005/LOT10/S07.56606

1.1 Product category and performance assessment

1.1.1 Introduction

The objective of this task has been assigned in the methodology preparatory study in the following way. This task should define the product categories and define the system boundaries of the "playing field" for ecodesign. If not perfectly defined in the existing legislation, categorisation will often be linked to the assessment of the primary product performance parameters (the "functional unit"). If needed, on the basis of functional performance characteristics, a further segmentation can be applied on the basis of Secondary product performance parameters.

The scope indicated by the title of the lot 10[2] is formulated as **"residential room conditioning appliances (airco and ventilation)"**. Air conditioning in the broadest sense encompasses all kinds of air treatment: heating, cooling, air renewal, humidity control, air purification …
First of all, boilers and air-conditioning central systems will not be treated in this study. Indeed boilers are already clearly addressed within lot 1 and built on site systems are not included in Ecodesign studies where only Energy using Products (EuP) are aimed at.
In this section ("Product category and performance assessment"), all air conditioning appliances are listed and shortly described. This enables to point out the primary functionalities of these EuP, a first categorization is then sought among the vast amount of products based on these primary functionalities. For every category, secondary functionalities are also mentioned. Functional units are associated to every functionality keeping in mind these must be quantifiable and measurable. Finally the specific scope of the study is narrowed based on this functional analysis along with other considerations mainly regarding limits of residential products.

1.1.2 Product definitions

An air conditioner is an appliance designed to maintain the temperature of indoor air at a given temperature level for a given heat load to be extracted.

Two main technical types of refrigeration cycles are used to this purpose.

The **absorption cycle** delivers cooling on a heat exchanger while it is supplied with heat. This enables to design solar thermal absorption machines but generally heat is supplied by a gas burner. Common absorption machines, that compete on the large capacity market (more than 300 or 400 kW cooling capacity), are chillers that deliver chilled water temperature at 7 °C for centralized air conditioning systems in the tertiary sector. A few manufacturers produce small capacity air to water absorption heat pumps that are reversible and can be used to supply chilled water[3]. First costs are high and energy efficiency at best equals 1; it has a value if electricity costs are high in summer and this is not the case in residences in Europe.

Air conditioners built on the **vapor compression cycle** use a refrigerant fluid which is compressed to high temperature and pressure in the compressor. Then it is cooled down in a condenser where it releases the heat taken inside to outside. Refrigerant then pass through an expansion valve where it expands to lower pressure and temperature. There, temperature is lower than the one of the cool vector that circulates in the evaporator. As a consequence, the cooling fluid that can be either air or water according to the type of system is cooled down by the refrigerant. The refrigerant fluid comes back to the compressor inlet.
The electricity supplied to the compressor can be obtained by burning of fuel or gas in an engine. There are at least two markets in the United States and in Japan for this kind of units for summer peak shaving. Nevertheless, in Europe, all air conditioners are directly driven by electricity from the grid.

[2] Contract TREN/D1/40-2005/LOT10/S07.56606
[3] http://www.robur.it

European residential air conditioners are therefore based on a vapour compression cycle and driven by grid electricity.

Residential sector air conditioners

The wording "residential air conditioners" covers a large variety of products and numerous different types of air conditioners are sold on the European market. Difference between air conditioners rely on very various aspects such as technical features as well as aesthetic, price or energy performance. All the systems listed here may be reversible by means of a four way valve, the air conditioner operating then as a heat pump. This is a very common feature, even a majority for split package air conditioners.

In this subsection, the different types of room air conditioners are presented following usual commercial classifications:

- Split-packaged units (also called mini-split or duct free split on the USA market)
- Multi Split packaged units
- Single packaged units (window air conditioners in Europe, but also package terminal air conditioners on the USA market)
- Single duct units
- Double duct units
- Residential chillers
- Central air conditioners (USA style, package ducted or split)

All products below can be reversible, meaning they can also provide heating. Heating can be provided either by an electric resistance, or by reversing the cycle, and eventually by both means, the electric resistance being included as a complementary heating means.

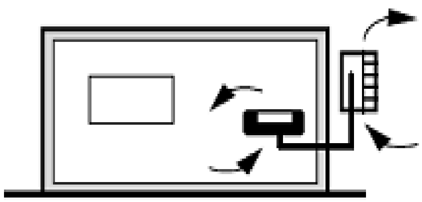
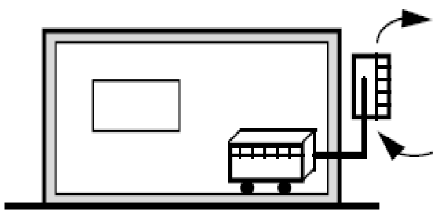
For all types of air conditioners here above, water could be used to cool the refrigerant whereas not existing in practice on the market for single duct, double duct and very uncommon for split and multi-split. Water cooled mini-chillers are sold in Europe mainly because of the recent development of geothermal and aquifer heat pumps in some Member States. Most water cooled single package air conditioners are part of a larger air conditioning systems for commercial centers or large offices called water loop heat pump.
For water cooled air conditioners that are not part of a Water Loop Heat Pump system, the water can come from a public network, a natural source or can be contained in a closed circuit. In the first case, the heated water is wasted, in the second case the heated water is rejected to the source and in the third case, the heated water is not wasted and must be cooled through a heat exchanger (dry cooler or cooling tower[4]). Thus in the two first cases, the water used to condense the refrigerant is taken from either a natural source or the network but is totally wasted, the water bill can then be very high. In the third case, the water used to condense the refrigerant is recycled totally or partially in the cooling tower. Water bill is then reduced. The water used in RAC could in principle be non-potable water but this is seldom available. As a result, the water used in a RAC must be taken into account in the assessment of environmental impact.

- Split-packaged units (split systems)

A split-packaged unit is defined as a factory assembly of components of a refrigeration system fixed on two or more mountings to form a matched unit. This type of appliance comprises two packages (one indoor and one outdoor unit) connected only by the pipe that transfers the refrigerant. The indoor unit includes the evaporator and a fan, while the outdoor unit has a compressor and a condenser.
Indoor unit(s) can be ducted or non ducted.

[4] In that case, the air conditioner cannot operate in the reverse cycle to supply heating.

- Non ducted indoor units can be either fixed – whether mounted high on a wall, floor-mounted or as ‘cassette’, ceiling-suspended, built-in horizontal or built-in vertical – or, mobile. The outdoor unit can be either fixed or mobile.
- Ducted indoor units can deliver cool air to several rooms or to several spots within a single room.

Type of air conditioner	Operating Schemes	Examples
Non ducted fixed split-packaged unit (split system)		Indoor unit: Wall mounted  Indoor unit: Console or ceiling suspended  Indoor unit: Cassette 
Non-ducted split-packaged unit with mobile indoor unit (mobile split)		Mobile indoor unit 

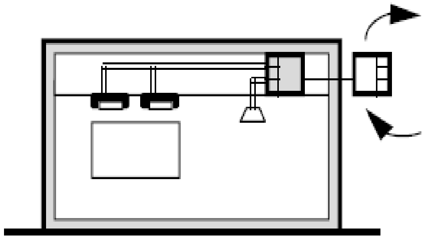
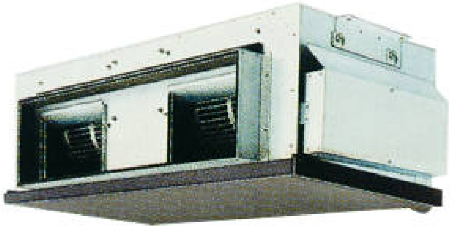
Ducted split-packaged unit (Ducted split system)		Ducted built-in horizontal indoor unit 

Table 1-1: Different types of split-packaged units (split) air conditioners

- Multi-split packaged units (multi split)

Multi-split packaged units comprise several interior units (up to 4) connected to one exterior unit. These units are similar to split interior and exterior units. Indoor units can be ducted or non ducted.

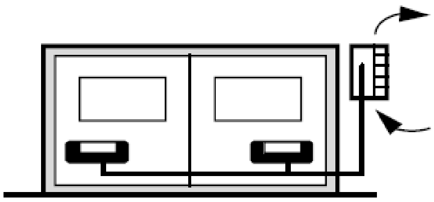
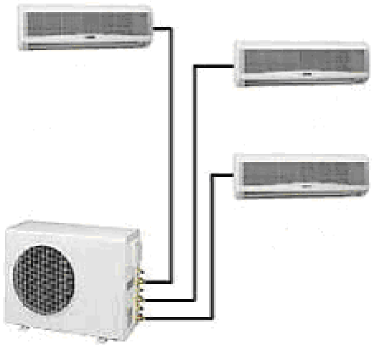
Type of air conditioner	Operating Scheme	Example
Multi-split-packaged units		

Table 1-2: Multi-split packaged (multi-split) air conditioners

Multi-split systems should not be mixed up with VRF systems (Variable Refrigerant Flow - (Adnot, 2003) is the name generally adopted to avoid to use a commercial name by Daikin VRV®).
In a multisplit unit, each inside unit is connected to the single outside unit individually. On the contrary, in VRF systems, inside units are connected on a refrigerant network and this system is typically a built-on-site system meaning design is adapted to every single building.

- Single-packaged units

Single-packaged units, commonly known as 'window' or 'through-the-wall' air conditioners (respectively room air conditioners and package terminal air conditioners in the USA), are strictly defined as a factory assembly of components of a refrigeration system fixed on a common mounting to form a single unit.
This type of equipment comprises a single package, one side of which is in contact with the outside air heat release outside, while the other side provides direct cooling to the air inside.
The two sides of the appliance are separated by a dividing wall, which is insulated to reduce heat transfer between the two sides.

This kind of unit often fits under or above a window or above a door. A distinction is generally made between those units having louvered sides (designed to be installed in a window opening) and those without louvered sides (designed to be installed in an opening in the exterior wall).
Wall type units including an air damper to control air change (hence supplying also air change) are called package terminal air conditioners.

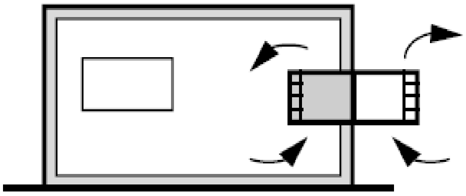
Type of air conditioner	Operating Scheme	Example
Single-packaged unit, through the wall		

Table 1-3: Window or through-the-wall package air conditioners

- Single-duct units

These are appliances whose condenser ejects hot air through a duct to the exterior: air used to cool the condenser is taken inside the room and rejected outside. They are generally movable, but in order to operate they must be set close to a window or a door through which the duct eliminates the hot air. In principle, a dedicated hole should be made in the envelope just for the appliance, as the use of doors and windows for the duct allows hot air to infiltrate.
There are difficulties in taking the thermal effect into account when measuring single-duct energy performance. Furthermore, such penetration in the building envelope has an acoustic impact.

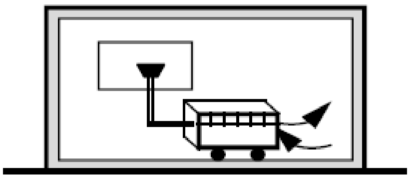
Type of air conditioner	Operating Scheme	Example
Single duct air conditioner		

Table 1-4: Single duct air conditioners

- Double-duct units

A cousin of the single duct air conditioner is the so called double duct which is an evolution of the single duct. There are two main types. The first type is exactly similar to a single duct but a second hole at the condenser enables to take the condenser air from outside thus avoiding outside air infiltration inside the room to be cooled. The second type is similar but of a more permanent installation through the wall and in that case, the two ducts may be concentric.

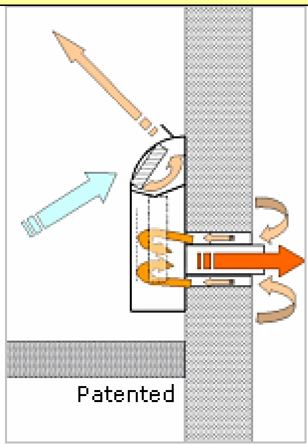
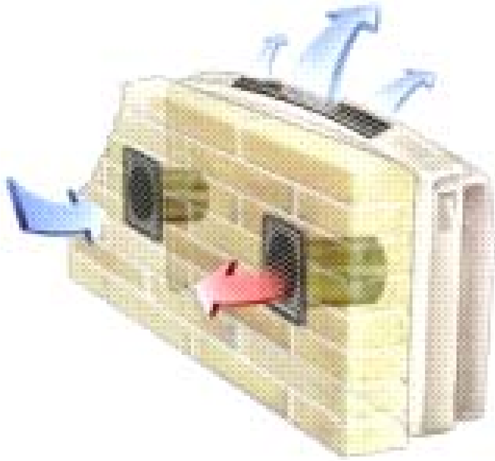
Type of air conditioner	Operating Scheme	Example
Double duct air conditioner (through the wall installation)		

Table 1-5: Double duct air conditioners

- Chiller based systems

Mini chillers produce cold water that is circulated within the house to feed cool ceilings, floors, panels or fan coils (water to air heat exchangers). For cool ceilings and panels, heat transfer is ensured by convection and mostly by radiation while it is convective only with fan coils. This centralized system, traditionally reserved to the tertiary sector can also be found now in dwellings.

- Central air conditioners

Very common in the United States and almost unknown in Europe, central air conditioners deliver cooling on the central air system of a dwelling. Air conditioners are either packaged air conditioners with a duct to blow cold air on the central air system of the residence, or split system with a cooling coil placed in the air stream of the centralized air system, that can be delivered with or without fan. The scheme of a split central air conditioner is reported in the figure below.

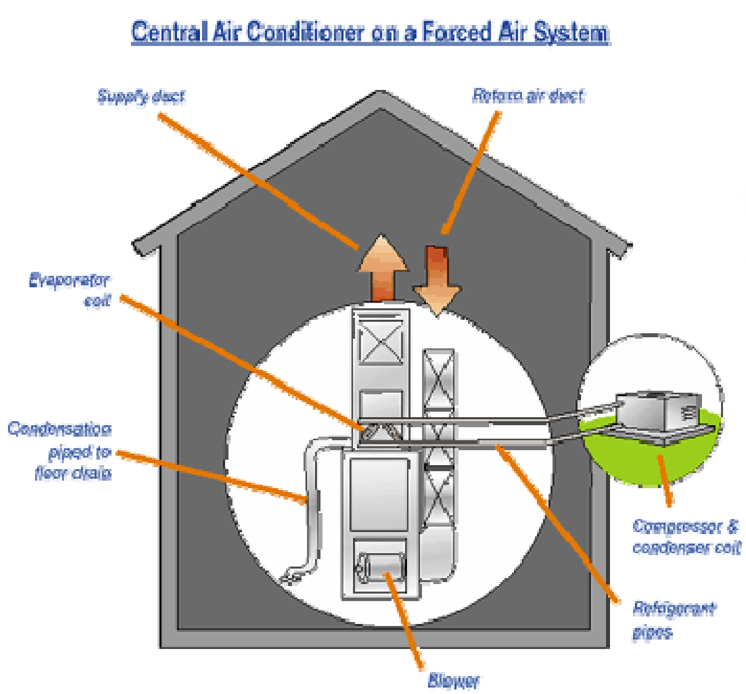


Figure 1-1: Central air conditioner of the split type[5]

Tertiary sector air conditioners

Since the lot refers only to "residential room conditioning appliances", systems specific to this sector are not to be considered. Nevertheless, it seems useful to give here a set of definitions that are needed to understand where to set the scope limitation. Moreover, it also reinforces that room air conditioners are not only used in the residential sector. Market shares were around 20 % for residential use and 80 % for tertiary use in 1996 according to the EERAC study – (Adnot, 1999).

A number of solutions are used to supply air conditioning to complete buildings in the tertiary sector.

In small offices, retails or hotels, similar systems as in the residential sector are used.

- Split and Multi Split systems: no difference with residential systems except higher capacities may be used.

For larger buildings, central system, generally built on site, are more common. Cooling can be distributed inside the building either with cool air, chilled water or refrigerant. Often, according to the layout of the building and the different cooling needs in its different parts (offices, computer rooms, conference rooms …), different systems can be used in different parts of the building.

- **Large package** systems: it can be located either into the room to treat or into another room or outside (**rooftop**) providing the air by ducts and grilles for a better temperature homogenization. It is the same working principle as the single package air conditioner but with higher capacities. It can be coupled with air ducts, as rooftops, to distribute air to several rooms. **Close control** units are specific air conditioners reserved to serve computer rooms or other spaces with restricted temperature and humidity inside conditions. **Control cabinets** cool down their own contents, mostly computer or electronic controls of other process.

[5] source http://www.energy.gov.on.ca/images/fig9_e.gif

- VRF systems: the **VRF** (Variable Refrigerant Flow) system is similar in shape to multisplit air conditioners. Nevertheless, in a multisplit unit, each inside unit is connected only to the single outside unit individually. On the contrary, in VRF systems, inside units are connected on a refrigerant network. **VRF 2 pipes**: the refrigerant network can be made of 2 tubes. When heating, one duct contains high pressure and high temperature refrigerant vapor. This vapor is cooled down in terminal units and brought back at low temperature low pressure in diphasic state. When cooling, diphasic low temperature low pressure refrigerant is circulated, used to cool the air in the terminal units and low pressure low temperature is brought back to the compressor located in the outside unit. **VRF 3 pipes**: a heat recovery version is able to offer both cooling and heating simultaneously from 8 indoor units on the same refrigerant circuit. Heat recovery is achieved by diverting heat from indoor units in cooling mode to those areas requiring heating. VRF systems can also be coupled with a centralized air system that enables to pretreat air entering termainl units, filtering, controlling fresh air renewal, etc…

- Central air conditioning systems: in large buildings, air conditioning systems have to be considered in a broadest sense that summer comfort only since they can provide all the different types of air treatment, heating, cooling, humidifying and dehumidifying, fresh air renewal, pollutant control, heat recovery and so on. For the cooling part, we will only distinguish here three main types of systems whereas a complete description can be found in (Adnot, 2003). In **all air systems**, cold air is prepared centrally, cold being released by a cooling coil fed in cold water at 7 °C by a central **chiller**. Cold air is then distributed inside the building by **air handling units (AHU)**. In **water based systems**, cold water is distributed inside the building inside pipes to terminal units that are generally **fan coil units**. A variation of this type of systems is to deal air and water to **terminal induction unit**. Common in the 70's and early 80's, this type of system has almost disappeared because of the lack of comfort but is reviving nowadays in Nordic countries. The third type of systems we have already mentioned here is the **water loop heat pump** system. A water loop, whose temperature is generally controlled within certain limits (between 20 and 30 °C for instance) by a **cooling tower and a boiler** circulates through the building and serves as a cold source or a hot source to terminal units that are **water to air package reversible heat pumps**. This system represents certainly the more important part of the market for water to air air conditioners on the European market. It is efficient since it enables to recover heat between the zones as VRF 3 pipes systems. Nevertheless, a compressor being located in each of the room to be conditioned, the noise is important for the final user. It is nowadays more common in malls.

1.1.3 Existing product categorisations

In the **Prodcom** inventory, air conditioners are only covered by NACE 29.23 ("Manufacture of non-domestic cooling and ventilation equipment"). Air conditioners are not in the list of electric domestic appliances (NACE 29.71), not even movable air conditioners.

Two design features are used but they are used only to specify what is included and not for making categories:

- A technical parameter, split or package,
    - self-contained (package units)
    - split system
- Window or wall

Both air cooled and water cooled air conditioners seem to be included. For split system, it can be guessed that both single split package and multi-split package are included.
In the precedent version of the PRODCOM categories, these categories 29.23.12.20 and 29.23.12.45 were limited to 7 kW cooling capacity. This category has been removed in 2002.

This split of air conditioners in two product codes is likely to aim at distinguishing individual or room air conditioners from central air conditioning equipment as chillers however, the wording is not clear enough to be sure of statistics it will contain.

Air conditioners (from 1995 to 2001)	
29.23.12.30	All self-contained window or wall air conditioning machines (incl. movables)
29.23.12.45	Air conditioning machines with refrigeration unit (excluding those used in motor vehicles, self-contained or split-systems machines)
29.23.12.50	Air conditioning machines with a refrigeration unit under 7kw and close control units incl. air cooled condenserless and water cooled custom packaged air handling units

Air conditioners (from 2002 onwards)	
29.23.12.20	Window or wall air conditioning systems, self-contained or split-systems
29.23.12.45	Air conditioning machines with refrigeration unit (excluding those used in motor vehicles, self-contained or split-systems machines)
29.23.13.73	Compression type units whose condensers are heat exchangers heat pumps

Table 1-6: Prodcom segmentation for air conditioners, before and after 2002

In the **EU custom code**, the category 8415 aims at gathering the “Air-conditioning machines, comprising a motor-driven fan and elements for changing the temperature and humidity, including those machines in which the humidity cannot be separately regulated”. Categories are separated whether air conditioners are package window or through the wall air conditioners.
For split system, it can be guessed that both single split package and multi-split package are included. A distinct category for reversible units has been created. Heating only products are considered as a separate category.

Air conditioners in the EU custom code	
8415.10.10	Window or wall types, self-contained systems
8415.10.90	Window or wall types, split systems
8415.81.00	Incorporating a refrigerating unit and a valve for reversal of the cooling/heat cycle (reversible heat pumps).

Table 1-7: EU custom code segmentation for air conditioners

The **European labelling directive of household air conditioners 2002/31/EC**, provides a more detailed segmentation. This labelling directive applies to electric operated household air-conditioners as defined in the harmonised European test standard EN 14511. It shall not apply to the following appliances:
- appliances that can also use other energy sources,
- air-to-water and water-to-water appliances,

– units with an output (cooling capacity) greater than **12 kW**[6].

Labelling classes in terms of EER (and COP, in the case for the heating mode) are defined for the categories listed below:

– Air-cooled air-conditioners:
  - o Split and multi-split appliances, Packaged, Single-duct and Double Duct
– Water-cooled air-conditioners:
  - o Split and multi-split appliances, Packaged

The segmentation leads to seven categories based on technical features. It is noticeable that this directive that aims at covering household air conditioners only applies to appliances with a cooling power lower than 12kW. A specific category is also reserved for movable appliances (Single Duct, Double Ducts).

Air conditioners							
Cooling capacity	< 12kW						
Heat rejection	Air cooled				Water cooled		
Type	Split	Multi-Split	Packaged	Single and Double Ducts	Split	Multi-Split	Packaged

Table 1-8: Segmentation applied to air conditioners in the European labelling directive

Two functions are identified, heating and cooling. Reversible units are thus characterised separately for each of the two distinct functions.

These categories are more detailed than the ones defined in the **EN14511** (CEN, 2004a) harmonised European test standard because the test standard is only concerned by differences in test conditions or experimental conditions. Air conditioners and heat pumps are classified according to different technical characteristics:

– the kind of fluid used at their evaporators and condensers, air, water, and both air and water for evaporatively-cooled condensers,
– the temperature level of the fluid inlets or outlets (both sides), which may translate different applications for the same fluid (for instance air conditioners on outside air or on exhaust air differ),
– equipment ducted and non ducted on air; an integral fan can enable to serve several rooms with a single unit but will consume more electricity for the same cooling capacity,
– with or without an integrated water pump for units with an heat exchanger with water or brine as a source.

Heat transfer medium		**Classification**
Outdoor heat exchanger	**Indoor heat exchanger**	
Air	Air	Air/air heat pump or air cooled air conditioner
Water	Air	Water/air heat pump cooled air conditioner

[6] The 12 kW cooling capacity limit also applies for reversible appliances. There is no specific limit on the heating mode.

Brine	Air	Brine/air heat pump or brine cooled air conditioner
Air	Water	Air/water heat pump or air cooled liquid chilling package
Water	Water	Water/water heat pump or water cooled liquid chilling package
Brine	Water	Brine/water heat pump or brine cooled chilling package

Table 1-9: Classification of air conditioners by source fluids, EN 14511

This system enables to define specific operation conditions for air conditioners designed to use specific air stream as exhaust air heat pumps. In that direction, single duct air conditioners are identified as a specific category because of a different testing procedure and different test conditions.

The **Eurovent-Certification** programme is a trans-national AC energy performance-certification programme. The managing body, Eurovent Certification, is a business association created specifically for the purpose. It is a branch of the manufacturers association Eurovent-Cecomaf[7], which covers almost all types of products in air conditioning.

The models in Eurovent directory (Eurovent, 2006) are sorted by categories similar with EN 14511, but with additional information. Every Room Air Conditioner is classified according to 5 parameters.

- cooling capacity (**<12 kW ; 12-45 kW; 45-100 kW**),
- heat rejection means: air cooled or water cooled,
- cooling heat exchanger type, direct (on air) or indirect (on water or other fluid),
- type of product: Split, MultiSplit and Packaged,
- reversible cycle or cooling only,
- mounting on the wall.

All these segmentations theoretically lead to 288 possibilities. Eurovent-Certification has notably introduced a capacity based products split (**< 12 kW / 12 – 45 kW / 45 – 100 kW**). Single and Double Duct air conditioners are not included in the certification programme even if the wording package could apply to them. The same applies to mobile split air conditioners that could be included in the split type but are not.

<table>
<tr><th colspan="9">Air conditioners</th></tr>
<tr><td>Cooling capacity</td><td colspan="3"><12kW</td><td colspan="3">12-45 kW</td><td colspan="2">45-100kW</td></tr>
<tr><td>Heat rejection</td><td colspan="4">Air cooled</td><td colspan="4">Water cooled</td></tr>
<tr><td>System</td><td colspan="3">Split</td><td colspan="3">Multi-Split</td><td colspan="2">Packaged</td></tr>
<tr><td>Operation</td><td colspan="4">Cooling only</td><td colspan="4">Reverse cycle</td></tr>
<tr><td>Mounting</td><td>High wall</td><td>Floor mounted</td><td>Cassette</td><td>Ceiling suspended</td><td>Built in horizontal</td><td>Built in vertical</td><td>Roof top</td><td>Window</td></tr>
</table>

[7] Simply renamed Eurovent in 2007.

Table 1-10: Eurovent segmentation

1.1.4 Functional analysis

In order to clarify the scope of the study, a segmentation of all the Energy using Products that have been presented and previously described is looked for. The technical categories must be restructured according to a functional approach. Indeed, as specified in the methodology, this segmentation must be linked to "primary functionalities" of products that could be defined as the answer to the question: "For which principal purpose(s) does the end-user buy a product?". For instance, safety and security of end users will be considered as constraints in such a functional analysis and not as functionalities. Only equipment having the same main function can be compared. These functionalities must be associated to functional units allowing to measure the product performances and environmental impact. A functional unit (or product performance parameter) aims at quantifying performance of a product for use as a reference unit in a life cycle assessment study. The functional unit is the reference value for any product considered within a category, and is independent of the type of product. It should also be noticed that a further segmentation could be made on the basis of secondary product performance parameters. Hence, the secondary functionalities are also listed hereafter.

Let recall the residential air conditioners products identified before:
- single duct air conditioner,
- double duct air conditioner,
- window or through the wall air conditioner,
- split package air conditioner,
- multi-split package air conditioner,
- mini-chiller.

1.1.4.1 Primary function

An air conditioner is an appliance designed to maintain the temperature of the indoor air temperature of a room at a given set point for a given heat load to be extracted.
The main corresponding product performance parameter is the cooling capacity or the heating capacity (for reversible units), in kW. Proper design should ensure this maximum capacity equals the maximum thermal load that has to be extracted from the dwelling. Since capacity is a function of outside air temperature (resp. water for water to air appliances), test standards define the reference outside air temperature (and humidity in heating mode) at which this capacity has to be measured, also called standard or design condition.

The review of **existing categorizations** shows that air conditioners are generally divided according to the following characteristics:
- Reversible or not (Eurovent, EN 14511 and other MEPS programmes),
- Cooling and heating capacity ranges (European labelling directive and all other MEPS programs, heat pump standard heating capacity ranges in the USA),
- Type of condensation means (air, water, brine, evaporatively cooled) (EN 14511),
- Type of cooling fluid (direct –air- systems, indirect –water- chiller) (EN 14511),
- Voltage (Australian MEPS programme),
- Ducted or non ducted with the EN14511 meaning as explained here: (this does not refer to single duct units whose outside unit is ducted but to indoor ducted units; this functionality enables for instance a single package split unit to serve, by the intermediary of two air ducts two different rooms thanks to the static pressure available at the indoor unit fan, that enables to cope with duct pressure losses)
- With or without a pump for air to water and water to water products (EN 14511),
- Mounting (Eurovent),

- Permanency of installation or movability (mobile split, single duct and double duct versus fix installations), (proposed at the first stakeholder meeting of this lot study),
- Spot coolers (for single duct air conditioners, USA),
- Including variable speed drive (Taiwan MEPS programme).

The MEEuP methodology established that categorization of products should be made on the basis of primary functional units, and if necessary, on the basis of secondary functional units.
In the list above, **reversibility**, **ducted or non ducted**, **with or without a pump for air to water or water to water chillers** are also functions, meaning that quantifiable product performance parameters can be defined. Variable speed drive is not a function per se; however, fast cooling by **overcapacity when starting** can be considered as a secondary function.
Other criteria are technical features that may certainly be very important for the end user or for the environmental impact of the product but that do not correspond to functions as defined in the MEEuP.

Reversibility
Heating function can be defined in the same way as cooling function, with heating capacity in kW as the performance parameter; depending on the location in Europe, reversible air conditioners are likely to be installed mainly for heating or cooling, then the main functional unit in this case would be heating. **This implies that specific categories should be created for cooling only air conditioners, reversible air conditioners and heating only heat pumps. However, heating only heat pumps are clearly out the scope of the lot that has to focus on airco and ventilation.**

1.1.4.2 Secondary functions

Several secondary functions have been identified for air conditioners:
- Overcapacity at starting,
- Inverter driven compressors,
- Ducted or non ducted (indoor unit),
- With or without a pump for air to water and water to water products,
- to decrease humidity inside a room (in the cooling mode),
- to increase humidity inside a room,
- to renew the inlet air,
- to purify the air of a room.

Overcapacity at starting
A number of manufacturers advertise a fast cooling mode for their air conditioner when starting. It is available for all technologies, variable speed drive compressors since the standard rated capacity is never the maximum frequency, but also standard single compressor air conditioner with a high speed fan not used for the standard rating or water spray for single duct units (CECED, 2007) to increase the refrigeration cycle capacity when starting by evaporative cooling on the condenser. It does not seem necessary to create a specific category for this technical characteristic that can be seen as an energy efficiency option.

Inverter
Inverter-driven units are a growing feature on the European market. This is an important and promising option for energy efficiency to be included in this study and could become later on a distinct category; however, the only function to be associated would be the overcapacity at starting that we already investigated here just before.

Ductability
Ducted air conditioners may serve several room or several spot in a single room; the available static pressure is the corresponding performance parameter. It enables to cover several rooms with a single inside unit and then can compete with multi-split systems being then very close to central air

conditioners (US type).
These “ducted” air conditioners are well identified by manufacturers. Their performance is corrected in the CEN testing standard EN14511 (see task 1.2), so as to subtract the electricity consumption used by the integral fan for air distribution. For the end user, the figures are thus made comparable with other air conditioners but it may be misleading since not all the electricity consumption is reported to the end user in the EER or COP.
The provisions of the test standards allow to keep them included completely in the family of air conditioners. However, the supplementary fan consumption due to static pressure availability should be made clear to the end user.

With or without a pump
Integrated pumps in chillers will help coping with the pressure head losses of the water network, then here again the available static pressure is the corresponding performance parameter. This could be used to generate different categories of air to water and water to water products. For the same reasons that for ductability, it does not seem necessary to create a specific category.

To decrease absolute humidity inside a room (in the cooling mode),
About all types of air conditioning equipment allow to decrease absolute humidity inside a room because the air is blown at low temperature and water condensates on the indoor coil, when the unit operates in the cooling mode. (The same applies to chiller based systems equipped with fan coils. When floor or panel cooling is used, no dehumidification can be done because of the risk of condensation on the floor / wall.)
If we focus on products identified as residential air conditioning products, the dehumidification is generally uncontrolled but the number of models that propose some kind of humidity control is increasing. The different options are explained hereafter:
- uncontrolled dehumidification when the unit is operated in cooling mode (general case),
- a specific dehumidifying mode is proposed, it is separated from the cooling mode and can be activated by the end user,
- cooling mode operation is managed such as controlling the condensation on the coil.

First, if a specific dehumidification mode is proposed, there is no reason why not to indicate to the end user the efficiency of this mode so that it is made comparable with other types of dehumidifiers. For the third dehumidification option, control of humidity would certainly have an impact on the efficiency of the cooling mode.
Since dehumidification is a general feature of all air conditioners operating in the cooling mode, this functionality will be taken into account in the environmental impact analysis but will not lead to a further segmentation.

In the heating mode, decreasing relative humidity would certainly not be a function but an undesired consequence of heating the air.

To increase absolute humidity inside a room
Some residential air conditioning products enable to increase humidity inside a room: a system to recover humidity outside a pump to spray water in the air stream of the fan used to distribute air.
This option may enable to reach required humidity levels within certain limitations linked to climate and to the specific system. Whether the comfort is improved, there is not major difference planed in the environmental impact of the unit because of the availability of this option.

To renew the air of a room
Window or package terminal air conditioners can be able to introduce outside air inside the building. Do they provide the function of air renewal? No, they would take advantage of this option for increasing the efficiency of the cooling or heating function or even for humidity control and not for air renewal as such; that would be most of the time in contradiction with their primary function with moreover very high air change values. This option could then be a BAT for these products as integrated free cooling, but does not make a distinct category.

To purify the air of a room
Air handling and filtering, elimination of odours or bacteria are some features offered by some manufacturers to support their marketing efforts (air-plasma purifier, active carbon filters…). Performance parameters can be defined here (see the following part on air purifiers), and there will certainly be interactions with the efficiency of primary functions since the more efficient the filter the higher the pressure loss the fan needs to cope with and the higher the fan electric consumption. This functionality can be taken into account in the environmental impact analysis but will not lead to a further segmentation.

1.1.4.3 Discussions on other categories identified

Permanency of installation or movability (mobile split, single duct and double duct versus fix installations), (proposed at the first stakeholder meeting of this lot study),
Despite its important consequences on the product, this is not considered as a function because there is no quantifiable parameter or “product performance parameter” that can be associated. This is thought to be one of the main technical parameters and will then be taken into account when establishing the environmental impact of these products, noticeably market data will give separated figures as far as possible. Nevertheless, following the EuP methodology, it does not seem possible to make a distinct category for movable air conditioners.

Case of single duct air conditioners
These products differ from other air conditioners because air used to cool the condenser is taken inside and rejected outside. Hence, they create a depression inside the room that is air conditioned that is likely to provoke air infiltration, from outside or from another room or space. This specificity is comparable to the one of open fireplace that aspires the air inside for the combustion of the wood in the fireplace and then contribute to the inlet of fresh outside air. As for open fireplaces, the balance of the operation, considering the complete room system, is possibly negative, the system contributing to cool down the house or room in average of the total air volume.
Nevertheless, for single duct air conditioners, the cooling function is ensured in a zone of the room in which the functional unit of air conditioners is respected: (an air conditioner is an appliance designed to maintain the temperature of the indoor air temperature of a room at a given set point for a given heat load to be extracted). The fact that the stratification of air, cool air remaining near the soil, is certainly an advantage as compared to open fireplaces.
Because this specificity implies important testing problems, it has been reported by manufacturers that the US is developing a specific test standard for these units that were previously included in the category spot coolers. This type of problem will be tackled in the part on testing standards. But it still does not enable to distinguish a dedicated category for these single duct units.

Cooling capacity range
This type of limitation will be discussed when trying to define the scope of the study hereafter.

Type of condensation means (air, water, brine, evaporatively cooled), Type of cooling fluid (direct –air- systems, indirect –water- chiller), Voltage, Mounting,
All these technical parameters cannot make distinct categories. They can be studied as technical parameters in the environmental impact study.

1.1.5 Product categories, primary functions, performance parameters

Finally, based on primary functions, air conditioning Energy using Products are divided into eight categories. Product performance parameters along with available test standards are summarised in a table for every functionality previously addressed. Test standards are necessary to provide a reliable basis for a comparison of functional parameters. The test standards listed hereunder are described in Part 2 of Task 1.

Table 1-11: Air conditioners, product categories and performance assessment

Lot 10 Energy Using Product Categories	Primary function(s)	Performance parameter(s)	Test standards	Products as presented in definitions
Cooling only air conditioners	To maintain air temperature inside a room (cooling)	Standard cooling capacity (kW)	EN 14511	Single duct, double duct, window and through the wall packages, split package, multi-split package, mini chillers
Reversible room air conditioners	To maintain air temperature inside a room (cooling and heating)	Standard Cooling capacity and Standard heating capacity (kW)	EN 14511	Single duct, double duct, window and through the wall packages, split package, multi-split package, mini chillers

Table 1-12: Air conditioners, primary and secondary functions

Functions	Reversible air conditioners	Cooling only air conditioners
To maintain air temperature inside a room (cooling and heating)	X	
To maintain air temperature inside a room (cooling)	X	X
To move air inside a room	x	x
To increase humidity inside a room	x	x
To decrease humidity inside a room	x	x
To change indoor air of a room	x	x
To filter the air inside a room	x	x
To be ductable (available static pressure)	x	x

In addition to the primary functions the secondary functions will be considered throughout the study when they may explain some environmental performance differences.

X: primary functionalities

x: secondary functionalities

1.1.6 Scope of the study on air conditioners

1.1.6.1 Introduction

The scope of the study should be defined by Armines in agreement with the stakeholders on the basis of:

- the terms of reference (namely the title) of the Call for tenders No. TREN/D1/40 lot 10 – 2005: "residential room air conditioning appliances: airco and ventilation",
- the EuP definition, article 2 (reminded partly hereafter) of the Ecodesign directive 2005/32/EC,
- the criteria of the article 15 (reminded hereafter) of the Ecodesign directive 2005/32/EC,
- cross sections with other lots.

> Article 2
> Definitions
> For the purposes of this Directive the following definitions shall apply:
> 1) "Energy-using Product" or "EuP" means a product which, once placed on the market and/or put into service, is dependent on energy input (electricity, fossil fuels and renewable energy sources) to work as intended, or a product for the generation, transfer and measurement of such energy, including parts dependent on energy input and intended to be incorporated into an EuP covered by this Directive which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently;
> 2) […]
>
> Article 15
> Implementing measures
> 1. When an EuP meets the criteria listed under paragraph 2, it shall be covered by an implementing measure or by a self-regulation measure in accordance with paragraph 3(b). When the Commission adopts implementing measures, it shall act in accordance with the procedure referred to in Article 19(2).
> 2. The criteria referred to in paragraph 1 are as follows:
> (a) the EuP shall represent a significant volume of sales and trade, indicatively more than 200 000 units a year within the Community according to most recently available figures;
> the EuP shall, considering the quantities placed on the market and/or put into service, have a significant environmental impact within the Community, as specified in Community strategic priorities as set out in Decision No 1600/2002/EC;
> (c) the EuP shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular:
> − the absence of other relevant Community legislation or failure of market forces to address the issue properly;
> − a wide disparity in the environmental performance of EuPs available on the market with equivalent functionality.

These criteria can be translated in the following conditions to exclude products from the scope of the study:

- Scope indicated by the lot wording: "residential" area, "room conditioning", "air conditioner", "ventilation". This has already partly been used in the general definitions to limit the products to be included.
- Limited environmental impact of a product category: it has to be deepened in tasks 2, 3 and 4; the 200 000 units criteria is a general indication useful for small appliances;
- Low potential for improvement: it has to be deepened in tasks 2, 3 and 4.
- The products are already included in another lot.

We screen hereafter the two categories of products that have been identified previously with the help of the functional analysis, keeping in mind the wording of the scope and products already considered partly in other lots in order to avoid cross section. When market figures are available, a first evaluation of European sales energy impact is given. Of course, it does not exactly answers the article 15 criteria of low environmental impact and the global environmental impact should be considered. However, it gives a first idea of the main stakes for this study to be consolidated with further data when available.

1.1.6.2 Cooling only air conditioners

This product group is limited to cooling only (for reverse cycle, see below) **air conditioners found in the residential sector that can also be used in the tertiary sector.**
At the moment, this includes:
- **single duct air conditioners,**
- **double duct air conditioners,**
- **package and through-the-wall air conditioners,**
- **split package air conditioners,**
- **multi-split package air conditioners,**
- **central air conditioners, package ducted or split (US style),**
- **mini chillers (*).**

The simplest limitation to translate the limit of "residential" air conditioners is to apply a capacity limitation. In Europe, the 12 kW capacity limit is already used in the labelling directive 2002/31/EC and for the Directive on Energy Performance of Buildings 2002/91/EC, where it puts a lower limit to central air conditioning systems. Furthermore, this limit is also used by manufacturers (Eurovent certification program).

We propose to keep the 12 kW limit for this study. Nevertheless, the following points should be added:
- higher capacity products may be in all points similar to products with a capacity limit lower than 12 kW; hence, in order to avoid market distortion, the possibility to extend future implementation measures on room air conditioners to higher capacity units should be investigated.
- Of course, within this limit of 12 kW, separated measures may appear necessary in the following tasks of the MEEuP methodology applied to this product, e.g stakeholders explained that smaller capacity products, below 6 kW (Eurovent-Cecomaf, 2006a)[8] or below 4 kW (CECED, 2006) had shorter design cycles.
- We certainly will have to split the category of air conditioners when we come to the technical study into technical categories, namely moveable and non moveable appliances, because some products need an installer and some other products are perfectly moveable.

1.1.6.3 Reversible air conditioners

The product considered are the same, except for reversible mini chillers, see hereafter, as for cooling only air conditioners. Capacity limitation is still 12 kW: heating capacity is limited by the cooling mode thermal capacity of 12 kW (as in the labelling directive 2002/31/EC).

Table 1-13: Energy impact estimate of air conditioners and reversible air conditioners sales, EU 25.

Categories	Products included	Approx numb of appliances sold / year	Gross estimation of average energy consumption / year

[8] Namely meeting on Sept, 8 and November, 8, 2006

<table>
<tr><td>Cooling only air conditioners</td><td>Single duct
Double duct
Window and through the wall package
Split package
Multi-split package
Central air conditioners (US type)
Mini-chillers (*)</td><td rowspan="2">Around 6 millions
(VHK, MEEuP)
(Sales figures 2005)</td><td rowspan="2">Average power: 1 kW ?
Nb of use: 500 h (2002/31/EC)
Yearly consumption: 500 kWh

Total Yearly Consumption of pieces sold in 2005
>[9] 3 TWh</td></tr>
<tr><td>Reversible air conditioners</td><td>Single duct
Double duct
Window and through the wall package
Split package
Multi-split package
Central air conditioners (US type)</td></tr>
</table>

(*) Mini chillers and reversible mini-chillers
Mini chillers, air to water and water to water cooling only units have the same functionality than air conditioners (air to air or water to air) to supply cooling capacity in order to maintain the indoor air temperature to a required value. Nevertheless, cooling is not delivered directly to the air but via a water network that supplies water, by the intermediary of a water pump, to cooling floors or panels and fan coil units.
This type of central air conditioning is clearly a system and as a consequence, it has not to be included in this study. However, mini chillers alone or with the pump integrated is an EuP product, and stakeholders have expressed the view they could be in competition with air conditioners in the residential sector – see Armines (2006). As a consequence, cooling only mini-chillers are included in the study. Market analysis will investigate the part of this segment on the European market but it is thought that cooling only units are not common in the residential area, the fast and growing market being linked to the development of reversible mini-chillers.
Reversible mini-chillers in Europe are thought to be used primarily for heating purpose, at least in the residential area: VHK[10], in the Lot 1 task 2 market analysis, states that the heat pump market is around 118000 units in 2004; the European Heat Pump Association (EHPA, 2006) finds about 130 000 sales reported by its members in the EC serving primarily heating purpose, the figures being limited to the residential area. It appears that the primary function is heating and cooling being a secondary function. As such, reversible mini-chillers are included within lot 1 as a design option for boilers, whereas cooling only air conditioners are included within the lot 10 study under the category air conditioner. Harmonisation between lot 1 and lot 10 studies will be ensured on this product category.

1.1.6.4 Final scope for the air conditioner study

We have identified 2 main product categories:
- air conditioners,
- reversible air conditioners,

The scope definition includes the following technical categories.

[9] At this point, it is not known which proportion of reversible air conditioners are really used for heating also. Then, 3 TWh includes only the cooling mode of reversible air conditioners.
[10] VHK, 2006, Ecodesign of Energy Using Product, Lot 1, Report of Task 2, Draft 2, December.

Table 1-14: Scope of the study on air conditioners

Categories	Products included	Scope limits
Cooling only air conditioners	Single duct Double duct Window and through the wall package Split package Multi-split package Central air conditioners (US type) Mini-chillers	Cooling power <= 12 kW[11]
Reversible air conditioners	Single duct Double duct Window and through the wall package Split package Multi-split package Central air conditioners (US type)	

[11] The 12 kW cooling capacity limit also applies for reversible appliances. There is no specific limit on the heating mode. This limit would become necessary if heating only were considered.

1.2 Test Standards

1.2.1 Introduction

In this section, the following objectives have been assigned to

"*Identify and shortly describe*:

- *the harmonised test standards;*
- *and additional sector-specific directions for product-testing.*

regarding the test procedures for:

- *the primary and secondary functional performance parameters mentioned above;*
- *resources use (energy, water, paper, toner, detergent, etc.) and emissions (NOx, CO, particulate matter) during*
- *product-life;*
- *safety (gas, oil, electricity, EMC, stability of the product, etc.);*
- *noise and vibrations (if applicable);*

Apart from mentioning these standards, including a short description, it should also be reported which new standards are being developed, which problems (e.g. regarding tolerances, etc.) exist and what alternatives are being developed. Furthermore, the (ongoing) work on an ecodesign-standard, mandated by the European Commission to standardisation bodies, should be considered[12]."

NOTE: in the light of the Article 10 of the Ecodesign Directive, the implementing measures, whether they should be preferably based on available harmonized test standards, can overcome problems encountered in the application of existing harmonized test standards, avoiding to wait for test standard revision and then to delay the application of the implementing measures.

1.2.2 Energy performance

The only international test standards in force concerns air cooled and water cooled air conditioners non ducted – test standard ISO 5151 – or ducted – test standard ISO 13253. The ISO working group TC86 SC6 has been working for a few years on an ISO test standard on air to water and water to water chillers (cooling mode only), but no final draft has been released yet.

1.2.2.1 International test standards

ISO 5151-2005 – 'Non-ducted air conditioners and heat pumps -- Testing and rating for performance'

Scope

The applicability of the ISO 5151 test procedure for the different types of air cooled air conditioners is indicated in the table hereunder.

The procedure applies to air conditioners of any capacity and type provided they are non-ducted including cooling-only and reversible, single-phase and three-phase, and air-cooled or water-cooled units. It also applies to "ducted air conditioners and heat pumps rated at less than 8 kW and intended to operate at external static pressures of less than 25 Pa" whereas for higher static pressure, the standard ISO 13253 should be applied.

The test procedure excludes single-duct room air conditioners and multi-split systems. The ISO/TC86/SC6 prepared a draft for a multi-split test standard - ISO 15042-2005 – Multiple split-system air-conditioners and air-to-air heat pumps — Testing and rating for performance' that is not a full test standard yet. Its content is in line with the multi-split development of the European standard EN 14511. Water-cooled heat-pumps (heating only) are not included. Part-load conditions are not tested.

[12] See http://www.europa.eu.int/comm/enterprise/eco_design/mandate.pdf

Table 1-15: Product types included/ excluded from ISO 5151 test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal (Wall package)	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser
N	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y[1]

[1] Heat pumps (heating only) with water-cooled condensers are excluded.

Summary of test procedure

The ISO 5151 test procedure consists of a series of cooling and heating (for reversible units only) tests as follows.

Cooling tests:
- rated cooling capacity,
- maximum cooling test,
- minimum cooling test,
- enclosure sweat and condensate disposal test,
- freeze-up test.

Heating tests:
- rated heating capacity,
- maximum heating test,
- minimum heating test,
- automatic defrost test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter[13]. The cooling and heating capacities can be calculated by either the calorimeter method or the air-enthalpy method. For the calorimeter method two simultaneous determinations of the cooling or heating capacities are required, one on the indoor-side and one on the outdoor side. These two simultaneous determinations have to agree with each other by within 4% for the test to be deemed valid.
Test conditions have to be maintained for a minimum of 1 hour before capacity data can begin to be recorded. The capacity tests last for 30 minutes with readings taken at least every 5 minutes.

The rated cooling performance of the air conditioner can be tested at one or more of three different sets of test conditions that are designed to represent performance under a moderate, cool or hot climate. The designated climate type must be indicated on the air conditioner. In practice the T1 test condition, indicating performance under a moderate climate, is the world standard condition for rating air conditioners.

The standard test conditions for the cooling capacity test are shown in the next table. The test conditions are always at full-load and with a single set of stable environmental conditions; the part-load performance of variable speed drive or capacity staged units and the operations at reduced fan speeds are not measured. Following the same idea, electric consumption when the unit is Off or when the unit is on but not cooling are not taken into consideration. The T2 and T3 conditions are not really useful to complement the T1 points for an air conditioner operating in classical summer

[13] In practical terms, there is a limit on the size of unit that can be tested using a calorimeter that depends on the particular test facility.

conditions because the inside temperature also varies while it is generally held constant by the air conditioner.

Table 1-16: Test conditions for the determination of cooling capacity, ISO

Parameter	Standard test conditions		
	T1	**T2**	**T3**
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 27 19	 21 15	 29 19
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb[1)]	 35 24	 27 19	 46 24
Condenser water temperature[2)] (°C) inlet outlet	 30 35	 22 27	 30 35
T1 = Standard cooling capacity rating conditions for **moderate** climates **T2** = Standard cooling capacity rating conditions for **cool** climates **T3** = Standard cooling capacity rating conditions for **hot** climates			
1) The wet-bulb temperature is not required when testing air-cooled condensers which do not evaporate the condensate. 2) Representative of equipment working with cooling towers. For equipment designed for other uses, the manufacturer shall designate the condenser water inlet and outlet temperatures or the water flow rates and the inlet temperature in the ratings			

In the 1994 standard, the heating capacity of reversible air conditioners must be tested at a minimum of the high and low heating conditions whether a unit cannot operate at the extra-low test condition, and in the three test conditions otherwise. In 2005, only the H1 condition appears mandatory.

Table 1-17: Test conditions for the determination of heating capacity

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb wet-bulb (maximum)	 20±1(0.3) 15±0.5(0.2)
Temperature of air entering outdoor side (high) (°C) dry-bulb wet-bulb	**H1** 7±1(0.3) 6±0.5(0.2)
Temperature of air entering outdoor side (low) (°C) dry-bulb wet-bulb	**H2** 2±1(0.3) 1±0.5(0.2)
Temperature of air entering outdoor side (extra low) (°C) dry-bulb wet-bulb	**H3** -7±1(0.3) -8±0.5(0.2)

Rating

Variables required to be measured, determined or declared are:
- Climate classification types
- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.1 kW)
- EER (expressed in multiples of 0.05)
- Heating capacity (as appropriate, rounded to the nearest 0.1 kW)

- COP (only applicable to reversible units operating in the heating-mode and expressed in multiples of 0.05)
- Rated voltages and frequencies
- Cooling power consumption
- Refrigerant designation and refrigerant mass charge

There is no constraint imposed over the maximum permissible uncertainty in the declared cooling and heating capacities. The electrical power must be measured within a maximum uncertainty of ±0.5%.

ISO 13253-2005 – 'Ducted air conditioners and heat pumps -- Testing and rating for performance'

Scope

The applicability of the ISO 13253 test procedure for ducted packaged air conditioners is indicated in the table below. The procedure applies to air conditioners of any capacity and type provided they are ducted (with a static pressure superior to 25 Pa otherwise they should be tested according to the ISO 5151 standard) with the exception of single-duct room air conditioners, multi-split systems and water-cooled heat-pumps but including: cooling-only and reversible, single-phase and three-phase, and air-cooled or water-cooled units. Part load is not considered.

Table 1-18: Product types included in or excluded from ISO 13253 test procedures

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser
Y	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y[1]

[1] Heat pumps (heating only) with water-cooled evaporator (outdoor heat exchanger) are excluded.

Summary of test procedure

The ISO 13253 test procedure consists of a series of cooling and heating (for reversible units only) tests as follows.

Cooling tests:
- rated cooling capacity,
- maximum cooling test,
- minimum cooling test,
- enclosure sweat and condensate disposal test,

Heating tests:
- rated heating capacity,
- maximum heating test,
- minimum heating test,
- automatic defrost test.

The test requires the indoor air-enthalpy method to be used to measure the cooling and/or heating capacity.

Test conditions, set of test conditions and testing conditions for measurement are similar to the conditions of the standard ISO 5151. In the revision, a table for minimum external static pressure has been added that enables to compare energy performance of ducted air conditioners on a fairer basis.

Table 1-19: Minimum external pressure for ducted air conditioners

Standard capacity ratings kW	Minimum external static pressure Pa [a b]
0 < Q < 8	25
8 ≤ Q < 12	37
12 ≤ Q < 20	50
20 ≤ Q < 30	62
30 ≤ Q < 45	75
45 ≤ Q < 82	100
82 ≤ Q < 117	125
117 ≤ Q < 147	150
Q ≥147	175

[a] For equipment tested without an air filter installed, the minimum external static pressure shall be increased by 10 Pa.
[b] If the manufacturer's installation instructions state that the maximum allowable discharge duct length is less than 1 m, then the required minimum external static pressure shall be 10 Pa.

Rating
Variables required to be measured, determined or declared for regulatory purposes are the same as in ISO 5151.

1.2.2.2 European test standards

EN14511-2004 'Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling'

This standard is being revised.

Part 1: Scope, Terms and definitions
As opposed to ISO or other regional test standards, the EN 14511 standard covers almost all types of air conditioners of the vapour compression type used for space heating or cooling. They are classified according to the fluids used at their evaporators and condensers as follows.

Table 1-20: Classification of air conditioners, EN 14511

Heat transfer medium		Classification
Outdoor heat exchanger	Indoor heat exchanger	
Air	Air	Air/air heat pump or air cooled air conditioner
Water	Air	Water/air heat pump cooled air conditioner
Brine	Air	Brine/air heat pump or brine cooled air conditioner
Air	Water	Air/water heat pump or air cooled liquid chilling package
Water	Water	Water/water heat pump or water cooled liquid chilling package
Brine	Water	Brine/water heat pump or brine cooled chilling package

This standard apply to factory-made units, which may be ducted. In the case of units consisting of several parts, the test standard apply only to those designed and supplied as a complete package, except for liquid chilling packages with remote condenser.
The following units are excluded:

- heat pumps for sanitary hot water,
- units using transcritical cycles, e.g. with CO2 as refrigerant,
- the units having their condenser cooled by air and by the evaporation of external additional water are not covered by this standard (covered by standard EN 15218), while to air cooled air conditioners which evaporate the condensate on the condenser side are included,
- water cooled multi-split are not included.

Single duct units are explicitly covered and there is no specific problem to test double duct units according to this standard, even if it is not explicit these units are included. Multi-split systems are explicitly covered. Part load testing of units is dealt with in the technical standard CEN/TS 14825.

The difficult exercise to try to define the limits between multi-split systems and what we have called VRF systems before has been attempted. These technical descriptions of what was on the market at the time the standard was written, including the way part load control is performed, the reversibility of what is defined as the basic multi-split, limit the value of the definitions. Nevertheless, referring to the preceding description of air conditioning systems we reported, it clearly appears that multi-split systems, VRF 2 tubes and VRF 3 tubes are intended to be included in the standard.

Part 2 : test conditions

This standard only defines tests for rating the performances of the units; only the tests in the standard conditions are mandatory. However, application rating performances should be published by manufacturers or manufacturers representatives whether application testing conditions lie in the range of operation specified. Complementary tests as defined in the ISO 5151 and 13253 standards are defined in part 4 and compatible with the ISO standards described herebefore for water to air and air to air units.

The test conditions are defined in the cooling mode and in the heating mode following the classification by evaporator and condenser external fluids shown before.

For corresponding units, testing conditions are compatible with ISO 5151 and with ISO 13253 standards both in cooling and heating mode. In the cooling mode, rating temperatures are the common T1 temperatures. Application temperatures are the T2 and T3 of ISO standards 5151 and 13253 conditions. Other conditions are defined for air cooled air conditioners not covered by the two mentioned ISO standards, namely single duct units, close control units and control cabinet air conditioners. Distinction are also made according to the type of air stream (exhaust air, outdoor air, recycled air) with the intent to better translate the conditions of operation of these products.

Table 1-21: Air to air, testing conditions in the cooling mode

		Outdoor heat exchanger		Indoor heat exchanger	
		Inlet dry bulb temperature °C	**Inlet wet bulb temperature °C**	**Inlet dry bulb temperature °C**	**Inlet wet bulb temperature °C**
Standard rating Conditions	Comfort (outdoor air / recycled air)	35	24 [a]	27	19
	Comfort (exhaust air / recycled air)	27	19	27	19
	Comfort (exhaust air / outdoor air)	27	19	35	24
	Single duct [b]	35	24	35	24
	Control cabinet	35	24	35	24
	Close control	35	24	24	17
Application rating conditions	Comfort (outdoor air / recycled air)	27	19 [a]	21	15
	Single duct [b]	27	19	27	19

	Comfort (outdoor air / recycled air)	46	24 [a]	29	19
	Control cabinet	50	30	35	24
	Close control	27	19	21	15

[a] The wet bulb temperature condition is not required when testing units which do not evaporate condensate.
[b] When using the calorimeter room method, pressure equilibrium between indoor and outdoor compartments shall be obtained by introducing into indoor compartment, air at the same rating temperature conditions.

Single duct: with the previous revision of the standard (in 2004), the testing conditions for single duct units that used to be the T1 conditions has been changed to A35/24 inside and outside. This increased the performance of the unit. It has been changed to ease testing.

Table 1-22: Air to air, testing conditions in the heating mode

		Outdoor heat exchanger		**Indoor heat exchanger**	
		Inlet dry bulb temperature °C	**Inlet wet bulb temperature °C**	**Inlet dry bulb temperature °C**	**Inlet wet bulb temperature °C**
Standard rating Conditions	Outdoor air / recycled air	7	6	20	15 max
	Exhaust air / recycled air	20	12	20	12
	Exhaust air / outdoor air	20	12	7	6
Application rating conditions	Outdoor air / recycled air	2	1	20	15 max.
	Outdoor air / recycled air	- 7	- 8	20	15 max.
	Outdoor air / recycled air	- 15	-	20	15 max.
	Exhaust air / outdoor air	20	12	2	1
	Exhaust air / outdoor air	20	12	-7	-8

Table 1-23: Water to air, testing conditions in the cooling mode

		Outdoor heat exchanger		**Indoor heat exchanger**	
		Inlet temperature °C	**Outlet temperature** °C	**Inlet dry bulb temperature** °C	**Inlet wet bulb temperature** °C
Standard rating conditions	Comfort	30	35	27	19
	Control cabinet	15	20	35	24
	Close control	30	35	24	17
Application rating conditions	Comfort	15	[a]	27	19
	Comfort	40	[a]	27	19
	Close control	15	[a]	21	15
	Close control	40	[a]	24	17

[a] The test is performed at the water flow rate obtained during the test at the corresponding standard rating conditions.

Table 1-24: Water to air, testing conditions in the heating mode

		Outdoor heat exchanger		**Inlet heat exchanger**	
		Inlet temperature °C	**Outlet temperature** °C	**Inlet dry bulb temperature °C**	**Inlet wet bulb temperature °C**
Standard rating conditions	Water	15	12/ [a]	20	15 max.
	Brine	0	-3/ [a]	20	15 max.

	Water loop	20	17/ [a]	20	15 max.
Application rating conditions	Water	10	b	20	15 max.
	Brine	5	b	20	15 max.
	Brine	- 5	b	20	15 max.
[a] For units designed for heating and cooling mode, the flow rate obtained during the test at standard rating conditions in cooling mode (see Table 6) is used. [b] The test is formed at the flow rate obtained dur the test at the corre ndin standard ratin conditions.					

Table 1-25: Air to water, testing conditions in the cooling mode

		Outdoor heat exchanger		Indoor heat exchanger	
		Inlet dry bulb temperature °C	**Inlet wet bulb temperature °C**	**Inlet temperature °C**	**Outlet temperature °C**
Standard rating conditions	water	35	-	12	7
	brine	35	-	0	- 5
	water (for floor cooling or similar application)	35	-	23	18
Application rating conditions	water	27	-	a	7
	water (for floor cooling or similar application)	27	-	a	18
	water	46	-	a	7
	brine	27	-	a	- 5
[a] The test is performed at the water flow rate obtained during the test at the corresponding standard rating conditions.					

Table 1-26: Air to water, testing conditions in the heating mode

		Outdoor heat exchanger		Indoor heat exchanger	
		Inlet dry bulb temperature °C	**Inlet wet bulb temperature °C**	**Inlet temperature °C**	**Outlet temperature °C**
Standard rating conditions	Outdoor air	7	6	40	45
	Exhaust air	20	12	40	45
	Outdoor air (for floor heating or similar application)	7	6	30	35
Application rating conditions	Outdoor air (for floor heating or similar application)	2	1	a	35
	Outdoor air (for floor heating or similar application)	- 7	- 8	a	35
	Outdoor air (for floor heating or similar application)	- 15	-	a	35
	Outdoor air	2	1	a	45
	Outdoor air	- 7	- 8	a	45
	Outdoor air	- 15	-	a	45
	Outdoor air	7	6	a	55
	Outdoor air	-7	-8	a	55
[a] The test is performed at the flow rate obtained during the test at the corresponding standard rating conditions.					

Table 1-27: Water to water, testing conditions in the cooling mode

Outdoor heat exchanger	Indoor heat exchanger

		Inlet temperature °C	Outlet temperature °C	Inlet temperature °C	Outlet temperature °C
Standard rating conditions	Water to water and brine to water	30	35	12	7
	Water to brine	30	35	0	- 5
	Water to water and brine to water (for floor cooling or similar application)	30	35	23	18
Application rating conditions	Water to water	15	a	a	7
	Water to brine	15	a	a	- 5

[a] The test is performed at the flow rate obtained during the test at the corresponding standard rating conditions.

Table 1-28: Water to water, testing conditions in the heating mode

		Outdoor heat exchanger		Indoor heat exchanger	
		Inlet temperature °C	Outlet temperature °C	Inlet temperature °C	Outlet temperature °C
Standard rating conditions	Water	10	7 [a]	40	45
	Brine	0	-3 [a]	40	45
	Water (for floor heating or similar application)	10	7 [a]	30	35
	Brine (for floor heating or similar application)	0	-3 [a]	30	35
Application rating conditions	Water	15	b	b	45
	Brine	5	b	b	45
	Brine (for floor heating or similar application)	5	b	b	35
	Brine	- 5	b	b	45
	Brine	0	b	b	55
	Water	10	b	b	55

[a] For units designed for heating and cooling mode, the flow rate obtained during the test at standard rating conditions in cooling mode (see Table 8) is used.
[b] The test is performed at the flow rate obtained during the test at the corresponding standard rating conditions.

VRF 3 pipes: a heat recovery test is required.

Table 1-29: Heat recovery conditions for multi-split system

			Three room calorimeter or air enthalpy		Two room Air enthalpy	
			Dry bulb temperature °C	Wet bulb temperature °C	Dry bulb temperature °C	Wet bulb temperature °C
Application rating conditions	Outdoor side		7	6	7	6
	Indoor side	Heating	20	-	20	19
		Cooling	27	19	20	19

Labelling annexe

A normative annexe is included inside the EN 14511 standard and deals with the application of the labelling directive Directive 2002/31/EC.
Rating conditions:

“Standard rating conditions “single-duct” indicated in Table 4 shall be used to determine the energy efficiency class of single-duct units. The cooling capacity, EER and the annual energy consumption shall be determined from the application rating conditions “single-duct” indicated in Table 4.”

It mentions that:
- *“Water-cooled multisplit to which Table 2.1 of Annex IV of Directive 2002/31/EC refers are not covered by EN 14511.”* This restriction should be raised nowadays that water cooled VRF systems are sold in Europe.
- *Single-duct units operating in the heating mode to which Table 3.3 of Annex IV of Directive 2002/31/EC refers are not covered by EN 14511.”* There is no explanation for this restriction; even if most reversible single duct perform heating with an electric resistance, some are real heat pumps with COP superior to 1.

<u>Part 3: Test methods</u>
Two testing methods are defined, namely the enthalpy method, which consists in the direct measurement of cooling capacity by measurement of air flow rates and inlet and outlet temperatures as well as weighting of the condensates on the coil. The other method is the indirect “calorimeter room” method that measures the heat and water that have been removed from the inside room by the unit. This latter method is reputed much more certain than the direct measurement method. For application of the labelling directive, only the calorimeter method is to be used.

Despite this, the labelling annexe recommends broad tolerance levels for application of the directive and let the possibility of a second test in case of failure:
- Tested cooling and heating capacity ≥ 0,88 . declared capacity
- Tested EER ≥ 0,85 . declared EER
- Tested COP ≥ 0,85 . declared COP

The calorimeter room method
The 2 rooms of the calorimeter simulate the indoor and outdoor environment of the unit in which temperature and humidity conditions are maintained. The total cooling capacity of the unit (P_C) is not directly measured. The capacity of the compensation system in the indoor room, to maintain the indoor conditions steady is measured. Assuming that there are no energy losses, the sensible cooling capacity (P_S) of the unit is equal to the heating capacity of the compensation system. The latent cooling capacity (P_L) is determined from the rate of condensate production. As a confirming method, the total cooling capacity can be deduced from the measurements in the outdoor compartment and the power input to the compressor.
A detailed description of the calorimeter installation is available, and includes the dimension of the rooms for different maximum cooling capacities to be measured until 12 kW. Measurement of cooling capacities as low as 1 or 1.5 kW can be achieved nowadays in Europe but at the cost of relatively high uncertainties of measurement (more than 10 %).
The only unit for which the calorimeter method is uncertain is for single duct units because of the air that has to be introduced from the outside. This has been solved by equalizing inside and outside temperature and humidity conditions. Nevertheless, measurement is still very uncertain, especially as far as latent capacity is concerned. The case of single duct should be clearly separated in order the high uncertainty of measurement figures does not prevail for other air to air units. One extreme solution to reduce the uncertainty for single duct units would be not to take into account the latent capacity of the units and to measure directly air flow and outlet temperature inside.

Indoor air enthalpy method
The total capacity is determined from the measurement of the temperature and humidity of the air at the inlet and outlet of the unit and from the measurement of the airflow rate through the unit.

For both methods, the cooling capacity is determined within a maximum uncertainty of 5% independent of the individual uncertainties of measurement. The electrical power shall be measured

within an uncertainty of 1%. This means a maximum 6% uncertainty is permissible for the rated EER.
The EER is then calculated from the total cooling capacity P_C and the effective power input (P_E) to the unit:
EER = P_C / P_E

Correction for fans and pumps
In order to avoid manufacturers to increase the energy efficiency of their products to the detriment of increased pressure losses that would not be credited to the unit but to the auxiliaries of the system (for manufacturers that supply units without internal fan or pump), the power needed to overcome the pressure losses at the inside heat exchanger is taken into account. Two cases may occur, whether or not an inside fan (or pump) is part of the unit:
Without fan or pump:
$P_2 = q . \Delta pi / \eta$ [in Watts]
where
- η is 0,3 by convention;
- Δpi is the measured internal static pressure difference, in Pascals;
- q is the nominal air flow rate, in cubic meters per second.
P_2 is to be added to the unit electric power, the cooling capacity must be decreased (and the heating capacity increased).

With fan or pump that deliver static pressure (for air, it concerns ducted units only):
$P_1 = q . \Delta pe / \eta$ [in Watts]
where
- η is 0,3 by convention;
- Δpe is the measured available external static pressure difference, in Pascals;
- q is the nominal air flow rate, in cubic meters per second.
P_1 is to be excluded from the unit electric power, removed from the cooling capacity (added to the heating capacity).

Non ducted air cooled air conditioners are rated equally by ISO 5151 standard and EN 14511.
For ducted units (or units supplied with a pump), the supplementary electric power that enables to deliver static pressure to the network for duct connection (or pipe connection) is not accounted for in the efficiency of the unit. It enables to make rated performances of ducted and non ducted units comparable. However, this does create a European specificity for ducted air to air units and water to air units as ISO 5151 and ISO 13253 standards do not take into account these corrections (for fans). It is also to be noted that the correction for chillers is generally not applied outside Europe. Big units being sold without a pump, this generally makes European rating lower, called net capacity lower than gross capacity, with also lower energy efficiencies.

Test of air to air inverter units
Inverter controlled units are in the scope of this standard. However, there is no indication in this standard on how to set up the full load conditions, in other words what is the frequency of the motor drive for testing. This does matter since rating performances vary with the frequency of the compressor.
For the testing laboratory, it is possible to force the air conditioner to full load with the calorimetric room testing method by maintaining the compensation load to a higher capacity than what the unit can supply. Nevertheless, some units are equipped with high capacity modes that are limited in time, supplying overcapacity for a limited period of time and then stabilizing to an inferior capacity which makes test cumbersome and it may happen that stabilized conditions are difficult or even impossible to reach. Sometimes, manufacturers explain a way to reach the T1 pre-programmed stabilized conditions for testing via the remote control.
Then, at the moment, manufacturers of inverter driven units can optimise the published rated performances of their air to air conditioners by choosing between higher capacity or higher

efficiency. However, most of the time, the published values in their documentations does not state at which capacity the performance was measured while showing the full capacity range.
For inverter driven multi-split units, the standard specifies the manufacturer (or a representative) should send an expert to help with the mounting and programming of the equipment.

Part 4: requirements
Supplementary requirements are defined in this part:
- a starting test,
- a maximum operating test (cooling mode),
- a freeze-up test,
- a test outside the operating range,
- a safety test consisting in shutting off the heat transfer medium flows,
- a complete power supply failure test,
- a condensate draining and enclosure sweat test,
- information on the defrosting means (where applicable).

Instruction are given for the information that should be marked on the plate of the unit (namely manufacturer and machine designation and rated performances).

The information that should be published in the technical documentation of the unit is also described. It entails:
- trade mark, model designation;
- power supply (voltage, frequency);
- denomination of the unit (e.g.: air-to-water);
- intended use of the unit (e.g.: control cabinet air conditioner);
- number of separate component units;
- type and mass of refrigerant charge;
- overall dimensions and weight of each separate component unit.
- the cooling capacity, the effective power input, the EER and the SHR (where applicable);
- the heating capacity, the effective power input and the COP (where applicable);
- the heat recovery capacity and the type of liquid (where applicable).
- non ducted air-to-air units: flow rates or rotational speeds of fans (rated point);
- non ducted air-to-water units: air flow rate or rotational speed of fan; water flow rate and pressure difference (rated point),
- unit intended to discharge into double floor: nominal flow rate and external static pressure difference (rated point),
- other types of units: nominal flow rates and external static pressure differences for air and water (rated point).
- Sound characteristics: the manufacturer shall provide the sound power level and the corresponding test method according to ENV 12102.

The manufacturer shall specify the electrical the characteristics in accordance with EN 60335-2-40 or EN 60204-1 as applicable and:
- maximum starting current of the unit, as defined in EN 61000-3-11;
- total power input and current at the rated point, excluding the starting period;
- reactive power or power factor at the rated point, for units with a total power input greater than 10 kW;
- power input of fan and pump if included in the units.
- limits of use (temperatures and flows);
- whether there are devices fitted which do not allow the unit to operate when these limits are exceeded.

If not already required by other standards, the manufacturer shall provide the supplementary information as described below:
- specify the refrigerant, air and liquid circuits preferably providing circuit diagrams, showing every

- functional unit, control and safety device and specifying their type;
- if the unit uses water in the heat exchangers specify the water capacity contained in the unit, and specify either the constructional materials of the heat exchangers or the water quality;
- if used, specify the type of brine and the concentration into any other liquid;
- specify the type of oil to be used in the compressor.
- specify the type and location of additional heating devices and their control and safety devices.
- state the functions achieved by the control and safety devices provided with the unit and specify when applicable their provision for adjustment and the method by which the safety devices are reset;
- provide specifications for any control or safety devices necessary to ensure correct operation of the unit but which are not provided with the unit;
- specify any limitation to the use of the rest of the installation.
- specify the required location conditions (whether units are to be installed outside or in a weather proof enclosure, or in a heated space);
- specify the requirements of physical layout, access and clearance;
- specify the requirements for the electrical, liquid, air and refrigerant connections, to be made on site;
- specify the location of warning and tripping devices;
- specify the installation precautions to be taken to ensure, in particular:
- advice for correct circulation of the heat transfer media;
- advice for water draining;
- advice for maintaining cleanliness of heat exchange surfaces;
- advice to minimise noise, vibration or other adverse effects.
- Special indications for units using soil, sea water, ground water or surface water: specify any materials which are in contact with the water or with the brine.
- content and frequency of routine maintenance operations to be performed by the user;
- content and frequency of maintenance and inspection operations which shall be performed by a specialist.

Tolerances

Round-robin test by Eurovent-Certification

The EN 14511 test standard for the application of the directive: this test standard in its Annex A, § 4 stipulates that the allowed tolerance between the claimed and measured efficiency is 15%. Eurovent-Certification (Saheb, 2006) points out that at the same time the difference between two successive classes is between 6 and 8 % and is concluding, that this is enabling manufacturers to jump easily to one or even two higher classes. Eurovent-Certification indicates the tolerances applied for its certification program is 8 %.

To evaluate the actual uncertainties of measurement using the European test standard EN 14511:2004 and to demonstrate that the tolerances specified in Annex A of the test standard are not reasonable, Eurovent-Certification organised a round robin test to compare the results obtained by different European independent laboratories for the measurement of the cooling and heating capacities of air conditioners and heat pumps, and of their EER and COP. Three laboratories[14] equipped with calorimetric room have been selected. Testing facility used in each laboratory was a balanced ambient room type calorimeter.

Eurovent-Certification communicates, the differences between the results of the three laboratories is small: The biggest deviation from the medium value for the capacities is 3,1%, and 3,7% for the efficiencies. These deviations would not only include the uncertainty of the measurement itself, but also the effect of the differences in the installation of the samples.

[14] At the time of this round robin test, these 3 laboratories were the only ones that were certified according to the standard ISO 17025 to test air conditioners according to the EN14511 standard.

Eurovent-Certification concludes on the basis of this survey, that the uncertainty of the measurement of cooling and heating capacities of an air conditioner or a heat pump by a recognised independent laboratory is fully within the maximum uncertainty required by the testing standard EN 14511-3, which is 5 %. Following these outcomes Eurovent-Certification proposes to set the requirements for tolerance to 8 % in order to prevent unjustified upgrading of energy classes.

Round-robin test by CECED

A similar test was organized with CECED that included 5 laboratories and two units, a single duct and a mono-split air conditioner. Concerning tolerances of the EN 14511 standard, the conclusions are,

"for the split test:
- Considering the Total Cooling Capacity (TCC) the difference between the maximum and the minimum value is 13.16%.
- In two cases the difference between the value and the average are more than 5% (+5.52%, -7.11%).
- Considering the Power Input (PI) the difference between the maximum and minimum value is 5.12%.
- Considering the Energy Efficiency Ratio (EER) the difference between that maximum and the minimum value is 11.16%.
- In one case the difference between the value and the average are more than 5% (-7.04%).
- We can have different classes: in one case the class is E, in the other cases the class is D.
- If we do not consider the Laboratory n° 2, the results are much more close.
- If we consider the average value as the "real value" the differences of the tests are within the tolerances permitted by the standard."

"for the single-duct test:
- Considering the Total Cooling Capacity, measured during the 27/27 test, the difference between the maximum and minimum value is 8.43 %.
- In one case the difference between the value and the average is more than 5% (+5.25%).
- We can have different classes: in two cases the class is F, in the other three cases the class is E.
- The differences between the value measured during the 35/35 test are a little bit lower.
- If we consider the average value as the "real value" the differences of the tests are within the tolerances permitted by the standard."

As a consequence, CECED advises "that standards of calibration and verification of air conditioning laboratories shall be developed in order to ensure to manufacturers and control authorities testing facilities able to provide comparable end reliable results".

However, to our knowledge, amongst the 5 laboratories, only 3 were certified according to the ISO 17025 standard for testing performances according to the EN14511 standard. Hence, these results do not show the tolerances could not be reduced for certified laboratories, but show that whether non certified laboratories are picked up for market surveillance by Member States, this may lead to some complications.
Hence, the final conclusion is that energy labelling of the units and market control should be achieved only in laboratories certified according to the ISO 17025 laboratory accreditation standard for testing according to the EN 14511 standard.

EN TS14825 -2003: Testing and rating at part load operation

This technical specification has the same scope as the EN14511 standard since it was first intended that this technical standard be the part 5 of the EN14511 standard but was set as technical standard because of the lack of data and experience. It is now being revised by the CEN/TC113/WG 7.

This standard defines a test at 50 % reduced capacity at the rated conditions defined in the EN14511 standard, part 2. It does not refer specifically to standard rating conditions but is generic. This standard does not consider variations of outside temperature (called reduced temperature) as in ARI 210/240 standard, nor system reduced capacity, which is for instance obtained when one inside unit over two of a bi-split system is switched off.

Inlet temperatures at both evaporator and condenser are maintained constant. For air to air and water to air units, the evaporator fan flow rate should be maintained. In case it is controlled by the unit, it must be let free to operate. The static pressure is maintained to the same value as at full load in case of ducted units.

Test methods are then defined according to the technology of capacity control.

ON-OFF unit
Units with only one compressor cycle the compressor On and Off to adapt their capacity to the required building load. In order to test the 50% EER or COP of this type of control, two methods are allowed:
- whether to force the cycling of the unit for ON periods of 30 minutes and ON periods of 30 minutes,
- whether to opt for a reduced compensation load method (dynamic testing method), where applicable.

Capacity staged units
Units with step controlled variable capacity adapt their capacity to the required building load by adaptation of the stage activated. In order to test the 50% EER or COP of this type of control, two methods are allowed:
- whether to force the operation at the step which is nearest to 50% of the rated capacity, the unit shall operate continuously during the reduced capacity test. The only discontinuity allowed is the defrost cycle for the reduced capacity test of a heat pump. The reduced capacity must lie in the range of 47 % to 53 %. If not, supplementary tests are performed.
- whether to opt for a reduced compensation load method (dynamic testing method).

Continuously controlled variable capacity (applies to inverter drive units)
Units with continuous controlled capacity, as inverters, adapt their capacity to the required building load by adaptation of the frequency of the drive of the inverter (other technologies exist, digital scroll® technology, slide valve for screw chillers ...).

In order to test the 50 % EER or COP of this type of control, two methods are allowed:
- whether to force the operation to the nearest reduced capacity as possible as 50% of the rated capacity; the unit shall operate continuously during the reduced capacity test. The only discontinuity allowed is the defrost cycle for the reduced capacity test of a heat pump. The reduced capacity must lie in the range of 47 % to 53 %. If not, supplementary tests are performed.
- whether to opt for a reduced compensation load method (dynamic testing method).

In the three cases, the uncertainty of measurement should remain inferior to 5 % for EER and COP at 50% capacity. It can be a problem for very small capacity units when reduced capacity is as low as 1 or 1.5 kW. Moreover, the uncertainty of measurement in cycling conditions or using the compensation load method is not known.

EN 15218-2006 'Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements'

This standard has been submitted to formal vote in August 2006. It is dedicated to evaporatively cooled air conditioners for space cooling having their condenser cooled by air and by the

evaporation of external additional water. Inside dry and humid bulb temperatures are compatible with the EN14511 standard. This standard defines the water temperature to be used for those tests according to its origin:
- for evaporatively cooled condenser air conditioner with continuous water supply circuit, a single water temperature of 15 °C is used,
- for evaporatively cooled condenser air conditioner with a water tank, water temperature is set to 35 °C for air-to-air air conditioners.

Air conditioners evaporating the indoor condensates at their condenser are excluded (included in the EN 14511 standard) since the water has to be "external", except if they have a water tank that can be filled in also with external water.

1.2.2.3 Full load performance test standards in third countries

An important number of countries have developed testing standards for rating cooling capacity and energy efficiency of air conditioners. According to specific legislative habits, standards may include not only temperatures and other test characteristics definitions but also capacity ranges, tolerances on testing results, labelling schemes or MEPS requirements as well as noise testing or even refrigerant legislation.

As stated above, most countries use the T1 condition of the ISO 5151 and 13253 standards to compare the energy efficiency of air conditioners, with sometimes minor modifications. The complete list of these countries has been extracted from the APEC-ESIS website and is reported hereunder (information may not be up to date). In order to make test results following different standards, APEC also prepared a report on how to EERs and COPs do compare when tested in standards with conditions that differ from the T1 conditions (Henderson, 2001).

Table 1-30: Test standards used for air conditioners in economies with existing standard/label program, source APEC-ESIS

COUNTRY	TEST STANDARDS	TYPE OF AC (APEC ESIS)	REFERENCE
Australia	AS/NZS 3823.1.1-1998	RACs split	ISO 5151
Australia	AS/NZS 3823.1.2-2001	RACs split	ISO 13253
Brazil	RESP/003-CAD	RACs Window	ISO 5151
Canada	CAN/CSA-C 368.1-M90	RACs Window	ISO 5151
Canada	CAN/CSA-C 744-93	RACs package terminal	ARI 310/380+93
Canada	CAN/CSA C 656-M 92	Central AC and heat pumps	ARI 210/240
Canada	CAN/CSA-C 273.3-M 91	Central AC split type	ARI 210/240
China	GB/T 7725-1996	RACs Window	ISO 5151
Chinese Taipei	CNS 3615-95	RACs Window	ISO 5151
Egypt	NT 81.133	RACs split	ISO 5151
Ghana	GS362: 2001	RACs split	ISO 5151
Hong Kong, China	ISO 5151	RACs Window	ISO 5151
Indonesia	ISO 5151	RACs Window	ISO 5151
Japan	JIS B 8616	RACs Window	ISO 5151-94 and ISO 13253-95
Japan	JIS C 9612	RACs Window	ISO 5151
Japan	JIS B 8615-1	RACs Window	ISO 5151
Japan	JIS B 8615-2	RACs package terminal	ISO 13253
Mexico	NOM-011-ENER-2002	Central AC Packaged Terminal	ANSI/ASHRAE-37-88
New Zealand	AS/NZS 3823.1.1-1998	Central AC and heat pumps	ISO 5151
New Zealand	AS/NZS 3823.1.2-2001	Central AC and heat pumps	ISO 13253

Philippines	PNS 240:1998	RACs Window	ISO 5151
Republic of Korea	KS C 9306-2002	RACs Window	ISO 5151
Russia	GOST 26963-86 (revised 1989)	Central AC split type	?
Saudi Arabia	SASO 386/1999	RACs Window	?
Singapore	SS CP24	RACs Window	ISO 5151
Singapore	ISO 5151	RACs split	ISO 5151
Thailand	TIS 1155-2536	RACs Window	ISO 5151
Venezuela	COVENIN 3537	RACs Window	US ANSI/AHAM
Venezuela	COVENIN 3560	RACs Window	US ANSI/AHAM
Viet Nam	TCVN 6576:1999	RACs Window	ISO 5151

1.2.2.4 Seasonal performance standards

Existing seasonal performance standards

Three economies have developed specific testing standards for seasonal performances of air to air conditioners. The USA have developed the first standard, and more recently Japan and Korea has developed such a standard, with formats similar to the American one. China is also planning to develop such a rating procedure but no further information has been identified until now. Another relevant standard for this study is the industry Eurovent standard for chillers. Whether it was designed for all European chillers (less centrifugal), it is also used for small chillers. Moreover, the seasonal method used is different than for air to air units.

The USA have been the leader in the adoption of seasonal efficiency as an indicator of energy efficiency, in cooling and in heating modes. Japan and now Korea have followed. Since it enables to include the impact on performances of temperature variations and heating and cooling load variations, seasonal performance indicators may give a better view on the real efficiency of the products on field than do standard EER and COP at full load in standard conditions and above all enable a comparison of energy performances of the products including more parameters that have an impact on energy performance.
Seasonal energy efficiency ratios would then allow to help the development of more efficient technologies at lower loads, as inverter or capacity staged units that have already important market shares in Europe. (Eurovent, 2006) reports market shares higher than 30 % for inverter driven compressors for the split air conditioners market in 2005. Moreover, it should also enable to achieve higher energy efficiency gains at lower investment costs (ECCJ, 2006) and then to open for higher energy efficiency targets. Since stakeholders have expressed their interest in developing such an approach, Lot 10 study will follow and help to the development of this type of indicator by CEN/TC113/WG7 that should end up with a draft for an harmonised European standard at the end of 2007. The standards that are described hereafter not only give a calculation method but also are also based on, existing testing procedures to make the standard operational. General standards as the CEN standard prEN 15316-4-2 to compute seasonal performances of heat pumps or the UNI 11135 standard, that do not give nor average operating conditions, nor test points or methods are not considered here.
It should also be noted that in the absence of a seasonal performance test standard, it could be useful to distinguish inverter air conditioners to avoid they be penalised at standard rating conditions (T1 condition and full load) because of the inverter efficiency whereas on the seasonal or yearly basis it could be a BAT, see (Adnot, 1999) for a literature review on inverter driven air conditioners (to be updated in the technical analysis of products of task 4.

Principles

According to the cooling and/or heating needs required, air conditioners adapt their capacity to match the energy that is to be added or removed from the building. The ratio between the energy needed and the capacity of the air conditioner for specific source conditions is called load ratio.
In practice, air flow rates are controlled by the air conditioner and then their value is not specified in the testing conditions of seasonal performance standards.

For air to air conditioners, annual energy consumption will vary with:
- in cooling mode: outdoor air temperature, inside air temperature and humidity, cooling load, stand-by energy consumption,
- in heating mode: outdoor air temperature and humidity, indoor air temperature, heating load, stand-by energy consumption.

Stand-by energy consumption is not accounted for in any of the available standards: only the period with energy requirement are considered to set up seasonal efficiency ratios.

Establishing the conditions of operation is not straightforward because the relationship between the outdoor and indoor conditions and the thermal load depends on the building characteristics, on the size of the apparatus as compared to the maximum thermal needs. For all seasonal performance standards, it is supposed than internal air temperature (and humidity ratio) can be maintained by the unit. A second simplification is made in the heating mode: the outdoor humidity ratio is supposed to follow the one of the H1, H2 and H3 points, independently of the given climate considered.

Thus, all standards are simply based on **a load curve** (annual occurrence of outdoor temperature and thermal load) and a sizing coefficient. A relationship between load required and outdoor temperature is generally established to define the conditions to compute energy efficiency. Then, the hours of occurrence of each couple (load, outdoor air temperature) are summed in order to calculate weighting factors of the different efficiencies.

Then, **performances of the units** have to be established for the different conditions of use (couples temperature and load). This can mix **testing and default modelling hypothesis** in order to reduce the number of testing points depending on the standards and the representation of the load curve chosen (more or less operating points to summarise yearly operations).

USA: ARI 210/240 – 2006, Central air conditioners and heat pumps - Performance rating of unitary air-conditioning and air-source heat pump equipment

<u>Scope</u>
A central air conditioner or heat pump is defined as a ‘product other than a packaged terminal air conditioner, which is powered by single phase electrical current, air cooled, rated below 65000 Btu/h (19.05 kW), not contained within the same cabinet as a furnace, the rated capacity of which is above 225000 Btu/hr and is a heat pump or cooling only unit’. This definition includes split-packaged (single and multi split) room air conditioners, cooling only and reversible. The official US test procedure is contained in DOE regulations Code of Federal Regulations 430 Appendix M. Test method for measuring the energy consumption of central air conditioners is the ARI 210/240-2006. The cooling and heating capacities, power input and energy efficiency ratio(s) are measured according to the method in ASHRAE-37-1988 *Methods of testing for rating unitary air conditioning and heat pump equipment.*

<u>Temperature and load conditions</u>

Cooling mode

A single load curve, representative of a typical building in a given climate, is used to represent the cooling period climate of the whole USA to compute the SEER (seasonal energy efficiency ratio).

The building cooling load is assumed to be a straight line function of outdoor air temperature. The sizing hypothesis is that at full load and outdoor air temperature of 95 °F (35 °C), the cooling capacity of the air conditioner is 110 % of the cooling needs, which is translated in the equation below:

$$BL(T_j) = \frac{T_j - 65}{95 - 65} \frac{P_c(FL, Rating)}{1.1}$$

with the following notations:
- Tj: temperature axis is discretized by intervals of 5 °F (about 2.8 °C)
- BL(Tj): building load for temperature of bin j in kW
- Pc(FL, rating): rated cooling capacity (P for power) at full load (FL), identical to ISO T1 condition, in kW.
- 65 °F = 18.3 °C ; 95 °F = 35 °C

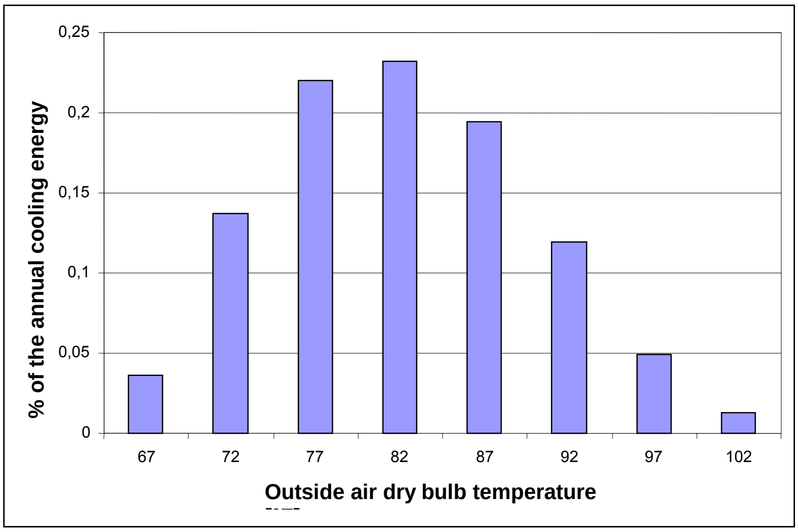
In order to be able to average the efficiency at different (load, temperature) conditions, hours of occurrence of each outdoor temperature during the cooling season are added for each of the bin intervals and the median temperature of the interval bounds is kept as representative.

Table 1-31: Distribution of fractional hours within cooling season temperature bins, ARI 210/240

Bin Temperature Range [°F]	**Representative temperature for bin °F | °C**		**Fraction of total temperature bin hours**
65-69	67	19,4	0.214
70-74	72	22,2	0.231
75-79	77	25,0	0.216
80-84	82	27,8	0.161
85-89	87	30,6	0.104
90-94	92	33,3	0.052
95-99	97	36,1	0.018
100-104	102	38,9	0.004

By multiplying cooling load (kW) by the fractional hours of operation ($\frac{n_j}{N}$, with N: number of hours with cooling operation and n_j: number of hours with cooling operation in temperature bin j), one can get an idea of the energy spent at each temperature level (or equivalently each load ratio).

Figure 1-2: Cooling energy needs as a function of outdoor air temperature, ARI 210/240



Hence, for standard SEER rating, energy is spent in average for an outdoor air temperature of about 82 °F (27.8 °C) and 52 % load.

Heating mode

The principle is similar in the heating mode. As opposed to the cooling conditions, heating conditions vary following 6 climatic zones whose main characteristics are reported below. This enables to take into account different outdoor design temperatures. Nevertheless, only the heating seasonal performance factor of the zone IV has to be published in the ratings; it is then the value used for comparison amongst several units and likely to be the design condition for reversible air conditioners HSPF.

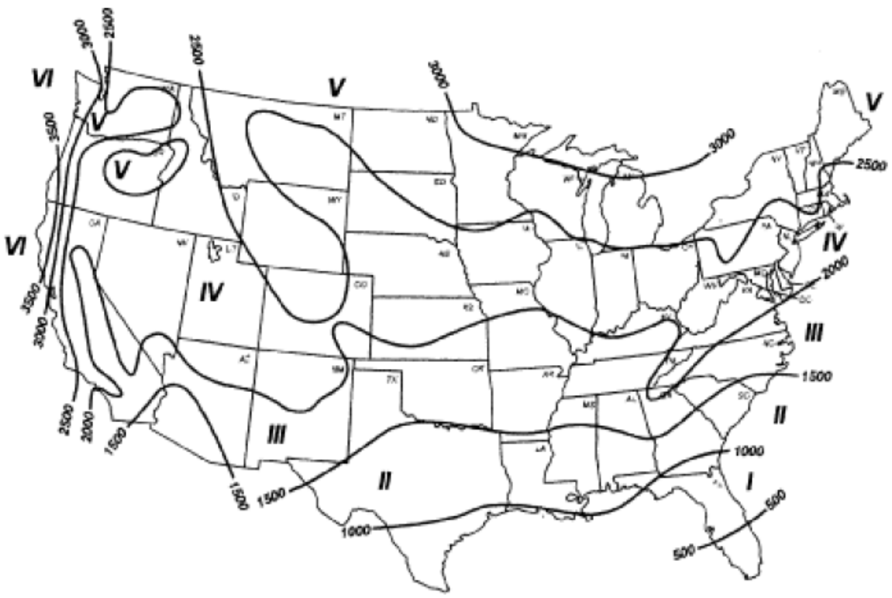


Table 17. Generalized Climatic Region Information

Region Number	I	II	III	IV	V	VI
Heating Load Hours, HLH	750	1250	1750	2250	2750	*2750
Outdoor Design Temperature, T_{OD}	37	27	17	5	-10	30
j Tj (°F)	Fractional Bin Hours n_j/N					
1 62	.291	.215	.153	.132	.106	.113
2 57	.239	.189	.142	.111	.092	.206
3 52	.194	.163	.138	.103	.086	.215
4 47	.129	.143	.137	.093	.076	.204
5 42	.081	.112	.135	.100	.078	.141
6 37	.041	.088	.118	.109	.087	.076
7 32	.019	.056	.092	.126	.102	.034
8 27	.005	.024	.042	.087	.094	.008
9 22	.001	.008	021	.055	.074	.003
10 17	0	.002	.009	.036	.055	0
11 12	0	0	.005	.026	.047	0
12 7	0	0	.002	.013	.038	0
13 2	0	0	.001	.006	.029	0
14 -3	0	0	0	.002	.018	0
15 -8	0	0	0	.001	.010	0
16 -13	0	0	0	0	.005	0
17 -18	0	0	0	0	.002	0
18 -23	0	0	0	0	.001	0

* Pacific Coast Region.

Figure 1-3: Heating climatic zones characteristics in the USA, ARI 210/240

The building load is a straight line versus outdoor air temperature with heating beginning when outdoor temperatures falls below 65 °F (18.3 °C).

$$BL(T_j) = \frac{(65 - T_j)}{65 - T_{OD}}.C.DHR$$

"C = 0.77, a correction factor which tends to improve the agreement between calculated and measured building loads, dimensionless." (ARI 210/240, 2006).

T_{OD} is the outdoor design temperature and depends on the climatic zone; for zone IV, it is 5 °F (-15 °C).

"Design Heating Requirement (DHR) is the amount of heating required to maintain a given indoor temperature at a particular outdoor design temperature." (ARI, 210/240). For the purpose of legislation, it is generally the minimum authorized value which is kept because of higher HSPF values and then:

$$BL(T_j) = \frac{(65 - T_j)}{60}.C.Q_H^{rated}$$

The rated heating capacity at full load (the source conditions are slightly different from the ISO 5151 H1 test point, outdoor 8.3 °C DB and 6.1 °C WB, indoor 21.1 °C DB and maximum 15.6 °C WB).

This equation translates a zero heating need balance point for 65 °F (18.3 °C) and a correction factor C that is a simplified manner to take into account internal gains indoor (solar, lighting, ..).
Temperatures in °F correspond to the following temperatures in °C:
37 °F= 2.8 °C
30 °F= -2 °C
27 °F= -2.8 °C
17 °F= -8.3 °C
5 °F= - 15 °C
-10 °F= -23.3 °C

In order to be able to average the efficiency at different (load, temperature) conditions, hours of occurrence of each outdoor temperature during the heating season are added for each of the bin intervals and the median temperature of the interval bounds is kept as representative, see Figure 1-3.

By multiplying heating load (kW) by the fractional hours of operation ($\frac{n_j}{N}$, with N: number of hours with heating operation, and n_j: number of hours with cooling operation in temperature bin j), one can get an idea of the energy spent at each temperature level (or equivalently each load ratio). For the heat load calculation, we refer only to zone IV, used for legislation. Heat load and repartition of energy are reported below. For heating load, percentages refer to the rated heating capacity at full load.

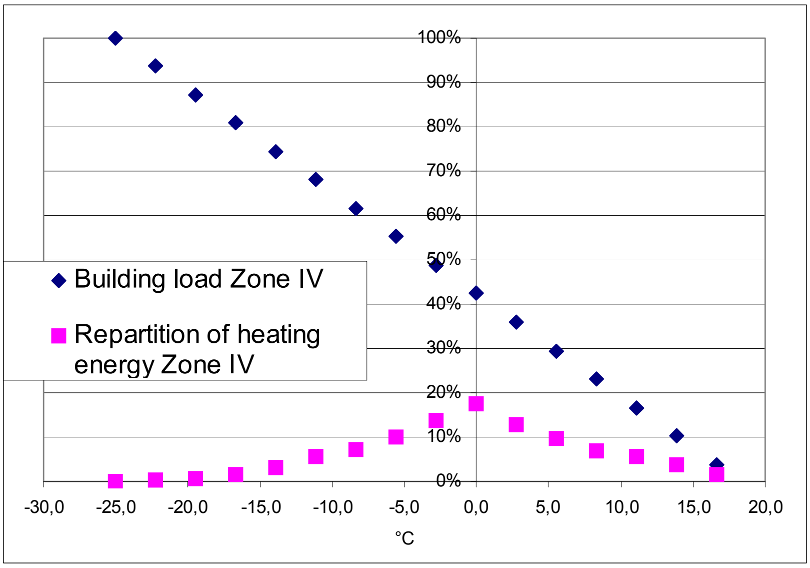


Figure 1-4: Heating load in percent of rated capacity and repartition of heating energy as a function of outdoor air temperature, adapted from ARI 210/240

Hence, for standard HSPF rating, energy is spent in average for an outdoor air temperature of about 32 °F (around 0 °C) and 42 % load (100 % load refers to rated capacity) and resistance heating is required at lower outdoor air temperatures.

<u>Computing seasonal and yearly performance</u>

Cooling mode: SEER

For each temperature (median temperature of the intervals of 5 °F), a given load ratio is associated via the building load straight line. Testing and modelling the performances of the unit for these different points enable to compute electric power for each one of these conditions. Then, the SEER is calculated as shown below by calculating the ratio of the energy delivered to the electric energy consumption.

$$\mathrm{SEER} = \frac{\sum_{j=1}^{8} \frac{q(T_j)}{N}}{\sum_{j=1}^{8} \frac{e(T_j)}{N}} \qquad (1)$$

T_j are the eight temperature bins defined in ARI 210/240 (section 2.12.1). For each temperature bins, two terms must be calculated:

$\frac{q(T_j)}{N}$: bin weighted net cooling loads with $\frac{q_c(T_j)}{N} = BL(T_j).\frac{n_j}{N}$

$\frac{e(T_j)}{N}$: bin weighted energy consumptions with $\frac{e_c(T_j)}{N} = \dot{Q}_e(T_j, X(T_j)).\frac{n_j}{N}$

Where X(Tj) is the load ratio for temperature in bin j: the ratio of the building load required to the cooling capacity of the air conditioner. The introduction of this factor enables to introduce the effect of part load in computing seasonal performances. $\dot{Q}_e$ and $\dot{Q}_c$ respectively refer to the electric power and to the cooling power (or capacity) of the unit.

Heating mode: HSPF

In heating mode, the computation of HSPF is similar except it accounts the heating delivered and the energy consumed by auxiliary resistive elements (RH(Tj): electric resistance power when operating below the balance point. This condition occurs when the building load exceeds the space heating capacity of the heat pump condenser.

$$HSPF = \frac{\sum_{j=1}^{...} BL(T_j)\frac{n_j}{N}}{\sum_{j=1}^{...}\left(\dot{Q}_e(T_j, X(T_j)) + RH(T_j)\right)\frac{n_j}{N}}$$

Annual performance factor: APF

Once computed SEER and HSPF (for a given zone), a formula makes it possible to compute regional annual performance factors (APFr) with the equation below and by using the reference cooling load hours CLHr and heating load hours HLHr reported below, that are equivalent full load hours.

$$APF = \frac{CLHr.Pc(rating) + HLHr.C.DHR}{\frac{CLHr.Pc(rating)}{SEER} + \frac{HLHr.C.DHR}{HSPF}}$$

Table 1-32: Heating and cooling load hours of USA climatic zones, ARI 210/240

Table 19. Representative Cooling and Heating Load Hours for Each Generalized Climatic Region

Region	CLH_R	HLH_R
I	2400	750
II	1800	1250
III	1200	1750
IV	800	2250
V	400	2750
VI	200	2750

Testing and modelling to compute performances for different (load, outdoor temperature) couples

In order to calculate the performances of the unit for each one of the bins, corresponding outdoor air temperature and humidity, (indoor air conditions are fixed) and load ratio, methods are separated by technology of air conditioners and heat pumps. The general principle is to build, with a few testing points, performance curves of the units. These performance curves give the cooling and heating capacity and the electric consumption as a function of outdoor air conditions for different capacity levels of the air conditioners (two capacity steps, minimum or maximum speed of an inverter …). As a consequence, the following paragraphs are split by technology type of capacity control.

Cooling mode

- Units with single speed compressor

Only two testing points are required, A and B in the table below. C and D points are optional, they are used to compute the coefficient of degradation of energy efficiency with decreasing load rates, which is supposed to be a straight line with shape factor equal to the coefficient C_D^c. Whether supplementary tests are performed, C_D^c can be computed, or alternatively a default value of 0.25 is kept.

Table 1-33: Single speed compressor test conditions in cooling mode, ARI 210/240

Test description	Air Entering Indoor Unit Temperature (°F)		Air Entering Outdoor Unit Temperature (°F)	
	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb
A Test—required (steady, wet coil)...	80	67	95	75 [1]
B Test—required (steady, wet coil)...	80	67	82	65 [1]
C Test—optional (steady, dry coil)....	80	(3)	82	....
D Test—optional (cyclic, dry coil)....	80	(3)	82	....

Notes:

(1) The specified test condition only applies if the unit rejects condensate to the outdoor coil.

The following simplified formula is used to compute the SEER: 82 °F and about 50 % load is the peak of the cooling needs distribution as reported before.

$$SEER = EER_B . PLF(0.5)$$

$$PLF(0.5) = \left(1 - 0.5.C_D^{\,c}\right)$$

With:

- EER_B = net steady-state efficiency (Btu/Wh) at the ARI B rating point
- PLF(0.5) = degradation of EER at 50 % load ratio

- Units with two capacity steps

Four testing points are required, the two cyclic testing points still being optional. As shown in the table below, 2 tests are required at full capacity for two different outdoor air temperature and two other tests on the smaller capacity step for the same temperature level.

Figure 1-5 gives shows the load curve and the capacity of the two stages of the air conditioner that vary with outdoor air temperature. The supposed linear variation is computed for each capacity stage thanks to the two testing points, hence capacity and electric power of each stage may be computed for a different temperature of the ones tested with the following formula (for capacity, with k =1 or 2).

$$\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(82) + \frac{\dot{Q}_c^{k=1}(95) - \dot{Q}_c^{k=1}(82)}{95-82}(T_j - 82)$$

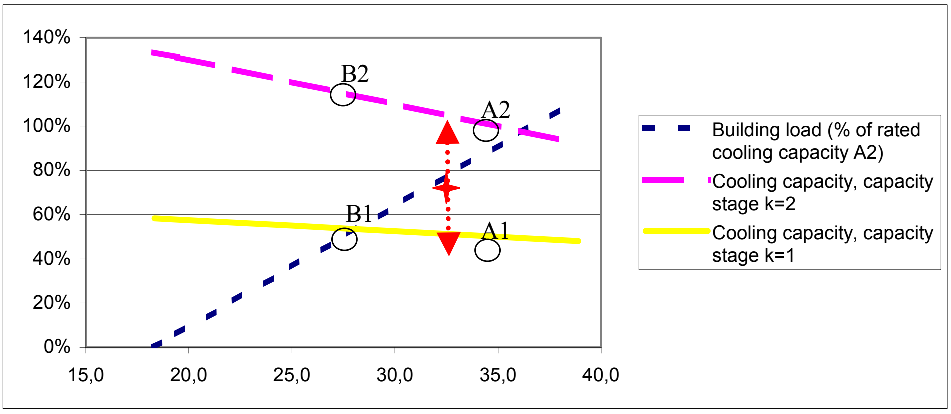
Table 1-34: Two-Capacity compressor test conditions in cooling mode, ARI 210/240

Test description	Air Entering Indoor Unit Temperature (°F)		Air Entering Outdoor Unit Temperature (°F)		Com-pressor Capacity
	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb	
A_2 Test—required (steady, wet coil)........	80	67	95	75 (1)	High
A_1 Test—required (steady, wet coil)........	80	67	95	75 (1)	Low
B_2 Test—required (steady, wet coil)........	80	67	82	65 (1)	High
B_1 Test—required (steady, wet coil)........	80	67	82	65 (1)	Low
C_1 Test (4)—optional (steady, dry coil).....	80	(4)	82	....	Low
D_1 Test (4)—optional (cyclic, dry coil)	80	(4)	82	....	Low

Notes:

(1) The specified test condition only applies if the unit rejects condensate to the outdoor coil.

Figure 1-5: Illustration of the procedure to compute SEER of a two steps air conditioner, ARI 210/240



In order to compute the electric power for a specific couple (Tj, BL(Tj)), two cases may occur.

- The building load $BL(T_j)$ is lower than the steady state capacity at low speed $\dot{Q}_c^{k=1}(T_j)$.

The cooling load factor for this temperature bin is defined as:

$$X^{k=1}(T_j)=\frac{BLT(T_j)}{\dot{Q}_c^{k=1}(T_j)} \qquad (2)$$

As for single speed air conditioner, cycling loss is modelled by PLF and C_D^c coefficient. The cooling capacity supplied equals to the building load while the electric power is increased by the cyclic degradation.

$$\frac{q_c(T_j)}{N}=X^{k=1}(T_j).\dot{Q}_c^{k=1}(T_j).\frac{n_j}{N} \quad \text{and} \quad \frac{e_c(T_j)}{N}=\frac{X^{k=1}(T_j).\dot{E}_c^{k=1}(T_j)}{PLF_j}.\frac{n_j}{N}$$

- The building load $BL(T_j)$ lies between than the steady state capacity of lower and higher stages.

In this configuration, the appliance cycles between the two stages to supply the required cooling capacity. Cooling capacity supplied by each stage can be computed as a simple barycentre:

$$X^{k=1}(T_j)=\frac{\dot{Q}_c^{k=2}(T_j)-BLT(T_j)}{\dot{Q}_c^{k=2}(T_j)-\dot{Q}_c^{k=1}(T_j)} \qquad \text{and} \qquad X^{k=2}(T_j)=1-X^{k=1}(T_j)$$

Electric power is then calculated as:

$$\frac{e_c(T_j)}{N} = \left[X^{k=1}(T_j).\dot{E}_c^{\,k=1}(T_j) + X^{k=2}(T_j).\dot{E}_c^{\,k=2}(T_j) \right] \frac{n_j}{N}$$

- Inverter driven units

The 5 tests required are presented in the table below. Intermediate frequency of test E_v is defined as: Intermediate speed = Low speed + (High speed – low speed)/3.
These tests enable to calculate the laws of variation of cooling capacity and electric power at low speed (B1, F1) and high speed (A2, B2). For intermediate frequency, law of performance evolution is computed from the two preceding performance curves.

Table 1-35: Inverter compressor test conditions in cooling mode, ARI 210/240

Test Description	Air Entering Indoor Unit Temperature		Air Entering Outdoor Unit Temperature		Compressor Speed
	Dry-Bulb °F °C	Wet-Bulb °F °C	Dry-Bulb °F °C	Wet-Bulb °F °C	
A_2 Test - required (steady, wet coil)	80.0 26.7	67.0 19.4	95.0 35.0	75.0(1) 23.9(1)	Maximum
B_2 Test - required (steady, wet coil)	80.0 26.7	67.0 19.4	82.0 27.8	65.0(1) 18.3(1)	Maximum
E_V Test - required (steady, wet coil)	80.0 26.7	67.0 19.4	87.0 30.6	69.0(1) 20.6(1)	Intermediate
B_1 Test - required (steady, wet coil)	80.0 26.7	67.0 19.4	82.0 27.8	65.0(1) 18.3(1)	Minimum
F_1 Test - required (steady, wet coil)	80.0 26.7	67.0 19.4	67.0 19.4	53.5(1) 11.9(1)	Minimum
G_1 Test(5) - optional (steady, dry coil)	80.0 26.7	(5)	67.0 19.4	—	Minimum
I_1 Test(5) - optional (cyclic, dry coil)	80.0 26.7	(5)	67.0 19.4	—	Minimum

Notes:

(1) The specified test condition only applies if the unit rejects condensate to the outdoor coil.

The only difference with the calculation method for two capacity steps units, is when the building load $BL(T_j)$ lies between than the steady state capacity of lower and higher stages (minimum and maximum compressor speed). It is assumed the energy efficiency ratio for cooling capacity that matches the building load in that interval can be expressed as a second order polynomial equation as follows:

$$EER^{k=i}(T_j) = A + B.T_j + C.T_j^2$$

In order to compute coefficients A, B and C, it is first necessary to identify the three points of interpolation between cooling capacity lines and the building load curve for the 3 frequencies.

Heating mode

There are 4 main differences with the cooling mode, to account for frost, for backup resistive electric heating and for backup resistive heating in case of heat comfort controller.
+ It is assumed that frost appears in the outdoor air temperature range [17 ; 45 °F] ([-8.3 ; 7.2 °C]).

+ Backup heating is computed by comparing the building load and the capacity that the heat pumps may supply.
+ Also, since tests in frost and defrost conditions do not account for possible resistance heating that could be used to prevent a cold blow indoor (blowing cold air inside the room during cycle inversion), a correction is added to take into account the supplementary resistance heating. For those heat pumps with heat comfort controller, indoor air temperature cannot fall below a temperature threshold, determined by testing and noted T_{CC}. Mass air flow rate, computed from the rating test, is then used to add resistive heating needed to maintain T_{CC} for all temperatures T_j.
+ Whether the heat pump stops at low outdoor air temperature is also taken into account.

- Units with single speed compressor

The testing procedure requires to perform 3 tests at 47 °F, 35 °F and 17 °F. Heating capacity and electric power is modeled by a straight line defined by, test points at 17 °F and 45 °F outside the frost range, and test points at 17 °F and 35 °F inside the frost range. Hence, 3 tests are needed at full load and one more to challenge the default cycling coefficient of 0.25 in heating mode.

Table 1-36: Single speed compressor test conditions in heating mode, ARI 210/240

Test Description	Air Entering Indoor Unit Temperature				Air Entering Outdoor Unit Temperature			
	Dry-Bulb		Wet-Bulb		Dry-Bulb		Wet-Bulb	
	°F	°C	°F	°C	°F	°C	°F	°C
H1 Test (required, steady)	70.0	21.1	60.0(max)	15.6	47.0	8.3	43.0	6.1
H1C Test (optional, cyclic)	70.0	21.1	60.0(max)	15.6	47.0	8.3	43.0	6.1
H2 Test (required)	70.0	21.1	60.0(max)	15.6	35.0	1.7	33.0	0.6
H3 Test (required, steady)	70.0	21.1	60.0(max)	15.6	17.0	-8.3	15.0	-9.4

- Units with two capacity steps

The testing procedure requires to perform 4 tests at 62 °F, 47 °F, 35 °F and 17 °F for stage k = 1 and 3 tests at 47 °F, 35 °F and 17 °F for k = 2. Heating capacity and electric power is modeled by a straight line defined by, test points at 17 °F and 35 °F inside the frost range, test points at 17 °F and 45 °F below the frost range (and above for k = 2), and test points 45 °F and 62 °F above the frost range for k = 1. Hence, 7 tests are needed at full load and one more to challenge the default cycling coefficient of 0.25 in heating mode.

Table 1-37: Two-Capacity compressor test conditions in cooling mode, ARI 210/240

Test Description	Air Entering Indoor Unit Temperature				Air Entering Outdoor Unit Temperature				Compressor Speed
	Dry-Bulb		Wet-Bulb		Dry-Bulb		Wet-Bulb		
	°F	°C	°F	°C	°F	°C	°F	°C	
$H0_1$ Test (required, steady)	70.0	21.1	60.0(max)	15.6	62.0	16.7	56.5	13.6	Low
$H0C_1$ Test (optional, cyclic)	70.0	21.1	60.0(max)	15.6	62.0	16.7	56.5	13.6	Low
$H1_2$ Test (required, steady)	70.0	21.1	60.0(max)	15.6	47.0	8.3	43.0	6.1	High
$H1_1$ Test (required, steady)	70.0	21.1	60.0(max)	15.6	47.0	8.3	43.0	6.1	Low
$H2_2$ Test (required)	70.0	21.1	60.0(max)	15.6	35.0	1.7	33.0	0.6	High
$H2_1$ Test(4) (required)	70.0	21.1	60.0(max)	15.6	35.0	1.7	33.0	0.6	Low
$H3_2$ Test (required, steady)	70.0	21.1	60.0(max)	15.6	17.0	-8.3	15.0	-9.4	High
$H3_1$ Test(4) (required, steady)	70.0	21.1	60.0(max)	15.6	17.0	-8.3	15.0	-9.4	Low

- Inverter driven units

The testing procedure requires to perform 2 tests at 62 °F and 47 °F at minimum speed, 1 test at 35 °F and intermediate speed and 2 tests at 47 °F and 17 °F at maximum speed.
Hence, 5 tests are needed at full load and one more to challenge the default cycling coefficient of 0.25 in heating mode.
Whether maximum speed in heating mode is lower than the one in cooling mode, the $H1_N$ test if required by the manufacturer enables to increase the DHR (maximum capacity at design outdoor temperature).
Also, the manufacturer can either leads the $H2_2$ test or default vales are proposed to compute heating capacity and electric power: the performances at 35 °F are interpolated on the lines of heating capacity and electric power obtained from 17 °F and 47 °F and heating capacity is decreased of 10 % and electricity consumption by 1.5 % (COP decreases by 8,7 %).

Heating capacities and electric power are then modeled for minimum and maximum speed as for the two capacity step units for intermediary speeds. Intermediate speed performance curves (capacity and power) are deduced from these performance curves and the $H2_V$ measurement. Then, as in the cooling mode, COP of the unit when matching the building load with intermediate speed is supposed to be a polynomial equation of second order whose coefficients are computed from the 3 points defined by the intersections of performance curves at minimum, intermediate and high speeds with the building load curve.

Table 1-38: Inverter compressor test conditions in heating mode, ARI 210/240

Test Description	Air Entering Indoor Unit Temperature				Air Entering Outdoor Unit Temperature				Compressor Speed
	Dry-Bulb		Wet-Bulb		Dry-Bulb		Wet-Bulb		
	°F	°C	°F	°C	°F	°C	°F	°C	
$H0_1$ Test (required, steady)	70.0	21.1	60.0$^{(max)}$	15.6	62.0	16.7	56.5	13.6	Minimum
$H0C_1$ Test (optional, cyclic)	70.0	21.1	60.0$^{(max)}$	15.6	62.0	16.7	56.5	13.6	Minimum
$H1_2$ Test (required, steady)	70.0	21.1	60.0$^{(max)}$	15.6	47.0	8.3	43.0	6.1	Maximum
$H1_1$ Test (required, steady)	70.0	21.1	60.0$^{(max)}$	15.6	47.0	8.3	43.0	6.1	Minimum
$H1_N$ Test (optional, steady)	70.0	21.1	60.0$^{(max)}$	15.6	47.0	8.3	43.0	6.1	Cooling Mode Maximum
$H2_2$ Test (optional)	70.0	21.1	60.0$^{(max)}$	15.6	35.0	1.7	33.0	0.6	Maximum
$H2_V$ Test (required)	70.0	21.1	60.0$^{(max)}$	15.6	35.0	1.7	33.0	0.6	Intermediate
$H3_2$ Test (required, steady)	70.0	21.1	60.0$^{(max)}$	15.6	17.0	-8.3	15.0	-9.4	Maximum

Conclusion on the ARI 210/240 standard

The table below gives a summary of the minimum number of testing points required following the technological type of air conditioner.

Table 1-39: Number of testing points required and optional, ARI 210/240

ARI 210/240	SEER		HSPF		TOTAL	
Nb of testing points	Min	Max	Min	Max	Min	Max
Single speed compressor	2	4	3	4	5	7
Two capacity stages	4	6	7	8	11	14
Inverter	5	7	5	8	10	15

Following (Dougherty, 2002), with the high cycling default values, manufacturers do challenge the defaut cycling coefficient of 0.25.

Although it gives a better index of comparison than full load ratings in Europe, several criticisms have been raised in the last few years on this standard that can be found in (Kavanaugh, 2002), in (Fairey, 2004) and in (SEC, 2004).
In cooling mode:
- Since the standard offers only one climatic representation and that performances of the units are not published, calculation for a specific climate zone cannot be done ; anyway, SEER should not be used to compute energy consumption of a specific house (SCE, 2004).
- Putting requirement on SEER only implies that some units still have low EER (until 2.0) despite SEER increases and raises peak problems for electric utilities.
- Indoor air temperature, too high, does not reflect USA habits.
- To increase EER at low loads, manufacturers increase the evaporating temperature and decrease air flow rates, leading to lower dehumidification capabilities. Since individual performance ratings are not published, it is not possible for installers to design the air conditioner to properly ensure dehumidification.
- In real use, USA central air conditioners may also ensure ventilation and it is not taken into account in the ARI procedure (SEC, 2004).
And in heating mode:
- Despite the standard offers several climate zones, performances of the units are not published and then calculation for other climates than zone IV cannot be done, resulting in false previsions of energy consumption for other zones than zone IV.
- Climate zones and associated climate representation leading to underestimate resistive heating use, majoring final HSPF.
- Resistive backup is underestimated as compared to field surveys ; for houses equipped with night set-backs, backup is activated on cold morning to establish comfort conditions, leading to important strip heating use.
- Underestimation of resistive electric heating may skew the comparison with other heating modes.

Japan: Standards JRA: 4046 (JRA, 2004) - “Calculating method of annual power consumption for room air conditioners” and JRA: 4048 (JRA, 2006) - “Annual Performance Factor of Package Air Conditioners”

A new method to evaluate energy efficiency of room air conditioners has been recently adopted in the new Energy Conservation Law of Japan (ECCJ, 2006). This method that defines the “Annual Performance Factor (APF)” is described in the JRA standard “Calculating method of annual power consumption for room air conditioners” [JRA, 2004], for air conditioners primarily intended to residential use (cooling capacity < 10 kW and electric power < 3 kW) and [JRA, 2006] for package air conditioners (cooling capacity < 28 kW), for air conditioners primarily intended to commercial use.
These two standards adopt the same methodology as in the ARI 210/240 standard. The CSPF (Cooling Seasonal Performance Factor – American SEER) and HSPF, in combination with cooling hours and heating hours give the APF. Differences in scope, building load curve, climate, testing and modeling performances, are reported hereafter. It is to be noted that the APF will be used from now on to compare energy efficiency merits of air conditioners and reversible heat pumps in Japan, this value replacing the old COP (COP(rated) + EER(rated)) / 2.

<u>Residential air conditioners, [JRA, 2004]</u>
This standard specifies room air conditioners to be sold in the Japanese market, which are classified as single-package type or split-system type with a rated cooling capacity not exceeding 10 kW and a rated electric power consumption not exceeding 3 kW. Moreover only air conditioners with single speed compressor or variable speed compressor are in the scope of this standard. Units with double speed compressors or two capacity stages are not sold on the Japanese market.

The standard APF value is computed for Tokyo mild climate, even if 17 other Japanese climates are available in the standard.
The cooling and heating building load curves are also straight lines, defined by the following formulas, respectively in cooling and heating mode:
- the rated cooling capacity Φ_{BL} is supposed to be equal to the load for an outdoor air temperature of 33 °C and the load is zero for an outdoor air temperature of 23 °C; cooling capacity is then supposed undersized by a few percents at 35 °C.

$$BL_c(T_j) = \frac{T_j - 23}{33 - 23}.\Phi_{BL}$$

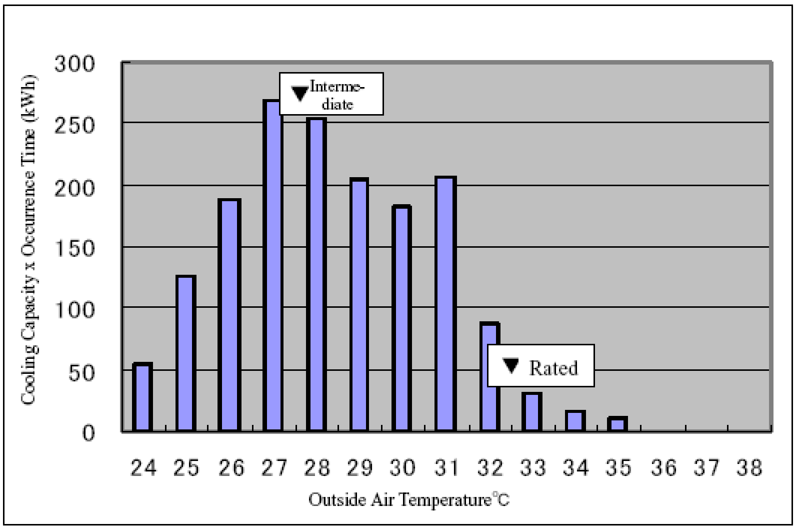


Figure 1-6: Repartition of cooling energy as a function of outdoor air temperature, (ECCJ, 2006)

To compute a number of hours of use, the cooling season is set as June-September in Tokyo and hours when outdoor temperature exceeds 24 °C are binned as a function of outdoor air temperature. The product of the number of hours and of the building load by temperature bin is represented above for the cooling season. The distribution average points is (54 % load, 28.4 °C).

- Heating load is zero at 17 °C outdoor and is equal to 1.025 times the rated cooling capacity at 0 °C outdoor (1.025 is the average ratio between heating capacity at 0 °C and the rated cooling capacity). Hence, the heat pump is sized for 0 °C outdoor.

$$BL_h(T_j) = 1.25.\Phi_{BL}.0.82\frac{17 - T_j}{17}$$

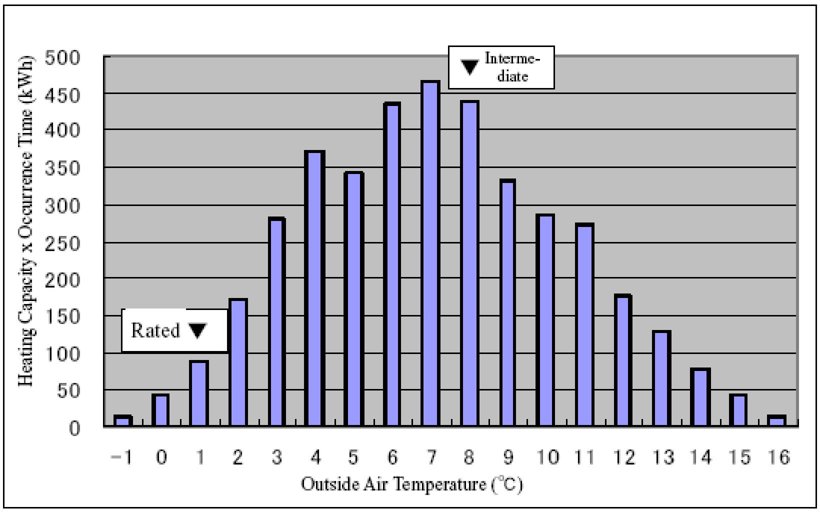


Figure 1-7: Repartition of heating energy as a function of outdoor air temperature, (ECCJ, 2006)

To compute a number of hours of use, the heating season is set as Nov- mid April in Tokyo and hours when outdoor temperature falls below 17 °C for heating (and above 24 °C for cooling) are binned as a function of outdoor air temperature. The product of the number of hours and of the building load by temperature bin is represented above for the cooling season. The distribution average points is around (60 % load, 7 °C). Interestingly, the sizing hypothesis is compatible for heating and cooling modes.

The number of testing points has been reduced as compared to the ARI 210/240 test standard. As opposed to the USA standard, ISO test conditions are used, ISO 5151 T1, H1, H2.

In cooling mode, for single speed units, the default C_D^C coefficient is set to 0.25 with no challenging test available. Performance curve of full load cooling capacity and power variation with outdoor air temperature is standardised by the following two relationships, that amounts to a 18 % increase for EER or 3 % increase by °C of outdoor temperature decrease.

$P_c(29\ °C)/P_c(35\ °C) = 1.077$ P_c: cooling capacity

$P_e(29\ °C)/P_e(35\ °C) = 0.914$ P_e: cooling power

Hence APF of these units is directly proportional to ISO 5151 full load EER with 13.5 % increase.
For variable speed units, only two tests are required, the ISO 5151 test and the "intermediary cooling capacity" test, whose percentage of reduced capacity is let free to manufacturers: this is an optimisation option let to manufacturers. Indeed, the lower the intermediary capacity, the lower the impact of cycling, but then intermediary efficiency may be lower than the maximum efficiency at reduced speed. As in the ARI 210/240 standard, performance curves are drawn by capacity stage (intermediary and full capacity). In both cases, performance curves are straight lines with the same laws of variation as for the single speed unit, EER increases by about 3 % for 1 °C outdoor dry bulb temperature decrease.
Hence, the only difference between APF of single speed and variable speed units is the effect of part load. Temperature effect, that corresponds to a 29.6 % increase of energy efficiency is not a competition factor between appliances.

In heating mode, the frost operation zone is considered to be between –7 °C and 5.5 °C. Outside this interval, performance curves are modelled by using the assumption that the average variation of heating capacity and electric power is the same for all appliances and is given by the following relationship, between H3 and H1 tests:

$P_H(-7\ °C)/\ P_H(7\ °C) = 0.64$ P_H: heating capacity

$P_e(-7\ °C)/\ P_e(7\ °C) = 0.82$ P_e: heating power

COP decreases by about 1.6 % for 1 °C outdoor dry bulb temperature decrease. There is also the possibility to add resistive electric heating. Nevertheless, for standard equipment and for Tokyo climate, there is no need for electric heating (assuming the following relationship between rated T1 cooling capacity and rated H1 heating capacity: $P_H(H1)=1.08*P_C+0.4$)[15] with balance point at about –3 °C.
For single speed heat pumps, only two tests are performed, H1 test and H2 test. Full load performance curves in the zone [-7 °C, 5.5 °C] are drawn from the H3 point (deduced from H1) and the H2 point. The default C_D^H coefficient is set to 0.25 with no challenging test available.
For variable speed heat pumps, there is only one supplementary test point at reduced capacity ("intermediate standard heating capacity") in H1 conditions. The full capacity performance curves are defined in the same manner as for single speed units. At reduced speed, the same coefficients of evolution of performance are used that at full load. The performances in frost conditions H2 at reduced speed are computed using the following relationship:

$P_{H,intermediate}(2\ °C)/\ P_{H\ intermediate}(7\ °C) = 0.78$ $P_{H\ intermediate}$: heating capacity at reduced speed

$P_{e\ intermediate}(2\ °C)/\ P_{e\ intermediate}(7\ °C) = 0.88$ $P_{e\ intermediate}$: heating power at reduced speed

This relationship translates a COP decrease of 8 % corresponding at the outdoor temperature decrease and a COP decrease of 4 % to take into account frost and defrost cycles impact. In

[15] Regression explained in task 4 and based on the Eurovent Certification online database, year 2006.

addition, variable speed reversible air conditioners are supposed to be able to operate at higher than rated speed to face peak heating requirements at low outdoor air temperature. Hence, a third high capacity stage is defined. It is defined by 2 default coefficients that translates heating capacity and power of this stage at –7 °C and 2 °C. Degradation of COP with outdoor air temperature of this stage is a bit higher than for other stages (1.8 % versus 1.6 %). Performance at 2 °C of this stage are defined as a function of the performances of the full load test in H2 conditions:

$P_{H,high\ speed}(2\ °C) / P_{H\ rated\ speed}(H2) = 1.12$ — $P_{H\ high\ speed}$: heating capacity at highest speed

$P_{e\ high\ speed}(2\ °C) / P_{e\ rated\ speed}(H2) = 1.06$ — $P_{e\ high\ speed}$: heating power at highest speed

This third stage favours inverter units as compared to single speed units since it enables to lower the balance point before needing addition of resistance heating by a few degrees.
The HSPF calculated with this method does not compare the units as regards to the effect of outdoor air temperature. Moreover, since average weighted outdoor air temperature for Tokyo is about 7 °C (7.14 °C) will not affect HSPF values. Only the effect of frost and part load will be compared, as well as the supplementary heat capacity available for variable speed units (in the case of other than the Tokyo climate).

With 583 hours of cooling and 1421 hours of heating, APF will increase by 8 to 10 % because of temperature effect (cooling mode operation at 28 °C) as compared to EER+COP / 2. APF will enable to include part load and defrost performances in addition to ISO T1 and H1 tests in previous index with the number of tests as shown in the table below.

<u>Package air conditioners, [JRA, 2006]</u>
As opposed to the previous standard, requirements for marking and for information to be included in the technical documentation of the air conditioner are described. Namely, all test results should be included in the technical documentation, which is very useful to installers. Whether the scope overlaps the one of the previous standard, it is likely that wall type air conditioners with cooling capacity lower than 4 kW be rated by the previous standard while higher capacity units and cassette types may be rated with this standard. The main difference is that building load curves and air conditioner use are specified for offices, stand-alone and tenant shops. Load curves in cooling and heating modes for standard [JRA, 2004] and these 3 building types are shown on the figure below.

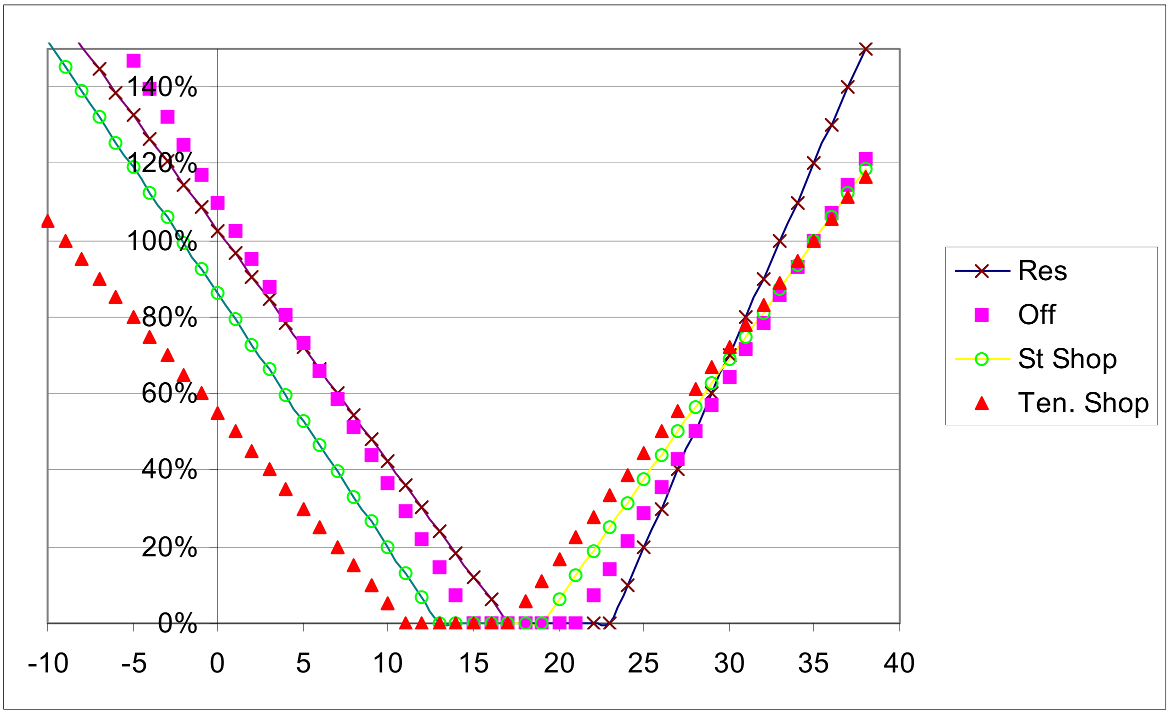


Figure 1-8: Building heating and cooling load, [JRA, 4046]and [JRA, 4048]

To compute hours of operation, opening and days schedule are set for the 3 types of buildings. Also a definition of the cooling and heating season is given for each of the buildings: "the cooling season starts from the day of the third-time occurrence of the mean day temperature is equal to or higher than 20 °C for stand-alone shops, 18 °C for tenant shops and 16 °C for offices and ends at the day of the third-time occurrence of the said temperature before the day when the said temperature is registered last." The same definition is applied for heating with respectively 12 °C, 10 °C and 8 °C. As for residential air conditioners, the default climate is also Tokyo.

Concerning testing and calculation for seasonal performances, the methodology is the same. Variable capacity units are treated as inverter units but the without allowance for extended operating range at low outdoor temperature in heating mode.
For multi-split units, different coefficients are to be used for the performance curves at intermediate speed or capacity in cooling mode and correction coefficients are supplied whether tests of indoor units are led in the same room instead of separate rooms.

Conclusions on the previous standard also apply to this standard for "package air conditioners".

Table 1-40: Number of testing points required and optional, JRA:4046 and JRA:4048

JRA:4046 and JRA:4048 Nb of testing points	CSPF Nb of testing points	HSPF Nb of testing points	APF Nb of testing points
Single speed compressor	1	2	3
Two capacity stages (JRA:4048 only)	2	3	5
Inverter	2	3	5

Korea

Room air conditioners and split air conditioners are covered by the standard KS C 9306 that aggregates the test standard, the rules for testing and rating of the seasonal performance factors, and the labelling of energy consumption and MEPS. It is not known whether this standard applies to all capacity ranges and which other products are included. The standard KS C 9306[16] defines the rating of room air conditioners, either package window type or non ducted split. Multi split are excluded. Rated cooling capacity ranges lower than 10 kW, and details the procedure for tests and calculations leading to the CSPF (Cooling Seasonal Performance Factor) and the HSPF factors. This development intends to support the development of efficient part load technologies.

CSPF : Cooling Seasonal Performance Factor
The ratio of the total cooling capacity to the total energy consumption for the two months of July and August, in Btu h^{-1} / W.
HSPF : Heating Seasonal Performance Factor
The ratio of the total heating capacity to the total energy consumption for the winter period, extending from October to February (5 months), in W / W.

Whereas CSPF is expressed in Btu h^{-1} / W, the calculation method is the same as in the [JRA, 2004] standard but adapted for the Korean climate (default climate being the Seoul one). Load curve for cooling is the same as for the residential standard in Japan [JRA, 2004]. In heating mode, zero load occurs at 16 °C and it is assumed than rated heating capacity equals to 1.39 times the rated cooling capacity and that this rated capacity equals the heating load when outdoor air temperature is – 4 °C.

Concerning testing and calculation of the seasonal performance index, method is the same as for the residential Japanese standard for single speed units, and the same as in the commercial standard

[16] The description of this part load performance test standard for Korea has been made available by LG.

(JRA, 2006) for two-steps and capacity modulation units. For inverter units, there is a slight difference in the conditions for testing at low temperature (not H3 conditions but –9.5 dry bulb and minus 8.5 WB). Moreover, there are three tests to be done in the cooling ISO T1 conditions and H1 conditions at minimum speed, standard speed and high speed. There is also a no frost test, but test condition is not known. The same coefficients as in the Japanese standard are used to calculate the performance curves for varying temperatures in cooling and in heating mode.
Hence, from available information, the Korean standard (as compared to the Japanese standards) seems to require more tests for the inverter units, 3 in cooling mode and 6 in heating mode. Testing points are presented in the following table, and is similar for single speed units but with other building and climate conditions.

Table 1-41: Test conditions for the determination of cooling and heating capacities, KS C 9306

	Cooling mode			**Heating mode**		
Type of capacity modulation	**Load**	**Air conditions (In/Out) DB / WB**		**Load**	**Air conditions (In/Out) DB / WB**	
Single speed compressor	Standard load	27/19.5	35/24	Standard load	20/15	7 / 6
				Defrosting	20/15	2 / 1
Capacity modulation & 2 stage compressor	Minimum load	27/19.5	35/24	Minimum load	20/15	7 / 6
	Standard load	27/19.5	35/24	Standard load	20/15	7 / 6
	-	-	-	Defrosting	20/15	2 / 1
Inverter compressor (Hz control)	Minimum load	27/19.5	35/24	Minimum load	20/15	7 / 6
				Middle load	20/15	7 / 6
	Middle load	27/19.5	35/24	Standard load	20/15	7 / 6
				Maximum load	20/15	-8.5/-9.5
	Standard load	27/19.5	35/24	Defrosting	20/15	2 / 1
				Defrosting (No frost)	20/15	2 / 1

Eurovent ESEER standard for chillers (Adnot, 2003)

The European SEER for Eurovent certified chillers, (air cooled and water cooled) was defined in the frame of the EECAC study (Adnot, 2003). Only seasonal efficiency in the cooling mode is assessed. The SEER figure is based on 4 points at 25%, 50%, 75% and 100% load for varied temperature conditions. For each point, the EER is calculated and then weighted by coefficients A, B, C and D (equation below). The coefficients represent the relative part of energy supplied by each of the four characterized steps of the chiller, they are non dimensional coefficient: % of design capacity*yearly occurrence in hour.

$$SEER = A.EER_{25\%} + B.EER_{50\%} + C.EER_{75\%} + D.EER_{100\%}$$

Table 1-42: Load curve and energy weighting coefficients, Eurovent ESEER (Adnot, 2003)

ESEER			
Part Load Ratio % of rated capacity	**Air cooled inlet temperature °C**	**Water cooled inlet temperature °C**	**Weighting coefficients**
100	35	30	3%
75	30	24	33%
50	25	22	41%
25	20	18	23%

To determine the four coefficients:

- representative load curves (simulated with the DO2 software) were determined by hourly building simulations using the DOE2 software; perfect sizing was performed (no oversizing coefficient);
- each load curve was reduced to four couples (temperature load).
- Based on the stock of chiller based systems, hourly load curves (four points) were aggregated to represent average European chiller operating conditions.

In order to establish the performance for each one of A, B, C and D points, the number of testing points will vary according to the capacity stages available for each specific chiller. In practice, Eurovent certifies the ESEER by testing two points in the table of performance supplied by the manufacturer for several condenser temperatures and capacity stages (with enough data to calculate the ESEER). This standard enables to compare products with different means of capacity reduction but also on performance at various inlet air or water temperature.

1.2.3 Refrigerant and Safety standards

Standards on safety are indirectly linked to the study as they could introduce some requirements that affect the design of the product, especially for the choice of the refrigerant fluid but are required by the MEEuP methodology. Refrigerant fluids might be toxic, inflammable or having a low potential of recycling thus refrigerating systems are the concern of many safety standards which imply material choice and construction requirements for the designer of the refrigerating system.

ISO 5149:1993 (2004) – "mechanical refrigerating systems used for cooling and heating – safety requirements"
Equivalent requirements are included in EN 378 and EN IEC 60335 standards.

EN 378 standard: Refrigerating systems and heat pumps — Safety and environmental requirements, CEN/TC 182 (Refrigerating systems, safety and environmental requirements)

The EN 378 "refrigerating systems and heat pumps – safety and environmental requirements" standard answers to the requirements of the European Directive on pressure equipment (97/23/EC) and to the European Directive on machinery (98/37/EC modified by 2006/42/EC). This standard is now being revised to satisfy the requirements of the regulation 2006/842/EC on fluorinated greenhouse gases.

Scope: Refrigerating systems and heat pumps.

Contents
This standard applies to the design of refrigerating systems and heat pumps concerning the use of any refrigerant fluid, toxic, inflammable or not.

The first part of this standard gives general definitions and indications concerning the design, installation and recovery of refrigerant fluids.
In this first part, annex C which is informative, gives indication on maximal refrigerant charge for air conditioning products. Limits are set in kg/m3; they depend both on the type of fluid (flammability and toxicity) and on the use of the space in which the system is located. Hydrocarbons should not be used for air conditioning. Moreover, above the fact the standard is informative, constraint for products using R407C and R410A have no consequences for the product inside this lot. The only products concerned would be package air conditioners located inside the room and the limits for nowadays fluids, R407C and R410A are very high since they are nonflammable.

The second part deals with the design, construction, testing, marking and documentation.
The third part deals with installation site and personal protection.
The fourth part deals with operation, maintenance, repair and recovery of refrigerant fluid.

Draft prEN 378 (2006)
Two main evolutions are to be noted for our study.
Annex C of part 1 became normative; limitations for main gases of interest here have not changed; nevertheless, hydrocarbons are now allowed for "factory sealed" AC systems and heat pumps with conditions depending upon the lower flammability limit or LFL (kg/m3), the height of the installed equipment in the room, the area of the room. Table C.1 for refrigerant safety group A3 (pag. 41) makes reference to clause C.3. C.3.1 applies in general to all AC system using A3 refrigerant (non only factory sealed). C.3.2 applies specifically to "non fixed factory sealed A/C". For R290 the relation between refrigerant charge and minimum room area is different from C.3.1. The formula (A_{min}=m/(0.25 LFL 2.2)) is the same of EN60335-2-40/A1:2006-04 clause GG.Z1.1. For propane if m=0.3 kg A_{min}=14.4 m^2 (CECED, 2007).

- The 3 kg limit of the Regulation on fluorinated gases 2006/842/EC concerning the regular inspection for leakage has been introduced. The project in its version of March 2006 does not include explicitely the reference to the 6 kg limit. Nevertheless, the definition for sealed system has been made compatible with the one of the Regulation 2006/842/EC and a standard to qualify components of sealed equipment is under preparation.

EN 13313 standard: Refrigerating systems and heat pumps — Competence of personnel
This standard defines 3 categories of personal for the installation, the maintenance and the design of refrigeration equipment. Requirements remain general: they should know about "energy efficiency" but what is not detailed. It is also to be updated to be made compliant with the Regulation 2006/842/EC.

EN 14276-1 and 2: Pressure equipment for refrigerating systems and heat pumps - Part 1 : vessels - General requirements - Part 2 : piping - General requirements
This standard sets the requirements in agreement with the pressure directive.

EN 60335 (2005) – "household and similar electrical appliances – safety "
The design, construction, installation, testing and use of electrical equipment shall be in accordance with the appropriate European standards, e.g. EN 60335-2-40.
This standard requirements enable products to be conform to the Low Voltage Directive and to the Machinery Directive.
Amendment EN 60335-2-40/A1:2006 considers the use of flammable refrigerants in air conditioning appliances following draft standard EN378 and gives specific requirements about design, refrigerant limit and warning labels (Delonghi, 2006). "EN 60335-2-40/A1:2006-04 permits in Europe to charge R290, propane, up to 0,3 kg in movable single duct" (CECED, 2007).

1.2.4 Noise

PR EN 12102 (2005): Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level

General laws for measuring the sound power level are standardized in ISO standards on noise, ISO 3741, …., ISO 3748. The standard EN 12102 gives specific test conditions that are the reference rating standard condition of EN14511 standard. The revision in 2005 aims at including inverter and chillers that were not covered in the 2000 version. Results are ratings in dB(A). As for the energy rating, noise measurement is done in specific conditions that are not the ones observed in real life, low fan speed, part load … Nevertheless, the standard leaves the choice to choose either rating or application conditions that may be a problem to compare noise of different units. Method and corrections are supplied for ducted units. There is a tolerance of 1 dB on the final sound power rating for the application of the labelling directive 2002/31/EC.

1.2.5 Conclusion on test standards

Concerning energy performance test standards for air conditioners, Europe has a very complete regularly updated test standard, derived from the ISO test standard, and covering heating and cooling functions.
The experimental part load test standard is now being revised to include both part load testing methods and seasonal performance index. This could help to start the transition from nominal full load EER and COP to seasonal performance indexes, as already done in some other economies with large air conditioner markets as in United States, Japan and Korea. This is a necessary transition to enable the comparison of the performances of the air conditioners not only at full load, conditions that barely occurs over the year, but on seasonal performances that include part load performances. This is the condition to enable the transition towards more intelligent part load control as capacity staged or inverter units.
A second important development is being done about the F-gas regulation in order to update standards in compliance with the new legislation.

1.3 Existing Legislation

According to the MEEuP Methodology the following review should identify relevant legislation for product categories identified in part 1.2 (Product category and performance assessment), that will or could impose consequences for the design of respective implementing measures. Therefore legislation at EU level, Member State or Third Country level is lying in the focus of this compilation. The authors intended to focus on legislature which could have direct implications.

1.3.1 Legislation and Agreements at EU-Level

Most relevant European Legislation – in the form of Directives and Regulation – is divided into the different following main fields:

- Environmental legislation
- Legislation related to energy use
- Legislation related to safety

1.3.1.1 Environmental Legislation

Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), amended by Directive 2003/108/EC

The Directive (effective 13 August 2005) requires separate collection, treatment and recovery of electrical and electronic waste. The Directive applies to the categories of electrical and electronic equipment which are dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields falling under the categories set out in Annex IA and designed for use with a voltage rating not exceeding 1 000 Volt for alternating current and 1 500 Volt for direct current […] "provided that the equipment concerned is not part of another type of equipment that does not fall within the scope of this Directive.

Clarification of the Scope of the Directive, given in Annex IB
According to the product categories provided in Annex IB of the Directive it applies to "Large Household Appliances", inter alia for "air conditioner appliances" resp. "other fanning, exhaust ventilation and conditioning equipment". As this Directive is very broad in scope room is left for interpretation, whether a specific category of room air conditioner may or may not be covered by this Directive (please see therefore Chapter 1.3.2.).

The clarifications taken from the – non legally binding – Document "Frequently Asked Questions on RoHS and WEEE Directive" (published by the Commission in May 2005, updated in August 2006) explain:
"With reference to Directive 89/336/EEC and the Official Guidelines for the Implementation of this Directive the decision criteria are "Finished Product" or "Fixed Installation".
Equipment which is part of another type of equipment is not to be considered a finished product. A finished product is any device or unit of equipment that has a direct function, its own enclosure and - if applicable - ports and connections intended for end users.
"Direct function" is defined as any function of a component or a finished product which fulfils the intended use specified by the manufacturer in the instructions for use for an end-user. This function can be available without further adjustment or connections other than simple ones which can be performed by any person.
If the "other type of equipment" is a fixed installation it will not fall under the scope of the WEEE Directive.
"Fixed installation" in the broadest sense is defined as "a combination of several equipment, systems, finished products and/or components (hereinafter called "parts") assembled and/or erected by an assembler/installer."

Product design (Art. 4)
"Member States shall encourage the design and production of electrical and electronic equipment which take into account and facilitate dismantling and recovery, in particular the reuse and recycling of WEEE, their components and materials. In this context, Member States shall take appropriate measures so that producers do not prevent, through specific design features or manufacturing processes, WEEE from being reused, unless such specific design features or manufacturing processes present overriding advantages, for example, with regard to the protection of the environment and/or safety requirements."

Separate collection (Art. 5)
"1. Member States shall adopt appropriate measures in order to minimise the disposal of WEEE as unsorted municipal waste and to achieve a high level of separate collection of WEEE.
2. For WEEE from private households, Member States shall ensure that by the 13 August 2005:
(a) systems are set up allowing final holders and distributors to return such waste at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities, taking into account in particular the population density;
(b) when supplying a new product, distributors shall be responsible for ensuring that such waste can be returned to the distributor at least free of charge on a one-to-one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment. Member States may depart from this provision provided they ensure that returning the WEEE is not thereby made more difficult for the final holder and provided that these systems remain free of charge for the final holder. Member States making use of this provision shall inform the Commission thereof;
(c) without prejudice to the provisions of (a) and (b), producers are allowed to set up and operate individual and/or collective take-back systems for WEEE from private households provided that these are in line with the objectives of this Directive;
(d) having regard to national and Community health and safety standards, WEEE that presents a health and safety risk to personnel because of contamination may be refused for return under (a) and (b). Member States shall make specific arrangements for such WEEE."

Treatment (Art. 6)
"For the purposes of environmental protection, Member states may set up minimum quality standards for the treatment of collected WEEE. […] Any establishment or undertaking carrying out treatment operations obtains a permit from the competent authorities. […]
"Derogation from the permit requirement […] may apply to recovery operations concerning WEEE if an inspection is carried out by the competent authorities before the registration […]"
"The treatment operation may also be undertaken outside the respective Member State or the Community provided that the shipment of WEEE is in compliance with Council Regulation (EEC) No 259/93 on the supervision and control of shipments of waste within, into and out of the European Community. "

According to ANNEX II "selective treatment for materials and components of waste electrical and electronic equipment in accordance with Article 6(1)" is required.
"1. As a minimum the following substances, preparations and components have to be removed from any separately collected WEEE: […]
— chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC), […][17]
These substances, preparations and components shall be disposed of or recovered in compliance with Article 4 of Council Directive 75/442/EEC."

[17] ANNEX II precises that it concerns "equipment containing gases that are ozone depleting or have a global warming potential (GWP) above 15".

Recovery (Art. 7)
for WEEE (for a certain category, e.g. in the case of RAC) , the rate of recovery shall be increased to a minimum of 80 % by an average weight per appliance, and component, material and substance reuse and recycling shall be increased to a minimum of 75 % by an average weight per appliance;

Financing
… WEEE from private households (Art. 8)
"1. Member States shall ensure that, by 13. August 2005, producers provide at least for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE from private households deposited at collection facilities, set up under Art. 5
2. For products put on the market later than 13 August 2005, each producer shall be responsible for financing the operations referred to in paragraph 1 relating to the waste from his own products. The producer can choose to fulfil this obligation either individually or by joining a collective scheme."

… WEEE from users other than private households (Art. 9)
"1. Member States shall ensure that, by 13 August 2005, the financing of the costs for the collection, treatment, recovery and environmentally sound disposal of WEEE from users other than private households from products put on the market after 13 August 2005 is to be provided for by producers. […]
For historical waste being replaced by new equivalent products or by new products fulfilling the same function, the financing of the costs shall be provided for by producers of those products when supplying them. Member States may, as an alternative, provide that users other than private households also be made, partly or totally, responsible for this financing.""

Information for users (Art. 10)
"Member States shall ensure that users of electrical and electronic equipment in private households are given the necessary information about:
the requirement not to dispose of WEEE as unsorted municipal waste and to collect such WEEE separately; […] the potential effects on the environment and human health as a result of the presence of hazardous substances in electrical and electronic equipment;"

Information for treatment facilities (Art. 11)
"Member States shall take the necessary measures to ensure that producers provide reuse and treatment information for each type of new EEE put on the market within one year after the equipment is put on the market. This information shall identify […] the different EEE components and materials, as well as the location of dangerous substances and preparations in EEE."

Implementation of WEEE
The implementation of WEEE Directive in the member states is ongoing. Impressions derived from first evaluation indicate there is no common or stringent understanding of which categories of RAC have to be covered by the application of the Directive (please see therefore Chapter 1.3.2.)

Review process in the framework of the WEEE Directive
An impact assessment will be produced to examine the cost and benefits of different policy options for the revision of the Directive, based on previously gathered information and according to the impact assessment guidelines (published in June 2005).
The review of the WEEE Directive will also be based on the experience of the application of the Directive and the ongoing development of the state of technology, environmental requirements and the functioning of the internal market. This review will also assess options that contribute to the Thematic Strategy on the prevention and recycling of waste contained in the Commission Communication 2005(666) Final and shall, as appropriate, be in line with the Community environmental policy.

The issues will be examined during 2006 and 2007. The European Commission will be launching a number of separate exercises to gather and analyse information to the review and seeking participation of stakeholders.

The review shall investigate changes to the scope of the Directive. The implementation of the scope by the Member States and in particular the exclusion clauses in article 2.1 (part of another equipment) beside others therefore need to be evaluated. Furthermore it needs to be analysed whether the current scope is appropriate from a qualitative perspective (amount of hazardous substances addressed) and from a quantitative perspective (link with the targets for recovery, reuse and recycling).

Options for change according to the Commission can address among other :

- The use of criteria to determine whether a product falls under the scope or not,
- The use of a fixed list of products,
- The inclusion of (other) types of equipment categories in the scope, e.g. those covered by the definition but not yet defined/concretised in Annex IA,
- The exclusion of certain types of equipment categories from the scope, e.g. those covered under "users other than private households" equipment or those with a low content of hazardous substances.

The review shall also evaluate the treatment requirements specified by the Directive in the light of actual and future technologies and assess options to further reduce the environmental and health impacts of WEEE. This will include an overview of the best practices in the EU 25 and an evaluation of how these can be further supported and developed.
As a minimum, the following options will be looked at, in connection with the related work under the IPPC Directive and the Thematic Strategy on the prevention and recycling of waste, as appropriate:

- the possibility to require use of specific technologies/techniques
- the inclusion of a set of criteria to determine if a treatment (technology) meets the adequate environmental standards and
- the inclusion of criteria on the required outputs of the treatment processes.

<u>Review process</u>

- Implementation Assessment

A research study to generate full understanding of implementation of the Directive by the Member States and to obtain feedback on potential areas for revision has been carried out and resulting in a report, available on the JRC website since 2006.
Data Gathering Exercise
Stakeholders have been requested to provide information for the review by 11 August 2006. The information gathered are presented at the CIRCA web site: http://forum.europa.eu.int/Public/irc/env/weee_2008/home

- Research Studies

Research Studies further analysing the impact and implementation of the WEEE Directive and potential changes are intended to be launched. The objective of these studies is to complete the information needed to inform an analyses of options for the review of the Directive and to provide that analysis, in particular by providing a thorough evaluation of the impacts, effectiveness and efficiency of the Directive.
Details can be found on http://ec.europa.eu/environment/waste/weee_index.htm
The studies will be conducted during the 2nd half of 2006 and 2007.

- Impact Assessment

An impact assessment will be produced to examine the costs and benefits of different policy options for the revision of the Directive, based on previously gathered information.
The indicative timing is 2nd half of 2007.

- Proposal & legislative procedures

As provided for in the Directive, the European Parliament and the Council, acting on a proposal from the Commission, shall establish new targets for collection, recovery and reuse/recycling, including the reuse of whole appliances as appropriate, and for the products falling under category 8 of Annex IA by 31 December 2008.

Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electric and electronic equipment (RoHS)

The Directive requires the substitution of substances as listed below:

- lead,
- mercury,
- cadmium,
- hexavalent chromium,
- polybrominated biphenyls (PBB) or
- polybrominated diphenyl ethers (PBDE)

in new electrical and electronic equipment put on the market from 1. July 2006.

The Directive applies to “Large Household Appliances” (“air conditioner appliances” resp. “other fanning, exhaust ventilation and conditioning equipment”) according to Art. 3, referring to 2002/96 (WEEE), Annex IA. This Directive covers assemblies or subassemblies of products.

Conclusion on WEEE and RoHS directives

Both the WEEE and the RoHs Directive are supposed to have a great influence on the ecodesign of energy using products and then on this study. WEEE is setting requirements for the collection, treatment and recovery for at least some categories of RACs.

Several approaches for the implementation illustrate a very divergent situation in the EU 25 market. Therefore strong efforts shall be foreseen to align deviating definitions of scope for the following reasons: on the one hand to support manufacturers (and distributors) fulfilling their obligations in the EU market, established by national markets setting various framework conditions. And on the other hand to ensure no category of RAC appliances fall off while laying in line with the objectives of the Directive.

The RoHS Directive applies the same scope as the WEEE Directive by referencing directly to the certain definitions provided by the WEEE Directive. It will still be a necessity to evaluate, whether manufacturers are applying different scopes regarding the respective Directives.

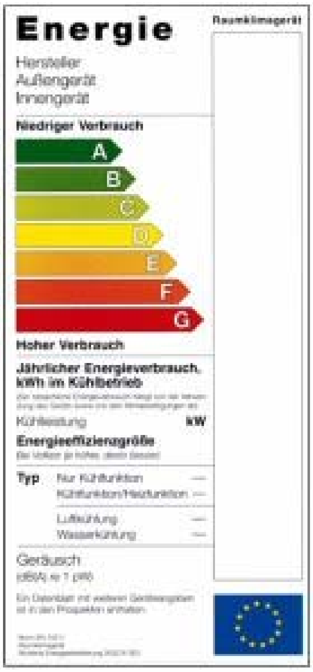
Further it has to be evaluated in following steps whether the WEEE Directive and the F-Gas-Regulation (posing requirements for recovery, too) are suitable to work as complimentary tools and therefore can reach a better coverage of the entire RAC range to be in line with the EU’s environmental policy aims. As the WEEE Directive sets the responsibilities primarily to the manufacturers (beside the Member States as such), the F-Gas Regulation defines the responsibilities to the operators of stationary equipment. It is an open point for discussion whether house or flat owners and small offices are in the position to fulfil the requirements appropriately.

1.3.1.2 Energy related legislation and agreements

The following legislation applies either to the product as an entity or to different stages of the manufacturing process.

Directive 2002/31/EC energy labelling of household air-conditioners

Figure 1-9: EU-energy label for household air-conditioners



This Directive applies to electric mains operated household air-conditioners as defined in the European standards EN 255-1, EN 814-1 or the harmonised test standards referred to in Article 2. It shall not apply to the following appliances:

- appliances that can also use other energy sources,
- air-to-water and water-to-water appliances,
- units with an output (cooling power) greater than 12 kW.

Requirements for EER (and COP, in the case of heating mode) are defined for the categories listed below:

Air-cooled air-conditioners:

- Split and multi-split appliances, Packaged, Single-duct

Water-cooled air-conditioners:

- Split and multi-split appliances, Packaged

The EU-label displays the energy efficiency class in a range from A (more efficient) – G (less efficient) different for each categories identified hereabove.

Table 1-43: EER labelling classes of Air-cooled air-conditioners

Energy Efficiency Class	Split and multi-split appliances	Packaged (*)	Single duct
A	3,2 < EER	3,0 < EER	2,6 < EER
B	3,2 ≥ EER > 3,0	3,0 ≥ EER > 2,8	2,6 ≥ EER > 2,4
C	3,0 ≥ EER > 2,8	2,8 ≥ EER > 2,6	2,4 ≥ EER > 2,2
D	2,8 ≥ EER > 2,6	2,6 ≥ EER > 2,4	2,2 ≥ EER > 2,0
E	2,6 ≥ EER > 2,4	2,4 ≥ EER > 2,2	2,0 ≥ EER > 1,8
F	2,4 ≥ EER > 2,2	2,2 ≥ EER > 2,0	1,8 ≥ EER > 1,6
G	2,2 ≥ EER	2,0 ≥ EER	1,6 ≥ EER

(*) Packaged 'double ducts' units (known commercially as 'double ducts') defined as 'Air conditioner completely positioned inside the conditioned space, with the condenser air intake and air discharge connected to the outside by means of two ducts', will be classified according to Table above with a correction factor of – 0,4.

Table 1-44: COP labelling classes of Air-cooled air-conditioners in heating mode

Energy Efficiency Class	Split and multi-split appliances	Packaged (*)	Single duct
A	3,6 < COP	3,4 < COP	3,0 < COP
B	3,6 ≥ COP > 3,4	3,4 ≥ COP > 3,2	3,0 ≥ COP > 2,8
C	3,4 ≥ COP > 3,2	3,2 ≥ COP > 3,0	2,8 ≥ COP > 2,6
D	3,2 ≥ COP > 2,8	3,0 ≥ COP > 2,6	2,6 ≥ COP > 2,4
E	2,8 ≥ COP > 2,6	2,6 ≥ COP > 2,4	2,4 ≥ COP > 2,1
F	2,6 ≥ COP > 2,4	2,4 ≥ COP > 2,2	2,1 ≥ COP > 1,8
G	2,4 ≥ COP	2,2 ≥ COP	1,8 ≥ COP

(*) Packaged 'double ducts' units (known commercially as 'double ducts') defined as 'Air conditioner completely positioned inside the conditioned space, with the condenser air intake and air discharge connected to the outside by means of two ducts', will be classified according to Table above with a correction factor of – 0,4.

Table 1-45: EER labelling classes of Water-cooled air-conditioners

Energy Efficiency Class	Split and multi-split appliances	Packaged (*)
A	3,6 < EER	4,4 < EER
B	3,6 ≥ EER > 3,3	4,4 ≥ EER > 4,1
C	3,3 ≥ EER > 3,1	4,1 ≥ EER > 3,8
D	3,1 ≥ EER > 2,8	3,8 ≥ EER > 3,5
E	2,8 ≥ EER > 2,5	3,5 ≥ EER > 3,2
F	2,5 ≥ EER > 2,2	3,2 ≥ EER > 2,9
G	2,2 ≥ EER	2,9 ≥ EER

(*) Packaged 'double ducts' units (known commercially as 'double ducts') defined as 'Air conditioner completely positioned inside the conditioned space, with the condenser air intake and air discharge connected to the outside by means of two ducts', will be classified according to Table above with a correction factor of – 0,4.

Table 1-46: Requirements for COP-Values of Water-cooled air-conditioners

Energy Efficiency Class	Split and multi-split appliances	Packaged (*)
A	4,0 < COP	4,7 < COP
B	4,0 ≥ COP > 3,7	4,7 ≥ COP > 4,4
C	3,7 ≥ COP > 3,4	4,4 ≥ COP > 4,1
D	3,4 ≥ COP > 3,1	4,1 ≥ COP > 3,8
E	3,1 ≥ COP > 2,8	3,8 ≥ COP > 3,5
F	2,8 ≥ COP > 2,5	3,5 ≥ COP > 3,2
G	2,5 ≥ COP	3,2 ≥ COP

(*) Packaged 'double ducts' units (known commercially as 'double ducts') defined as 'Air conditioner completely positioned inside the conditioned space, with the condenser air intake and air discharge connected to the outside by means of two ducts', will be classified according to Table above with a correction factor of – 0,4.

Information on noise level is not mandatory but may be required by Member States.

Directive 2002/91/EC energy performance of buildings

The Directive came into force on 4 January 2003 and must be translated into national law by 4 January 2006. However, the implementation of certain parts of the Directive by national Government can be delayed if there is a lack of suitably qualified independent experts. If this proves to be the case then member states will be given an extra period of three years to fully apply the provisions in articles 7, 8 and 9. If a member state feels this to be necessary then they need to notify the EC, providing justification for the delay and a time schedule to implement the Directive.

The objective of the Directive is to “promote the improvement of the energy performance of buildings within the European Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.”

This is to be achieved through five main actions:

- the creation of a general methodology following a framework provided by the Directive that can be used to calculate the energy performance of buildings. This will encompass aspects of building design, construction and services. It will allow building designers and managers to meet energy reduction standards in a flexible and cost-effective manner, as well as incorporating simple energy indicators;
- the application of minimum requirements, as measured by the methodology above, to all new residential and tertiary (generally public and commercial) buildings and to the major refurbishment of existing buildings with floor areas greater than 1,000 square metres;
- the introduction of an energy performance certificate to be available whenever a building is constructed, rented out or sold. This should include legal standards and benchmarks, as well as recommendations for cost-effective improvement of energy performance. The certificate should be displayed prominently when applied to public buildings or buildings serving large numbers of the public;
- regular inspection of boilers with outputs of more than 20 kW and inspection every two years for boilers of more than 100 kW. Where the boiler is more than 15 years old a one-off inspection should be carried out that covers the entire heating system;
- regular inspection of air conditioning systems with outputs of more than 12 kW.

The most relevant requirements according to the scope of this study are pointed out in detail as follows:

<u>Setting of energy performance requirements (Art. 4)</u>
“Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings are set […] Member States may differentiate between new and existing buildings and different categories of buildings. These requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and the age of the building.”

<u>Existing buildings (Art. 6)</u>
“Member States shall take the necessary measures to ensure that when buildings with a total useful floor area over 1 000 m2 undergo major renovation, their energy performance is upgraded in order to meet minimum requirements in so far as this is technically, functionally and economically feasible.”

<u>Energy performance certificate (Art. 7)</u>
“Member States shall ensure that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be.”

<u>Inspection of air-conditioning systems (Art. 9)</u>

"With regard to reducing energy consumption and limiting carbon dioxide emissions, Member States shall lay down the necessary measures to establish a regular inspection of air-conditioning systems of an effective rated output of more than 12 kW.
This inspection shall include an assessment of the air-conditioning efficiency and the sizing compared to the cooling requirements of the building. Appropriate advice shall be provided to the users on possible improvement or replacement of the air-conditioning system and on alternative solutions."

Despite the fact the Directive should apply from the beginning of 2006, most of the Member States are still lagging behind.
Moreover there are different views in interpreting the 12 kW limit for air conditioning systems, while Commission's interpretation is that buildings where the total installed power is over 12 kW are subject to regular inspection. (please see therefore Chapter 1.3.3)

Ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps, CEC 2007

A final document has been adopted to award the EU eco-label to heat pumps, heating only and reversible.

The following criteria have to be fulfilled (only the ones relevant to products in the scope are considered). Certification body as Eurovent or the DACH program are acknowledged as regards to checking of the performance according to EN 14511 standard.

"1. Efficiency in heating mode (COP)
The efficiency of the heat pump unit shall exceed the following minimum requirements of the coefficient of performance (COP) and primary energy ratio (PER)."

Figures for minimum coefficients of performance are reported in the following table. "The primary energy ratio (PER) is given by: COP × 0,40 (or COP/2,5) for electrically driven heat pumps and by COP × 0,91 (or COP/1,1) for gas driven or gas absorption heat pumps, where 0,40 is the current European average electricity power generation efficiency including grid losses and 0,91 is the current European average gas efficiency including distribution losses according to Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end use efficiency and energy services and repealing Council Directive 93/76/EEC (1)."

Type of heat pump: heat source/heat sink	Outdoor unit (°C)	Indoor unit (°C)	Min. COP Electric heat pump	Min. COP Gas heat pump	Min. PER
air/air	Inlet dry bulb: 2 Inlet wet bulb: 1	Inlet dry bulb: 20 Inlet wet bulb: 15 max	2,90	1,27	1,16
air/water	Inlet dry bulb: 2 Inlet wet bulb: 1	Inlet temperature: 30 Outlet temperature: 35	3,10	1,36	1,24
		Inlet temperature: 40 Outlet temperature: 45	2,60	1,14	1,04
brine/air	Inlet temp.: 0 Outlet temp.: 3	Inlet dry bulb: 20 Inlet wet bulb: 15 max	3,40	1,49	1,36
brine/water	Inlet temp: 0 Outlet temp: 3	Inlet temperature: 30 Outlet temperature: 35	4,30	1,89	1,72
		Inlet temperature: 40 Outlet temperature: 45	3,50	1,54	1,40
water/water	Inlet temp: 10 Outlet temp: 7	Inlet temperature: 30 Outlet temperature: 35	5,10	2,24	2,04
		Inlet temperature: 40 Outlet temperature: 45	4,20	1,85	1,68
water/air	Inlet temp: 15 Outlet temp: 12	Inlet dry bulb: 20 Inlet wet bulb: 15 max	4,70	2,07	1,88
	(water loop source) Inlet temp: 20 Outlet temp: 17	Inlet dry bulb: 20 Inlet wet bulb: 15 max	4,40	1,93	1,76

Table 1-47: Minimum COP of the EU Ecolabel, source (CEC, 2007)

"2. Efficiency in cooling mode (EER)

If the heat pump is reversible and can cool, then the efficiency of the heat pump unit shall exceed the following minimum requirements of the energy efficiency ratio (EER) in cooling mode."

Figures for minimum energy efficiency ratios in for reversible units in cooling mode are reported in the following table.

Type of heat pump	Outdoor unit (°C)	Indoor unit (°C)	Min. EER Electric heat pump	Min. EER Gas heat pump	Min. PER
air/air	Inlet dry bulb: 35 Inlet wet bulb: 24	Inlet dry bulb: 27 Inlet wet bulb: 19	3,20	1,41	1,3
air/water	Inlet dry bulb: 35 Inlet wet bulb:	Inlet temperature: 23 Outlet temperature: 18	2,20	0,97	0,9
		Inlet temperature: 12 Outlet temperature: 7	2,20	0,97	0,9
brine/air	Inlet temp: 30 Outlet temp: 35	Inlet dry bulb: 27 Inlet wet bulb: 19 max	3,30	1,45	1,3
brine/water	Inlet temp: 30 Outlet temp: 35	Inlet temperature: 23 Outlet temperature: 18	3,00	1,32	1,2
		Inlet temperature: 12 Outlet temperature: 7	3,00	1,32	1,2
water/water	Inlet temp: 30 Outlet temp: 35	Inlet temperature: 23 Outlet temperature: 18	3,20	1,41	1,3
		Inlet temperature: 12 Outlet temperature: 7	3,20	1,41	1,3
water/air	Inlet temp: 30 Outlet temp: 35	Inlet dry bulb: 27 Inlet wet bulb: 19	4,40	1,93	1,8

Table 1-48: Minimum EER of the EU Ecolabel, source (CEC, 2007)

"3. Refrigerant
The global warming potential (GWP) for the refrigerant must not exceed GWP value > 2 000 over a 100 year period. If the refrigerant has a GWP of less than 150 then the minimum requirements of the coefficient of performance (COP) and primary energy ratio (PER) in heating mode and the energy efficiency ratio (EER) in cooling mode, as set out in criteria 1 and 2 of this Annex, shall be reduced by 15 %. GWP values considered will be those set out in Annex 1 of Regulation (EC) No 842/2006 of the European Parliament and of the Council (1)."

"5. Noise
The sound power level(s) shall be tested and stated in dB(A) on the information fiche. Assessment and verification: Testing shall be performed in accordance with ENV-12 102. The test report shall be submitted with the application."

"6. Heavy metals and flame retardants
Cadmium, lead, mercury, chromium 6+ or the flame retardants, i.e. poly-brominated biphenyl (PBB) or polybrominated diphenyl ether (PBDE) flame retardants as listed in Article 4 of Directive 2002/95/EC of the European Parliament and Council (1), may not be used in the heat pump or in the heat pump system, taking into account the tolerances specified in Commission Decision 2005/618/EC (2) amending Directive 2002/95/EC. This requirement for flame retardants shall take account of subsequent adaptations and amendments made to that Directive regarding the use of Deca-BDE. Assessment and verification: A certificate signed by the producer of the heat pump."

"9. Spare parts availability
The applicant shall ensure the availability of spare parts for a period of 10 years from the date of sale. Assessment and verification: A declaration that spare parts will be made available for 10 years shall be submitted with the application along with an explanation of how this availability will be guaranteed."

Supplementary advise to the end-user and information that should be supplied by the installer is given.

1.3.1.3 Legislation related to Safety

Directive 98/37/EC on machinery, amended by 2006/42/EC

The Directive applies to machinery, defined as "an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application".
The Directive addresses essential health an safety requirements relating to the design and construction of machinery. These requirements are provided in the Annex IA of the Directive.
Effective 29 June 2006, this Directive has to be transposed at the member state level before 29 June 2008.

Directive 97/23/EC on Pressure Equipment

The Directive applies to the design, manufacture and conformity assessment of pressure equipment and assemblies of pressure equipment with maximum allowable pressure greater than 0.5 bar above atmospheric pressure (i.e. 1.5 bar of absolute pressure).

The term "pressure equipment" includes vessels, piping, safety accessories and pressure accessories. Where applicable, pressure equipment includes elements attached to pressurised parts, such as flanges, nozzles, couplings, supports, lifting lugs etc.

Its purpose is to harmonise national laws of Member States regarding the design, manufacture and testing and conformity assessment of pressure equipment and assemblies of pressure equipment by setting:
- A classification of the equipments
- Essential safety requirements impacting on material choice, conception and manufacturing
- Conformity evaluation procedures

Directive 2001/95/EC on General Product Safety

This Directive covers all the products "which are intended for consumers or likely, under reasonable foreseeable conditions, to be used by consumers even if not intended for them, and are supplied or made available in the course of a commercial activity, and whether new, used or reconditioned".

The Directive requires producers to place only safe products on the market, and to inform about risks. A safe product is defined as one which, "under normal or reasonably foreseeable conditions of use including duration […] does not present any risk or only the minimum risk compatible with the product's use, considered to be acceptable and consistent with a high level of protection for the safety and health of persons […]". It obliges Member States to survey products on the market.

This Directive has been effective since 15 January 2004.

Directive 2004/108/EC on Electromagnetic Compatibility

The EMC Directive 2004/108/EC (which is an update of the previous Directive 89/336/EEC) sets restrictions on the emission of electromagnetic radiation and the immunity against electromagnetic radiation for electronic products. Countries outside the EU have similar regulations although the detailed requirements differ.

Directive 2006/95/EEC on Low Voltage Equipments (LVD)

According to the Directive, electrical equipment are defined as "any equipment designed for use with a voltage rating of between 50 and 1000V for alternating current and between 75 and 1500 V for direct current, other than the equipment and phenomena listed in Annex II" of the Directive.

The Directive covers all risks arising from the use of electrical equipment, including not just electrical ones but also mechanical, chemical (such as, in particular, emissions of aggressive substances), health aspects of noise and vibrations, and ergonomic aspects as far as ergonomic requirements are necessary to protect against hazards in the sense of the Directive. The LVD lays down eleven "safety objectives", which represent the essential requirements of this Directive.

The Directive was amended by the Directive 93/68/EEC which adds that before being placed on the market, the electrical equipment referred to in Article 1 must have affixed to it the CE marking provided for in Article 10 attesting to its conformity to the provisions of this Directive, including the conformity assessment procedure described in Annex IV of the Directive.

Directive 2004/42/CE on VOC (Volatile Organic Components)

Directive 2004/42/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain paints and varnishes and vehicle refinishing products (the so-called **VOC Paints Directive**) establishes limit values for the maximum VOC contents of decorative paints and other products covered by the Directive. The consequence for manufacturers of air conditioners is an increase in the price of solvents and paintings.

1.3.1.4 Legislation related to the Refrigerant Fluids

Directive 2000/2037/EC on Ozone Depleting Substances (ODS)

This regulation covers production, importation, exportation, placing on the market, use, recovery, recycling and destruction of chlorofluorocarbons, other fully halogenated chlorofluorocarbons, halons, carbon tetrachloride, 1,1,1-trichloroethane, methyl bromide hydrobromofluorocarbons and hydrochlorofluorocarbons. The regulation also imposes the reporting of information on these substances.

This regulation also applies to importation, production, placing on the market, use of substances enumerated in Annex I of the regulation.

It also set a schedule for the elimination of the substances listed in Annex I of the regulation. It indicates the interdiction of CFC molecules and the future interdiction of HCFC (total interdiction planned for 2010-2015). This regulation doesn't concern HFC.

Regulation 2006/842/EC fluorinated greenhouse gases

This Regulation entered in force on 4 July 2006 and apply with effect 4 July 2007 (except from Art. 9 and Annex II, which apply on 4 July 2006) to certain "fluorinated greenhouse gases […] listed in Annex 1 and preparations containing these substances …" (Art. 1)

The objective of this regulation is to "contain, prevent and thereby reduce emissions of the fluorinates greenhouse gases covered by the Kyoto Protocol. It shall apply to the fluorinated greenhouse gases listed in Annex A to that Protocol", which are listed as follows: 23, 32, 41, 43-10mee, 125, 134, 134a, 152a, 143, 143a, 227ea, 236cbm, 236ea, 236fa, 245ca, 245fa, 365mfc

This Regulation addresses:
- The containment, the use, the recovery and the destruction of the fluorinated greenhouse gases
- The labelling and disposal of products and equipment containing those gases; the reporting of information on those gases
- The control of uses
- The placing on the market prohibitions of certain products and equipment
- The training and certification of personnel and companies involved in activities provided for by this regulation

A certain schedule of prohibition of placing on the market of products and equipments containing fluorinated greenhouse gases is listed in the Annex I of the regulation. This schedule is not affecting common refrigerants used in RACs for the European market.

The requirements are pointed out in detail as follows:

<u>Containment (Art. 3)</u>
"1. Operators of the following stationary applications: refrigeration, air conditioning and heat pump equipment, including their circuits, as well as fire protection systems, which contain fluorinated greenhouse gases listed in Annex I, shall, using all measures which are technically feasible and do not entail disproportionate cost: (a) prevent leakage of these gases; and (b) as soon as possible repair any detected leakage.
2. Operators of the applications referred to in paragraph 1 shall ensure that they are checked for leakage by certified personnel who comply with the requirements of Article 5, according to the following schedule:
(a) applications containing 3 kg or more of fluorinated greenhouse gases shall be checked for leakage at least once every 12 months; this shall not apply to equipment with hermetically sealed

systems, which are labelled as such and contain less than 6 kg of fluorinated greenhouse gases; […]"

This article means that inspection does not apply to about any product in the scope of this study that contain less than 3 kg (equivalent to more than 10 kW of cooling capacity, please refer to task 4 for more information on ratios in kg/kW).

Recovery (Art. 4)
"1. Operators of the following types of stationary equipment shall be responsible for putting in place arrangements for the proper recovery by certified personnel, who comply with the requirements of Article 5, of fluorinated greenhouse gases to ensure their recycling, reclamation or destruction:
(a) the cooling circuits of refrigeration, air-conditioning and heat pump equipment; […]"

"3. The fluorinated greenhouse gases contained in other products and equipment, including mobile equipment unless it is serving military operations, shall, to the extent that it is technically feasible and does not entail disproportionate cost, be recovered by appropriately qualified personnel, to ensure their recycling, reclamation or destruction.
4. Recovery, for the purpose of recycling, reclamation or destruction of the fluorinated greenhouse gases, pursuant to paragraphs 1 to 3, shall take place before the final disposal of that equipment and, when appropriate, during its servicing and maintenance."

Training and certification (Art. 5)
"1. By 4 July 2007, on the basis of information received from Member States and in consultation with the relevant sectors, minimum requirements and the conditions for mutual recognition shall be established in accordance with the procedure referred to in Article 12(2) in respect of training programmes and certification for both the companies and the relevant personnel involved in installation, maintenance or servicing of the equipment and systems covered by Article 3(1) as well as for the personnel involved in the activities provided for in Articles 3 and 4.

2. By 4 July 2008, Member States shall establish or adapt their own training and certification requirements, on the basis of the minimum requirements referred to in paragraph 1. Member States shall notify the Commission of their training and certification programmes. Member States shall give recognition to the certificates issued in another Member State and shall not restrict the freedom to provide services or the freedom of establishment for reasons relating to the certification issued in another Member State.

3. The operator of the relevant application shall ensure that the relevant personnel have obtained the necessary certification, referred to in paragraph 2, which implies appropriate knowledge of the applicable regulations and standards as well as the necessary competence in emission prevention and recovery of fluorinated greenhouse gases and handling safely the relevant type and size of equipment.

4. By 4 July 2009 Member States shall ensure that the companies involved in carrying out the activities provided for in Articles 3 and 4 shall only take delivery of fluorinated greenhouse gases where their relevant personnel hold the certificates mentioned in paragraph 2 of this Article.

5. By 4 July 2007 the Commission shall determine, in accordance with the procedure referred to in Article 12(2), the format of the notification referred to in paragraph 2 of this Article."

Labelling (Art. 7)
1. Without prejudice to the provisions of Directive 67/548/EEC (1) and of Directive 1999/45/EC (2) in respect of the labelling of dangerous substances and preparations, the products and equipment, listed in paragraph 2, containing fluorinated greenhouse gases shall not be placed on the market

unless the chemical names of the fluorinated greenhouse gases are identified by way of a label using the accepted industry nomenclature. Such label shall clearly indicate that the product or equipment contains fluorinated greenhouse gases covered by the Kyoto Protocol and their quantity, and this shall be clearly and indelibly stated on the product or equipment, adjacent to the service points for charging or recovering the fluorinated greenhouse gas, or on that part of the product or equipment which contains the fluorinated greenhouse gas. Hermetically sealed systems shall be labelled as such.
Information on the fluorinated greenhouse gases, including their global warming potential, shall be included in the instruction manuals provided for such products and equipment.
2. Paragraph 1 shall apply to the following types of products and equipment:
[…]
(b) refrigeration and air conditioning products and equipment (other than those contained in motor vehicles), heat pumps, fire protection systems and fire extinguishers, if the respective type of product or equipment contains hydrofluorocarbons or preparations containing hydrofluorocarbons;
[…]

Placing on the market (Art. 9)
"[…] Where a Member State has, by 31. December 2005, adopted national measures which are stricter than those […] maintain those national measures until 31 December 2012." (Art. 9)
"In the light of revisions provided for by Article 5(3) of the Kyoto Protocol and accepted by the Community and its Member States, Annex I may be reviewed and if appropriate may then be updated." (Art. 1)

Additional regulations to Regulation 2006/842/EC on fluorinated greenhouse gases

All regulations hereunder deal with fluorinated green house gases and their use in stationary applications for refrigeration, air-conditioning and heat pump equipment.

Regulation 2007/1494/EC: labelling requirement

The labelling affixed on equipment should indicate "Contains fluorinated greenhouse gases covered by the Kyoto Protocol", the refrigerant name, the refrigerant charge, the text 'hermetically sealed' where applicable.
"Where fluorinated greenhouse gases may be added outside the manufacturing site and the resulting total quantity is not defined by the manufacturer, the label shall contain the quantity charged in the manufacturing plant and shall provide space on the label for the quantity to be added outside the manufacturing plant as well as for the resulting total quantity of fluorinated greenhouse gases."
"For air conditioning products and equipment as well as heat pumps with separate indoor and outdoor sections connected by refrigerant piping, the label information shall be placed on that part of the equipment which is initially charged with the refrigerant."

Regulation 2007/1516/EC defines standard leakage checking requirements. Regulation 2008/303/EC defines minimum requirements and the conditions for mutual recognition for the certification of companies and personnel. Regulation 2008/308/EC defines the format for notification of the training and certification programmes.

1.3.2 Voluntary Instruments: Agreements and Labelling Systems

Eurovent Certification programme

General information

Eurovent-Certification program works on the same principle as the USA ARI certification programme. By participating in the Eurovent-Certification scheme and allowing their products to be independently tested, manufacturers have the right to include their products in the annual Eurovent-Certification product directory, which is circulated among consultants and installers. They are also allowed to use the Eurovent-Certification label (hereunder).	EUROVENT CERTIFIED PERFORMANCE Label stamped on Eurovent certified appliances.

For a low cost manufacturers can, depending on the number of models, have all their models listed in the directory and the performance certified. This is a tool useful in the present study, provided the system is managed with integrity and accredited. The equipment to be tested is independently selected by Eurovent-Certification (not by the manufacturer) and then tested independently according to international test standards and the specific requirements of Eurovent-Certificatio. In the ARI system, air conditioners are picked up on the production line or inside the custom containers for imported models. This is being studied for air conditioners but not yet implemented. (Of course this is not feasible for chillers or other large capacity or products made on demand).
In order to ensure true comparability and reproducibility of the test results all equipment are tested in a single designated test centre. Selecting well calibrated laboratories enables to reduce tolerance levels.
There is always a risk that some manufacturers certify only their best equipment. Eurovent-Certification has moved, following a similar move by their American counterpart, ARI, to a "Certify All" policy wherein a manufacturer can only report performance data of equipment BEING ALL certified if it wants to claim the benefits of its participation to the Eurovent-Certification scheme. This is good for the representativity of the data base for the products that are included.

Air conditioners certification program

Concerning air conditioners, Eurovent until now has not established a programme in certifying the performance of Single and Double ducts. In a similar way we do not find the mobile splits (disconnectable) identified as such, which is another source of non comprehensiveness of Eurovent-Certification figures.
The air conditioners models in Eurovent-Certification directory (Eurovent-Certification, 2006) are sorted by categories similar with EN 14511, but with additional information. Every Air Conditioner is classified according to 5 parameters.

- The first one aims at classifying RAC in three categories according to their cooling capacity (<12kW ; 12-45 kW; 45-100kW).
- Then, a second segmentation is made regarding the heat rejection way: air cooled or water cooled.
- A third segmentation is made regarding the type of system: Split, MultiSplit and Packaged.
- A fourth segmentation is made regarding the type of operation: reversible or cooling only.
- Finally the last segmentation is made regarding the mounting on the wall.

Programme	Code	Heat rejection	Code	System	Code	Operation	Code	Mounting*	Code
Comfort Air Conditoners up to 12 kW12 to 45 kW45 to 100 kW	AC1 AC2 AC3	Air cooled	A	Split	S	Cooling only	C	High wall	W
								Floor mounted	L
								Cassette	C
				Multisplit	M			Ceiling suspended	S
		Water cooled	W			Reverse cycle	R	Built-in-horizontal	B
								Built-in-vertical	V
				Packaged	P			Roof top	R
								Window	Wi

This figure is not known exactly today by programme but Eurovent-Certification has undertaken this task [Eurovent, 2007] by certification programme, only giving between 50 and 90 % as an estimate.
Concerning the AC1 programme, manufacturers participating in the scheme have been compared with main brands by country in the BSRIA data. Almost all the most important manufacturers take part in the scheme and representativity of the brands inside Eurovent is superior to 70 %.
This could provide a basis for the establishment of voluntary and transparent agreements between the EU and the manufacturers. Eurovent-Certification has been accredited under number BELCERT/090PR according to EN 45011 for the purpose of certifying product performance. Laboratories testing Eurovent certified products should be certified according to the ISO 17025 standard for the certification program they test units. The number of models indexed in the Eurovent 2006 directory is 6248. The distribution among categories of air conditioners is as follows:

Table 1-49: Number of models in the Eurovent catalogue, 2006

	Number of listed models
Air cooled packages	**378**
Air cooled packaged - Reverse Cycle	154
Air cooled packaged - Cooling only	224
Water cooled packages	**25**
Water cooled packaged - Reverse Cycle	21
Water cooled packaged - Cooling only	4
Air cooled Split	**4284**
Air cooled Split - Reverse Cycle	3121
Air cooled Split - Cooling only	1163
Air cooled Multisplit	**1561**
Air cooled Multisplit - Reverse Cycle	1082
Air cooled Multisplit - Cooling only	479
Total	**6248**

<u>Voluntary MEPS program for air conditioners</u>
A minimum EER for air conditioners (0-12 kW) is required to enter the directory. This combines well with « Certify All »: all manufactured products should meet the requirements
Eurovent has implemented the minimum energy efficiency for air conditioners up to 12 kW cooling capacity in 2004. Starting at 1 January 2004, Class G, as defined in the Labelling Directive, was eliminated from the Eurovent Certification.
According to a position paper from the Eurovent working group 6B "Air Conditioners" (dated from July 2005), Eurovent intends to pursue the same kind of actions and eliminate Classes E and F in the near future. It has been proposed to split air conditioners in two parts

- up to 4 kW cooling capacity,
- from 4 to 12 kW cooling capacity,

and to apply different schedules for each part.

A justification of this separation is given through following rationale:

- the largest part of the market (more than 80%) is made up of units with cooling capacity under 4 kW. Therefore the implementation of minimum efficiency will have more impact.
- the life cycle of these smaller units is much shorter (2 to 3 years) than that of larger units (5 to 10 years). Therefore, the implementation of minimum efficiency is less difficult for smaller units.

Thus, starting with 1 January 2008, Eurovent WG 6B proposes to eliminate from Certification:

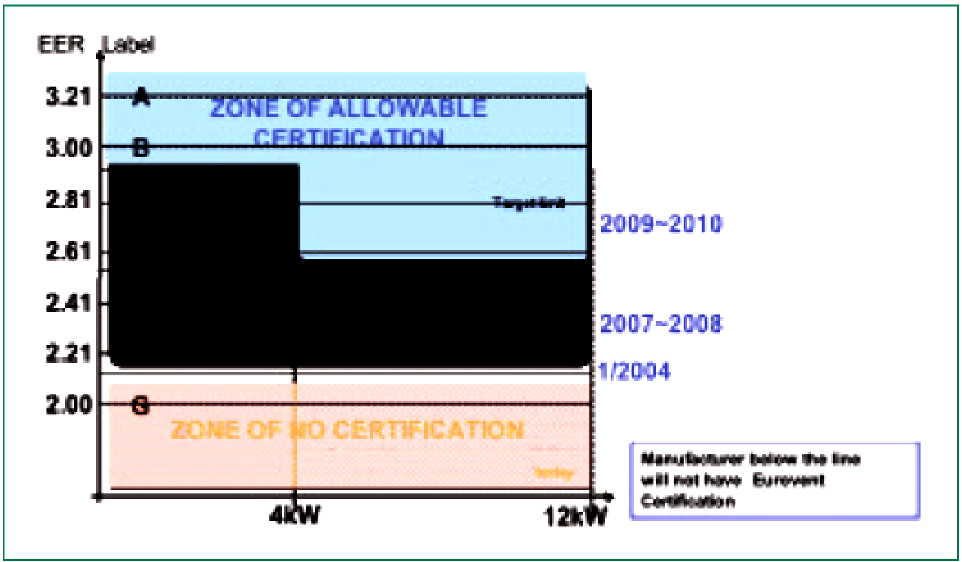
- classes E and F for air conditioners with less than 4 kW cooling capacity
- class F for air conditioners with cooling capacity from 4 to 12 kW

And from 1st January 2010, Eurovent WG 6B proposes to eliminate from Certification:

- classes C and D for air conditioners with less than 4 kW cooling capacity
- class E for air conditioners with cooling capacity from 4 to 12 kW

By this measure no Manufacturers will be allowed to participate to the Eurovent Certification Programme for Air Conditioners if his products do not comply with the minimum Energy Efficiency requirements.

Figure 1-10: Eurovent's time schedule for energy efficiency deployment



The effect of the ban of class G has been reported in (Saheb, 2006): from 2003 to 2005, the average EER of all certified air conditioners increased from 2.58 to 2.87, i.e. 11%.
The transformation is illustrated hereafter by the evolution of the products energy efficiency classes between 2002 and 2006.

Table 1-50: Eurovent-Certification registered products in 2002 with a cooling power below or equal 12 kW regarding Label-Classes for different types (Source: MTP, BNAC02: The European Directive on energy labelling of household air conditioners, 2006)

Energy classes	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**All**
	Units	Units	Units	Units	Units	Units	Units	Units
Air cooled								
Split and multi-split (cooling only)	76	97	268	505	561	334	163	2004
Split and multi-split (reverse cycle, cooling)	66	82	256	606	733	534	209	2486
Split and multi-split (reverse cycle, heating)	69	91	231	1063	619	300	113	2486
Packaged (cooling only)	1	3	78	49	45	20	4	200
Packaged (reverse cycling, cooling)	0	2	22	36	23	35	4	122
Packaged (reverse cycling, heating)	2	1	11	69	30	19	2	134

Water cooled								
Split and multi-split	-	-	-	-	-	-	-	-
Packaged (cooling only)	0	0	1	5	8	7	10	31
Packaged (reverse cycling, cooling)	0	0	2	1	8	9	6	26
Packaged (reverse cycling, heating)	0	0	3	6	12	4	1	26
Total	**214**	**276**	**872**	**2340**	**2039**	**1262**	**512**	**7515**
Percentages	**3%**	**4%**	**12%**	**31%**	**27%**	**17%**	**17%**	**100%**

Table 1-51: Eurovent-Certification registered products in 2006 with a cooling power below or equal 12 kW regarding Label-Classes for different types, Evaluations based on Eurovent-Certification Catalogue 2006 – (Eurovent-Certification, 2006)

Energy classes	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**All**
	Units	Units	Units	Units	Units	Units	Units	Units
Air cooled								
Split (cooling only)	110	83	147	257	259	138	1	995
Split (reverse cycle, cooling)	814	302	404	449	408	287	4	2668
Split (reverse cycle, heating)	587	334	401	789	439	117	1	2668
multi-split (cooling only)	146	61	86	96	50	34	0	473
multi-split (reverse cycle, cooling)	363	191	179	173	55	33	0	994
multi-split (reverse cycle, heating)	287	173	245	223	38	28	0	994
Packaged (cooling only)	0	1	24	13	22	4	0	64
Packaged (reverse cycling, cooling)	0	1	10	10	3	7	0	31
Packaged (reverse cycling, heating)	0	5	5	15	0	6	0	31
Water cooled								
Split and multi-split	-	-	-	-	-	-	-	-
Packaged (cooling only)	0	0	0	0	0	1	0	1
Packaged (reverse cycling, cooling)	1	0	1	2	11	5	0	20
Packaged (reverse cycling, heating)	0	1	1	11	8	0	0	20
Total	**2308**	**1152**	**1503**	**2038**	**1293**	**660**	**6**	**8959**
Percentages	**26%**	**13%**	**17%**	**23%**	**14%**	**7%**	**0%**	**100%**

Table 1-52: Comparison of Eurovent-Certification registered products with a cooling power below or equal 12 kW regarding Label-Classes – total numbers

Energy classes	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Total**
Eurovent Catalogue 2002	214	276	872	2340	2039	1262	512	7515
Eurovent Catalogue 2006	2308	1152	1503	2038	1293	660	6	8960

Figure 1-11: AC below 12 kW regarding Label-Classes – total numbers

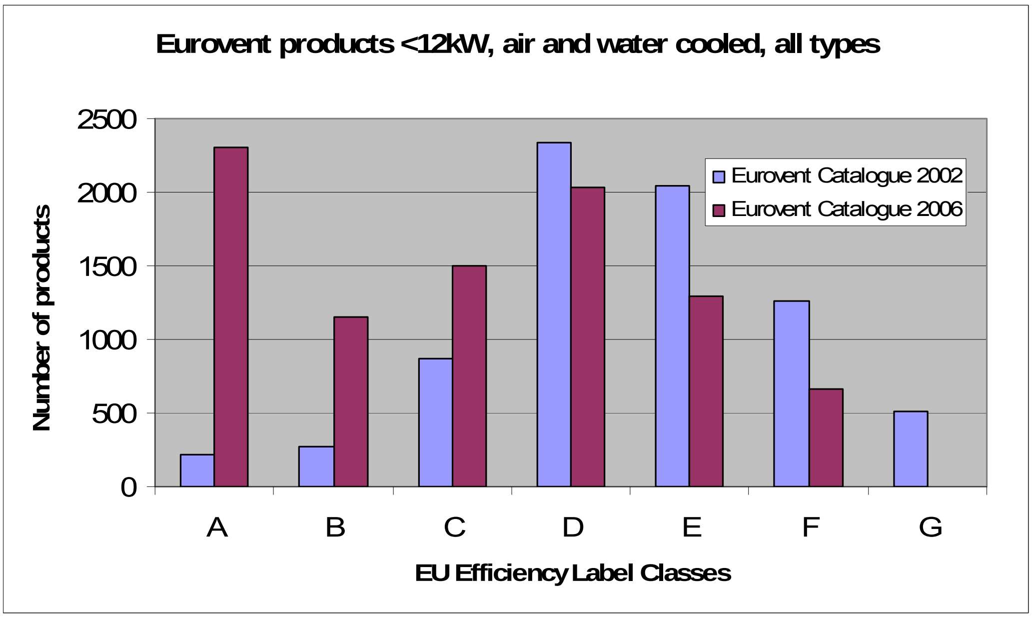
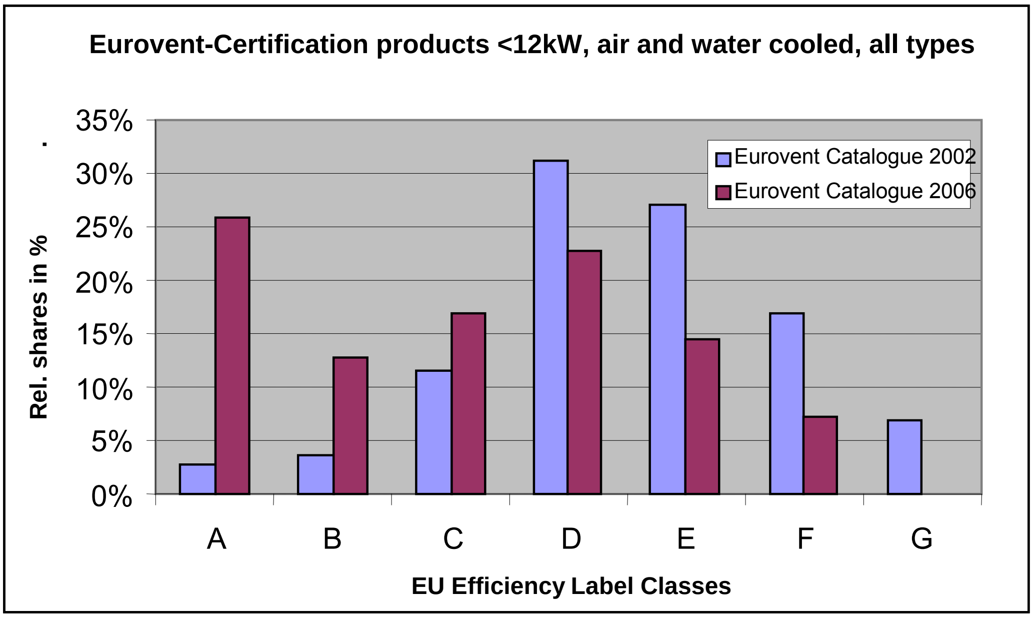


Table 1-53: AC below 12 kW regarding Label-Classes – relative shares

Energy classes	A	B	C	D	E	F	G	Total
Eurovent Catalogue 2002	3%	4%	12%	31%	27%	17%	7%	100%
Eurovent Catalogue 2006	25,8%	12,9%	16,8%	22,7%	14,4%	7,4%	0,1%	100%

Figure 1-12: Comparison of Eurovent-Certification registered products with a cooling power below or equal 12 kW regarding Label-Classes – relative shares



EU Ecolabel for heat pumps

The European Eco-label is voluntary tool which was established in 1992 and revised in 2000, when its scope was extended from products to services. Its Flower logo is awarded to the products which have the least environmental impact throughout their entire life-cycle. It enables manufacturers to attract attention to their environmentally friendly products or services and helps consumers identify them. The Eco-label products are checked by independent bodies to ensure that they comply with the environmental performance criteria.

The European Eco-label is only awarded to products or services which are at least as efficient as conventional ones. More than 310 companies have been awarded the Flower Eco-label logo so far. The Flower logo can, therefore, be found on several hundreds of products today.

A initiative has been started in 2005 to develop eco label criteria for heat pumps. This could be of relevance for this study, as definitions and requirements can work as a precursor for air conditioning equipment regarding the requirements for energy efficiency and refrigerants, too. A first discussion draft for ecological criteria for the award of the Community eco-label to heat pump system is available since November 2005.
A final draft for Ecolabelling criterial for heat pumps was published on 28 November 2006.

The scope for these criteria shall be
- single heat pump units and
- heat pump systems for indoor air heating and hot water supply

The product group is covering applications for cooling and heating in combination, too.

The key criteria comprise the following requirements:
- Heat production efficiency
- Global warming impact
- Refrigerant
- Cooling medium / secondary refrigerant
- Heavy metals and flame retardants
- Noise
- Competence
- Information to the user

Regarding energy efficiency in detail, heat production efficiency shall exceed 80%, calculated as the produced useful heat per primary energy used during a defined period of time. If the heat pump is equipped with a cooling function, the heat pump shall be tested during use for all defined test temperatures in the test standard. Furthermore if the heat pump unit can be used for cooling as well , the efficiency shall be declared.

The criteria requires a refrigerant's GWP (global warming potential) lower than 2000 over 100 year period. If a refrigerant with a GWP value of more than 100 is used,
- the impact of the green house effect from the use of refrigerant with a GWP greater than 100 shall be compensated though a higher efficiency
- the system must not be constructed as an open system on both sides of the heat pump

More general than up-to-date-Information can be found on the website http://ec.europa.eu/environment/ecolabel/product/pg_heatpumps_en.htm

German Label "Blauer Engel"

A spotlight has to put to the German Eco-label system "Blauer Engel", which comprises definitions for heat pumps by now, applying the TEWI-approach. The document "BASIC CRITERIA FOR THE AWARD OF THE ENVIRONMENTAL LABEL – Energy-Efficient Heat Pumps using an Electrically Powered Compressor, RAL-UZ 121" gives the references.

Figure 1-13: Label "Blauer Engel"

These Award Criteria apply to heat pumps using an electrically powered compressor according to DIN EN 255/EN 14511 taking into account VDI Directive 4650, Sheet 1, “Assessment of heat pumps - Short-cut method for the calculation of the annual effort figure of heat pumps - Electrically powered heat pumps for room heating” (original title “Berechnung von Wärmepumpen; Kurzverfahren zur Berechnung der Jahresaufwandszahlen von Wärmepumpenanlagen; Elektro-Wärmepumpen zur Raumheizung“) with a total thermal output of up to 100 kW at a flow temperature of 45°C meeting the requirements defined below. These Award Criteria refer to factory manufactured compact units for room heating purposes.

The “global warming potential” (GWP) of a substance measures its negative impact on the climate. The GWP values are related to CO_2 as a reference substance and a time horizon of 100 years.
The energetic efficiency of the systems is expressed by the seasonal performance factor (SPF) for the respective systems (water, brine, air). The SPF measures the heating efficiency of a system taking the local operating conditions and the course of the year into account.
TEWI (total equivalent warming impact) is a system parameter for an ecological evaluation of heat pumps. This balance value measures the impact of a system on the climate by means of a CO_2 equivalent. It considers the direct influence of the refrigerant used as well as the indirect influence of the climate change potentials arising from the driving energy. It ensures that the emissions from climate-changing refrigerants are taken into account in an overall assessment.
SPF as well as GWP and the filling quantity of the refrigerant are used as system specific quantities when determining the TEWI value.

Requirements
Declaration of Conformity
A prerequisite for award of the Environmental Label shall be a declaration of conformity (e.g. Gas Appliances Directive) and the authorization to use the CE Label for the heat pump unit.

TEWI Limits
The climate-changing emissions from heat pumps are evaluated by using the TEWI value as system parameter. TEWI describes the climate effect of a system via a CO_2-equivalent. Fixing TEWI limits instead of seasonal performance factor limits of the heat pump system or the GWP of refrigerants allows to compensate emissions from refrigerants with a high global warming potential for very low energy-related Emissions (highly efficient systems) and vice versa.
The applicant shall demonstrate that the TEWI value of a heat pump system does not exceed the limits specified in Table 1. Lower TEWI values will have to be observed from 1 January 2008.

Compliance with these values can be achieved by

- using refrigerants with a low GWP in energy-efficient products (state of the art)

or

- further increasing the efficiency of products using refrigerants with a high GWP.

Table 1-54: TEWI Limits (the second value - i.e. the value in brackets- will be binding from 1 January 2008)

Type of heat pump	Thermal output [kW]	TEWI value (flow temperature 35°C) [kg CO2]	TEWI value (flow temperature 45°C) [kg CO2]
Water-to-Water	0 - 20	35,000 (32,500)	37,500 (35,000)
	> 20	70,000 (65,000)	75,000 (70,000)
Brine-To-Water	0 - 20	42,000 (39,000)	45,000 (42,000)
	> 20	84,000 (78,000)	90,000 (84,000)
Air-to-Water	0 - 20	51,500 (48,000)	55,000 (51,500)
	> 20	103,000 (96,000)	110,000 (103,000)
Exhaust air-to-water	0 - 20	46,000 (43,000)	50,000 (47,000)
	> 20	92,000 (86,000)	100,000 (94,000)

The TEWI value is calculated using the following formula:

$$TEWI = GWP * (ER * n * m + \alpha_v * m) + n * \beta * Q/SPF$$

using the following operands:

- GWP: Global warming potential [-]
- ER: Emission rate [%/a]
- n: Life of a system [a]
- m: Filling quality of refrigerant [kg]
- α_v: Disposal loss [%]
- β: Conversion factor [kg CO_2/kWh]
- Q_h: Heat demand [kWh/a]
- SPF: Seasonal performance factor [-]

Calculation shall be performed using the following parameters:

- annual emission rate of 2 %
- product life of 15 years
- disposal loss of 20 %
- uniform conversion factor: 0.683 kg CO_2/kWh
- heat demand for systems up to 20 kW: 15.000 kWh/year
- heat demand for systems over 20 kW: 30.000 kWh/year

The Global Warming Potentials (GWP values) listed in Table 2 shall be used.

Table 1-55: Global Warming Potential of selected refrigerants (list to be extended)

Refrigerant (Code designation)	Refrigerant (Chemical designation)	Global Warming Potential (GWP100)
R 134a	Tetrafluoroethane	1300
R 290	Propane	3
R 404A	Mixture of trifluoroethane, tetrafluoroethane, pentafluoroethane	3260
R 407C	Mixture of difluoromethane, tetrafluoroethane, pentafluoroethane	1526
R 410A	Mixture of difluoromethane, pentafluoroethane	1725
R 417A	Mixture of butane, tetrafluoroethane, pentafluoroethane	1965
R 744	Carbon dioxide	1
R 1270	Propene (propylene)	3

At present no heat pump is registered in the data base for fulfilling the above mentioned requirements.

Nordic Ecolabelling – Ecolabelling of Small heat pumps

General requirements

The current version (1.7, 3 May 2006) of the specification for ecolabelling of small heat pumps defines requirements for the following criteria:

- choice of refrigerants and cooling media,
- materials employed,
- design of the heating system,
- efficiency and noise,
- scope available for materials recycling, and for the selection of plastic, paint and coating materials,
- a certain level of quality in production,
- a comprehensive installation manual. Great emphasis is placed on the contents. The objective is that the manufacturer shall ensure that the customer is informed of how the installation and operation must be carried out in order for the heat pump to perform as an environ-mentally appropriate heating system.

The product group comprises small stationary, electrically driven heat pumps with a compressor motor rating between 1 kW and 10 kW at the nominal operating point, which corresponds to around 3 kW to 30 kW heat output for heating smaller houses or groups of houses. Solar collectors can be a part of the heating system.
At present one manufacturer (IVT Industrier AB) is holding a license for two of his product lines.

The requirements regarding refrigerants and efficiency are listed below in detail:

Refrigerants

The refrigerant and its constituents must not have an ODP value > 0 nor a GWP value > 1,900 over a 100 year period. ODP is the abbreviation for ozone depletion potential and GWP the abbreviation for global warming potential.

Requirements on efficiency of the heat pump

The coefficient of performance (COP), calculated on the basis of the coefficient of performance in the refrigeration cycle, related to water/water, liquid/water and outdoor air/water, must correspond to at least 25% of the thermodynamically attainable limit value on the basis of the temperatures of the cooling medium and the heating medium. Corresponding requirements relating to outdoor air/air, water/air and liquid/air mean that the coefficient of performance must correspond to at least 9%.

The coefficient of performance (COP) when tested in accordance with chapter 7.3, and at the operating points tested in accordance with EN 255 shall exceed:

For water/water, liquid/water and outdoor air/water

$$COPmin = 0.25 * Tk / (Ts-Tk) +1$$

For outdoor air/air, exhaust air/air, water/air and liquid/air:

$$COPmin = 0.09 * Tk / (Ts-Tk) +1$$

where:
Ts = heating medium temperature in Kelvin as per EN 255
Tk = cooling medium temperature in Kelvin as per EN 255

For air cooled ("COP20") and water cooled (leaving water temperature 35 °C –"W35" and 45 °C – "W45") heat pumps, these minimum performances are shown on the graph below.

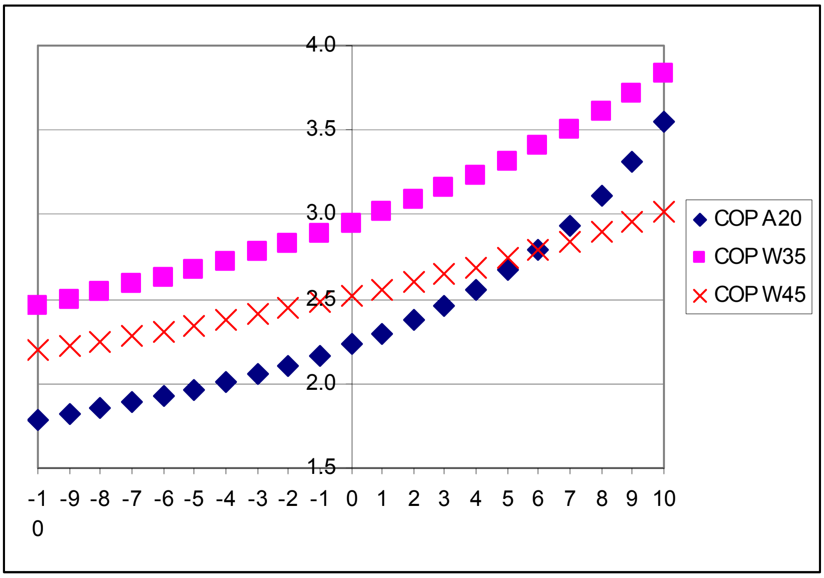


Figure 1-14: Nordic Ecolabelling, minimum allowable coefficient of performance as a function of the cool source temperature

1.3.3 Legislation at Member State Level

Since legislation at Member State level follow the European Directives, there appears to be no other particular outstanding legislation at member state level with relevance for the scope of this study apart from different approaches and time schedules for the national application of the Directives.

Nevertheless major differences in the concrete application of Directives may challenge a comprehensive and detailed review of the relevant frame work conditions on Member State level in regard to the Directives' topics.

1.3.3.1 Application of environmental Directives (RoHS, WEEE)

As the WEEE Directive is based on Article 175 of the Treaty establishing the European Community Member States see high flexibility in matters of application. Whereas for RoHS Directive there is a slightly different starting position, because this is based on Article 95 addressing the establishment and functioning of the internal market. National applications of the WEEE Directive – as already mentioned - are quite divergent.

The question how manufacturers adapt to the variation in national implementation schemes regarding the WEEE directive is not completely answered. Information on existing importance of refurbishment, recycling, scrapping and how is this likely to change is not available.

The national approaches for the definition of the scope (Categories of electrical and electronic equipment covered by the directive) in correspondence to the scope of this study need further evaluation.
It was noticed that several countries are distinguishing between mobile appliances and fix installations in particular Split, Window, Packaged are excluded in the view of several applications.

For the WEEE directive, three main approaches – not necessarily excluding each other - are considered in discussions with stakeholders:
- All plug in appliances (to be connected to the mains by a plug) are covered, because the others are to be installed and dismantled by professionals only (valid for the UK) – fixed installations are seen as a system and a part of the building, not an appliance
- All room air conditioners to be covered, which the Energy Labelling Directive applies to (valid for Italy and The Netherlands in the future)
- All room air conditioners to be covered, which are under a certain limit of rated cooling performance (valid for Portugal (7kW), Italy 12 kW, opposite to Greece, which has no limit in force).

For countries where the ROHS directive has been transposed (Eurovent, 2007), it appears that air conditioners with a cooling capacity lower than 12 kW (covered by the energy label) are included and then it covers the scope of our study.

Stakeholders[18] have also recalled that preceding application of the set up of a collecting system for air conditioner in Holland was already experimented by the past. A fee was collected from manufacturer in a system similar to nowadays WEEE collecting scheme but no unit came back so that the fee stopped to be collected and the system was abandoned. Two reasons have been given for the failure: first, air conditioners are a growing market so that fees are collected today on an important number of models but little units are recovered and treated. First experience in Spain exhibited ratios of 5 %. Second, because of its high copper content, split air conditioners have a high commercial value. Then, there is little reason why not to recover this money (with possible refrigerant gas venting to the atmosphere to separate indoor and outdoor units).

[18] In the minutes of the second stakeholder meeting.

<u>Term “Post-RoHS Room Air conditioner”:</u>

A significant number of pieces had to be redesigned (e.g. electronics, sheet metals galvanized with Cr, PCBs. Problems have occurred with suppliers that were not supplying for the automotive industry too, concerning the availability of pieces.

1.3.3.2 Issues related to Energy Performance of Buildings or Building Codes

Effects and prospects of Energy Performance of the EPB Directive are expected, namely those addressed by Art. 4 “Performance”, Art. 6 ”Existing buildings”, Art. 7 ”performance certificate”

Art. 9 «Inspection of AC-Systems»
The EPBD defines an air-conditioning system as “a combination of all components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity, and air cleanliness”. Moreover, “the effective rated output (expressed in kW) is the maximum calorific output specified and guaranteed by the manufacturer as being deliverable during continuous operation while complying with the useful efficiency indicated by the manufacturer”. However, even after defining those terms, article 9 remains unclear because the 12-kilowatt limit can be defined in several ways. Member States will have to define the meaning of the 12-kilowatt limit through a cost/benefit analysis (Dupont, Adnot, 2005).
That limit is associated on the one hand to an energy saving potential and on the other hand to a workload (number of inspections). The lower the limit (the wider the scope), the higher the workload but the higher the energy savings. One can understand the weight of consequences generated by that definition. There are 4 main ways to understand the boundary:
- 12 kW per cooling system. Only systems with an effective rated output over 12 kilowatts will be taken into account.
- 12 kW per temperature controlled zone. Every cooling system included in the same thermal zone (bound by a common control system) but with a total effective rated output of the zone over 12 kW is taken into account. (The rated output of each system can be lower than 12kW)
- 12 kW per building. Every cooling system included in the same building (bound by exterior walls) but with a total effective rated output for the building over 12 kW is taken into account. (The rated output of each system can be lower than 12kW)
- 12 kW per owner (or tenant) in a given building. Based on previous technical definitions, the scope may be extended to the real ownership in case of a share of the building.

The first definition is really simple and any building owner can easily determine eligible equipments by looking at nameplates. Indeed, any central air-conditioning (CAC) system is necessarily taken into account. However, most of room air-conditioning (RAC) systems and certain distributed air-conditioning systems (such as water loop heat pump systems) are not included in the scope, thus reducing the energy saving potential of such a measure.
The second definition integrates installations based on low capacity equipment and Equipped with a common control system. This new definition widens the scope under certain conditions. In a water loop heat pump system, one (ore more) low capacity heat pump is installed in each thermal zone but its control is independent. These reversible heat pumps operate on a water loop the temperature of which is controlled by a heating system (boiler, heat recovery exchanger) during winter, by a cooling system (cooling unit, cooling tower) during summer or both during intermediate seasons. Although not very common , these large installations should be included into the scope but are excluded by the previous definition.
The third definition allows inspection to take into account any equipment included in a building even if its capacity is lower than 12 kW, since the total effective rated output of all systems is higher

than 12 kW. The scope of regular inspection is thus widened but now takes into account some equipment for which the potential energy savings are low.
Although using the same technical definitions of the 12kW limit, the fourth definition takes into account the ownership of the building and systems. Indeed, it is very difficult to imagine that that owners of different parts of a single building will exchange technical information about their systems. With this definition, there are as many inspections as there are owners in a building, but we know who is responsible for the inspection : the owner. The definition allows us to define easily who is the responsible of the installation and links the inspection responsibility to those who can best take action on the results. Where buildings have multiple tenants whose leases include the provision of air-conditioning as a landlord service, this definition reverts to 12kW per building.
Globally, the inspection must avoid introducing distortions into the air-conditioning market. Indeed, too heavy, too long, too frequent and thus in short too constraining and expensive procedures for the building owner could lead him to buy equipment not covered by inspection. For example, the fourth definition above provides an incentive for to provide each tenant with an installation of less than 12kW capacity (rather than a centralised system), even though the total installed capacity of the building is high. (It is an open question which solution would be the more energy efficient).

1.3.3.3 Issues related to Refrigerants

According to Art. 9 (3) of the F-Gas Regulation Austria and Denmark have successfully claimed for bans imposed on certain fluorinated greenhouse gases (F-gases).

In Germany, the German Regulation “Chemikalien-Klimaschutzverordnung” entered into force on 1 August 2008 and includes national measures which are stricter than those of the Regulation 2006/842/EC on fluorinated greenhouse gases. The German law sets the following maximum limits for the leakage of hydrofluorocarbons from systems installed after 30 June 2008: 1% per year for systems containing more than 100 kg of refrigerant and 3% for systems with less than 10 kg of HFCs.

Regarding the situation in Austria, the responsible body, the Federal Ministry of Agriculture, Forestry, Environment and Water Management is considering an amendment, aiming at a rescission of the former position.
At least one country, France, has specific limitations for the use of refrigerating equipment that contain refrigerant in buildings intended to welcome public, in addition to existing EN 378 standard.

1.3.4 Third Country Legislation

Several economies worldwide are tightening (and will tighten in near future) minimum requirements for Room Air conditioners. The most ambitious Minimum Energy Performance Standards (MEPS) programmes are presented below. The main source of information used is the very complete website of APEC-ESIS.

1.3.4.1 Australia

Energy conservation

Current and future MEPS requirements are set out in AS/NZS 3823.2-2005[19].

MEPS: MINIMUM EER FOR AIR COOLED CONDENSER AIRCONDITIONERS (from AS/NZS 3823.2-2005)

Table 1-56: Non ducted unitary (window/wall)

Cooling only or reverse cycle	Rated cooling capacity (kW)	Min EER 1 Oct 2004	Min EER 1 Apr 2006	Min EER 1 Oct 2007	Min EER 1 Oct 2008
Cooling Only	< 7.5	2.45	2.75	2.75	2.84
	7.5 to <10	2.45	2.45	2.75	2.84
	10.0 to 18.9	2.45	2.45	2.75	2.75
Reverse Cycle	< 7.5	2.30	2.75	2.75	2.84
	7.5 to < 10	2.30	2.30	2.75	2.84
	10.0 to 18.9	2.30	2.30	2.75	2.75

Table 1-57: Non ducted split

Cooling only or reverse cycle	Rated cooling capacity (kW)	Min EER 1 Oct 2004	Min EER 1 Apr 2006	Min EER 1 Oct 2007	Min EER 1 Oct 2008
Cooling Only	< 4	2.45	3.05	3.05	3.33
	4 to < 7.5	2.45	2.75	2.75	2.93
	7.5 to < 10	2.45	2.45	2.75	2.93
	10.0 to 18.9	2.45	2.45	2.75	2.75
Reverse Cycle	< 4	2.30	3.05	3.05	3.33
	4 to < 7.5	2.30	2.75	2.75	2.93
	7.5 to < 10	2.30	2.30	2.75	2.93
	10.0 to 18.9	2.30	2.30	2.75	2.75

As specified in the analysis of the ISO 5151 standard, the CEN standard EN 14511 corrects the EER value of ducted units to make EER of ducted and non ducted units comparable. Hence, specific requirements of ducted units are not reported.

In addition, "for MEPS purposes:
- at least one unit has to be tested (or simulated) and results supplied with the application
- physical tests in a calorimeter or using the enthalpy method are acceptable
- simulation to AS/NZS 3823.3 is an acceptable alternative to physical tests
- cooling capacity and energy consumption is determined to condition T1

[19] More information is available on http://www.energyrating.gov.au/pac1.html.

- heating capacity and energy consumption is determined to condition H1 (ISO condition "high")
- for each unit tested, the measured capacity shall be > 0.95 of the rated value
- for each unit tested, the measured energy consumption shall be < 1.05 of the rated value."

Hence, **tolerance of 10 % is allowed on the EER**.

Stand-by program

Australia is planning to fix stand-by targets, in OFF-mode and passive stand-by mode for air conditioners as described below, with targets in 2007 and 2012. Mandatory reporting of standby for energy labelling registrations is also in progress (AGO, 2006). Requirements are reported below:

"Interim year and target: 2007,
• Single phase unitary units and all portable units: less than 1 Watt in off mode, less than 2 Watts in passive standby mode.
• Split system units and three phase units up to 65 kW cooling capacity: less than 1 Watt in off mode, less than 2 Watts in passive standby mode.
• Units with sump heaters: mandatory use of Positive Temperature Coefficient heaters from 2007 (the heater must be controlled as a function of outdoor air temperature).

Final 2012 target:
• Single phase unitary units and all portable units: less than 0.3 Watts in off mode, less than 1 Watt in passive standby mode.
• Split system units and three phase units up to 65 kW cooling capacity: less than 0.3 Watts in off mode, less than 1 Watt in passive standby mode.
• Units with sump heaters: mandatory use of Positive Temperature Coefficient heaters from 2007. "

1.3.4.2 Canada

Energy conservation

Mandatory MEPS for window/wall air conditioners

Canada has mandatory MEP applied to single-phase electric room air conditioners that are not "packaged terminal air conditioners" and that do not exceed 10.55 kilowatts (36 000 Btu/h).
In proposed amendment to this regulation, units offering reverse cycle are explicitly covered. Two categories are recognized separately and are defined as follows:
Casement-only: a room air conditioner designed for mounting in a casement window with an encased assembly with a width of 376 mm (14.8 in.) or less and a height of 284 mm (11.2 in.) or less.
Casement-slider: a room air conditioner with an encased assembly designed for mounting in a sliding or casement window with a width of 394 mm (15.5 in.) or less.

Table 1-58: MEPS Requirements Minimum allowable EER

Product Class	**Cooling (Heating) Power in Btu/h (kW)**	**Minimum EER, ratio Btu/h / W (W/W)**
	Cooling Only	
with louvered sides	Less than 6000 (1.76)	9.7 (2.84)
	6000 (1.76) to 7999 (2.34)	9.7 (2.84)
	8000 (2.34) to 13 999 (4.10)	9.8 (2.87)
	14 000 (4.10) to 19 999 (5.86)	9.7 (2.84)
	20 000 (5.86) and over	8.5 (2.49)
without louvered sides	Less than 6000 (1.76)	9.0 (2.64)
	6000 (1.76) to 7999 (2.34)	9.0 (2.64)

	8000 (2.34) to 13 999 (4.10)	8.5 (2.49)
	14 000 (4.10) to 19 999 (5.86)	8.5 (2.49)
	20 000 (5.86) or more	8.5 (2.49)
Cooling and Heating		
with louvered sides	less than 20 000 (5.86)	9.0 (2.64)
	and 20,000 (5.86) or more	8.5 (2.49)
without louvered sides	less than 14 000 (4.10)	8.5 (2.49)
	and 14 000 (4.10) or more	8.0 (2.34)
Casement-Only		8.7 (2.55)
Casement-Slider		9.5 (2.78)

Where EER = Energy efficiency ratio - a ratio calculated by dividing the cooling capacity in Btu per hour by the power input in watts at any given set of rating conditions.
1 Btu/h is 0,2931 W

These MEPS requirements are effective from January 2003.

Implementing Agency: Office of Energy Efficiency
More Information: http://oee.nrcan.gc.ca - Office of Energy Efficiency

Mandatory MEPS for central air conditioners

For air conditioners and heat pumps of less than 19 kW (65,000 Btu/h) and within the scope of the CSA C656-05 test method, NRCan expects to reference the following minimum Seasonal Energy Efficiency Ratings (SEER) and Heating Season Performance Factors – Region V (HSPF V):
These MEPS requirements are effective from November 2006.

Table 1-59: MEPS requirements for central air conditioners - Canada

	SEER	**HSPF (Climate Zone V)**
Air Conditioners – single pkg & split-system – cooling only	13 (3.8)	
Heat Pumps – single pkg & split-system – cooling and heating	13 (3.8)	6.7 (2.0)
AC & HP – through-the-wall, cooling and heating – (until January 22, 2010)	10.9 (3.2)	6.2 (1.8)
AC & HP – through-the-wall, cooling – (after January 23, 2010)	12 (3.5)	6.4 (1.9)
AC & HP – small duct, high velocity (SDHV) – cooling and heating	11 (3.2)	5.9 (1.7)

Where
SEER = Seasonal energy efficiency ratio – the total cooling of a central air conditioner or heat pump in Btu during its normal annual usage period for cooling, divided by the electric power usage in watt-hours during the same period
HSPF = Heating seasonal performance factor (Region V) – the total heating output of a heat pump during its normal annual usage period for heating, divided by the total electric power input in watt-hours during the same time period

More information:

http://oee.nrcan.gc.ca/regulations/november2005-ac-heatpumps.cfm?text=Y&printview=N

1.3.4.3 China

Product environmental legislation

- Administrative Measure on the Control of Pollution Caused by Electronic Information Products (China RoHS)

As of March 1, 2007, manufacturers are required to restrict the use of the same substances as targeted by the EU RoHS Directive. The difference is that all products have to be tested in an authorised laboratory before they can be sold in China. Air conditioners are included. However, the legislation is not covering export from China.

Products are defined in the "Note for Classification of Electronic Information Products". Legal text (unofficial translation from AeA), http://www.aeanet.org/governmentaffairs/gabl_ChinaRoHS_FINAL_March2006.asp. Product list (unofficial translation from AeA): http://www.aeanet.org/governmentaffairs/gabl_HK_Art3_EIPTranslation.asp

- Management Regulation for Recycling and Re-use of Household Electronic Products. (2003)

The draft “Management Regulation on the Recycling and Disposal of Used Home Appliances and Electronics Products” has provisions on mandatory reclamation by manufacturers of five home appliances including television, refrigerator, washing machine, air conditioner and computer.

Energy conservation

GB 12021.3-2000/2004 - The limited value of energy efficiency and evaluating values of energy conservation for room air conditioners

Program Type: Minimum Energy Performance Standard - Mandatory
Product: RACs (Split, Window)
Test Standard: GB/T 7725-1996 , GB 12021.3-2000
Reference Test Standard: ISO 5151

Table 1-60: MEPS Requirements - China Room Air Conditioner Energy Efficiency Criteria

Type	Rated Cooling Capacity (CC) kW	EER W/W	
		Cooling Only	Heat Pump
Single-Package	CC ≤ 4.5	2.35	2.30
	CC > 4.5	-	-
Split	CC ≤ 2.5	2.85	2.75
	2.5 < CC ≤ 4.5	2.70	2.60
	CC > 4.5	2.55	2.45

Year Published: 17-09-2000
GB 12021.3-2000 - revised MEPS
Year Effective: 2001
The above table of revised Chinese MEPS for room air-conditioners (GB 12021.3-2000) became effective in 2001 First MEPS number: GB 12021.3-1989, The limited value of energy consumption and method of testing for room air conditioners; published 25 December 1989

China's New Standard for Room Air Conditioners

China's new standard for air conditioners sets two tiers of performance requirements, with the first tier going into effect on March 1, 2005, and the second tier going into effect on January 1, 2009. The 2005 requirements are listed in the table below. The measured value of energy efficiency ratio (EER) of room air conditioners must be greater than or equal to the values shown.

Table 1-61: MEPS Requirements - Energy Efficiency Ratios (EER) (effective March 1, 2005), from (Lin, 2006)

Type	Rated Cooling Capacity (CC) kW	EER W/W
Single-Package	-	2.30
Split	CC $\leq$ 4.5	2.60
	4.5 < CC $\leq$ 7.1	2.50
	7.1 < CC $\leq$ 14	2.40

In addition to setting the minimum requirement, China's new AC test standard also include classification requirements for the newly established Energy Information Label, as well as the certification requirement for CECP's Energy Conservation Label.

For China's voluntary energy endorsement label (managed by China Standard Certification Center), the EER requirements of room air conditioners must be greater than or equal to the values shown below. This voluntary label should become the new MEPS levels on 1 January 2009 (Announcement of Newly Approved National Standards of P.R.China 2004 No.9).

Table 1-62: Energy Efficiency voluntary label and MEPS levels 2009

Type	Rated Cooling Capacity (CC) kW	EER W/W
Single-Package	-	2.90
Split	CC $\leq$ 4.5	3.20
	4.5 < CC $\leq$ 7.1	3.10
	7.1 < CC $\leq$ 14	3.00

Plans for heating mode minimum COP are not known.

1.3.4.4 Japan

Product environmental legislation

- Electrical Appliance & Material Safety Law JGPSSI (Japan Green Procurement Survey Standardisation Initiative)

* Governs the use and control of hazardous substances in sold products .
* A voluntary industry collaboration for selecting suppliers.
Suppliers must eliminate up to 35 hazardous substances, including leaded solders from electronics.

Legal text (unofficial translation)
http://www.jetro.go.jp/en/market/regulations/pdf/denan-2001nov-e.pdf

Product list
http://www.jetro.go.jp/en/market/regulations/pdf/denansekourei2001nov-e.pdf

- HARL--Home Appliance Recycling Law (2002) & Landfill Restrictions (2001)

The "Law for Recycling of Specified Kinds of Home Appliances" (Home Appliance Recycling Law) came into force in April 2001. It is clarifying the role-sharing between consumers, retailers and home appliance manufacturers in managing used home appliances discharged from households, with the aim of promoting waste reduction and recycling.
Home appliances to be regulated are air conditioners, television sets (limited to CRT-types), refrigerators, freezers, and washing machines.
http://www.meti.go.jp/policy/recycle/main/data/pamphlet/pdf/cRecycle3R.pdf

Energy conservation

Top Runner Program for Room AC (unitary with colling capacity < 28 kW)

Japan does not have MEPS; instead it operates the Top Runner standards program. This program aims to improve energy efficiency of appliances by setting target values based on the current highest efficiency level of each type of product instead of the current average efficiency level. Manufacturers and importers have to ensure the average (sales weighted) efficiency of all their appliances meet this standard by a specified date (the target year). The program allows a continuum for improvement over time making manufacturers constantly increase the efficiency of appliances. The Top Runner standards are voluntary as there is no minimum level, however penalties can be evoked if the average efficiency target is not met. The Ministry of Economy Trade and Industry monitor the program and it is legislated through the Energy Conservation Law. The program so far has been quite successful with most manufacturers gearing up to meet the targets. When the target year is reached, new target levels can be established.

1) Target Scope: Air conditioners, heaters and air conditioners. Excludes equipment using energy sources other than electricity for heating, types whose cooling capacity is over 28 kW, water-cooled types, and others stipulated under Ministry of Economy, Trade and Industry ordinances.

2) Energy Consumption Efficiency: Cooling energy consumption efficiency is a numeric value obtained by calculating cooling capacity as measured in the manner stipulated by Japanese Industrial Standards (JIS) B8615-1 or B8615-2, divided by cooling power consumption measured in the same way (known as COP).
For air conditioners/heaters, it is a numeric value acquired by calculating total cooling energy consumption efficiency and heating energy consumption efficiency, obtained in the same manner as cooling energy consumption efficiency, divided by two as the average of cooling/heating energy consumption efficiency.

3) Category and Target Values:

Table 1-63: Top runner requirements for air conditioners

Category		Energy efficiency targets	
Unit type	**Cooling capacity**	**Reversible air conditioners (COP+EER)/2**	**Cooling only air conditioners EER**
Non-ducted window- or wall-installed type		2.85	2.67
Non-ducted wall-mounted type (excluding individually operated indoor units in the group of a multi type)	Less than 2.5 kW	5.27	3.64
	2.5 or more and up to 3.2 kW	4.90	3.64
	3.2 or more and up to 4.0 kW	3.65	3.08
	4.0 or more and up to 7.1 kW	3.17	2.91
	More than 7.1 kW	3.10	2.81
Other non-ducted type (excluding individually operated indoor units in the group of a multi type)	Less than 2.5 kW	3.96	2.88
	2.5 or more and up to 3.2 kW	3.96	2.88
	3.2 or more and up to 4.0 kW	3.20	2.88
	4.0 or more and up to 7.1 kW	3.12	2.85
	More than 7.1 kW	3.06	2.85
Ducted type (excluding individually operated indoor units in the group of a multi type)	Less than 4.0 kW	3.02	2.72
	4.0 or more and up to 7.1 kW	3.02	2.71
	More than 7.1 kW	3.02	2.71
Multi type with individually controlled operation of indoor units	Less than 4.0 kW	4.12	3.23
	4.0 or more and up to 7.1 kW	3.23	3.23
	More than 7.1 kW	3.07	2.47

Revision of the Top Runner Program for Room AC (unitary with cooling capacity < 28 kW)
The Target Fiscal Year for achievement of the average COP is:
- the Refrigerating year 2007: October 1, 2006 to September 30, 2007
- Refrigerating year 2004 (October 1, 2003 to September 30, 2004) for non-ducted wall-mounted types for cooling/heating of less than 4 kW.

Given the high energy efficiency levels reached, the manufacturers decided to adopt targets in terms of annual performance factor values. Proposed values are:
- Up to 3.2 kW: APF of 5.8 for units that have defined (restricted) dimensions, 6.6 for physically larger ones)
- 3.2 to 4 kW: APF of 4.9 and 6.0 for limited size and no restriction respectively

Tolerances
The heating and cooling capacities must be not less than 92% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 23%.

These tolerances have been reduced in the two APF standards (JRA, 2004 and 2006) to 15 % for residential products and 10 % for commercial products.

Stand-by 1 W program

The air conditioning industry committed in a 1 W program: all air conditioners with cooling capacity inferior to 4 kW sold in 2004 had to respect a maximum 1 W stand-by electric consumption. It is reported by JRAIA that 75 % of all sold units already achieved the targets in 2003 and that the target has been reached in 2004 (ECCJ, 2006). Electric oil heater, as a necessary function, is not embedded in the 1 W consumption since temperature measurement are done at 35 °C and that all these units have some kind of positive temperature controller.

Sources
http://www.eccj.or.jp/index_e.html - Energy Conservation Centre Japan
http://www.eccj.or.jp/law/e_machine/01.html

1.3.4.5 Korea

Product environmental legislation

Korea follows RoHS and WEEE, with the difference that the Korean law covers both electronics and automotives in the same legislation.

Energy conservation program

MEPS requirements for Split Air Conditioners

This MEPS level is available to both room-air conditioner with a constant speed compressor and variable-speed. RCC is the rated cooling capacity.

Table 1-64: MEPS Requirements for split appliances

	EER
RCC < 4.0 kW	3.37
RCC 4.0 kW - 10.0 kW	2.97
RCC 10.0 kW - 17.5 kW	2.76

This MEPS level is effective from 1 January 2004.

More information:
Korea Energy Management Corporation - http://www.kemco.or.kr/english/index.html
Korea Institute of Energy Research - http://www.kier.re.kr/indexe.htm

MEPS requirements for window Air Conditioners

EER>= 2.88
Year Published: 16-02-2002
Year Effective: 01-01-2004

Stand by

Korea adopted a warning label to highlight air conditioners (and other appliances) that did not respect the 1 W (stand by or off mode) target.

1.3.4.6 Chinese Taipei

Energy conservation program

MEPS Requirements for package air conditioners

Table 1-65: MEPS Requirements for Packaged air conditioners

	allowable minimum EER (W/W)
Air Cooled (power consumption < 3 kW)	2.84
Water Cooled	3.69

Noise Level for the Package Unit
Rating Capacity below 13 kW - Indoor below 63 dBA - Outdoor below 68 dBA
Rating Capacity below 26 kW - Indoor below 66 dBA - Outdoor below 71 dBA

Year Effective: 01-01-2002

Test Standard: CNS 3615-95 , CNS 7183

MEPS Requirements for split appliances

It is based on testing standards CNS 3615, CNS 14464 and CNS 7183 (Noise Level)

Table 1-66: MEPS Requirements for split appliances

Cooling Capacity	allowable minimum EER (W/W)
less than 4.1 kW General	2.97
less than 4.1 kW Inverter (60 Hz)	2.77
more than 4.1 kW General & Inverter (60 Hz)	2.73

Noise Level for the Room Air Conditioners
- Rating Cooling Capacity less than 2.6 kW - Indoor 53 dBA - Outdoor 58 dBA
- Rating Cooling Capacity between 2.6 kW and 4.1 kW - Indoor 58 dBA - Outdoor 63 dBA
- Rating Cooling Capacity more than 4.1 kW - Indoor 63 dBA - Outdoor 68 dBA

Year Effective: 01-01-2002

How to obtain additional information:
http://www.moeaec.gov.tw - Energy Commission

MEPS Requirements window appliances

It is based on testing standards CNS 3615, CNS 14464 and CNS 7183 (Noise Level)

Table 1-67: MEPS Requirements for window appliances

Cooling Capacity	allowable minimum EER (W/W)
less than 2.3 kW General	2.71
between 2.3 kW and 4.1 kW	2.77
more than 4.1 kW	2.60

Noise Level for the Room Air Conditioners
- Rating Cooling Capacity less than 2240 KCal/hr - Indoor 53 - Outdoor 58
- Rating Cooling Capacity between 2500 and 3550 KCal/hr - Indoor 58 - Outdoor 63
- Rating Cooling Capacity more than 4000 KCal/hr - Indoor 63 - Outdoor 68

Tolerances

Tolerances on EER is fixed to 20 %.

Year Effective: 01-01-2002

How to obtain additional information:
http://www.moeaec.gov.tw - Energy Commission

1.3.4.7 USA

Product environmental legislation

In the United States, there is no federal or national environmental regulation equivalent to the European Union's WEEE and RoHS. California and Massachusetts have laws restricting the use of hazardous substances.
Appliance manufacturers and the US Environmental Protection Agency have developed a voluntary program to reduce hydrofluorocarbon (HFC) emissions from the manufacture of household refrigerators and freezers in the US.

The California Senate Bill No. 50 (Chapter 863) prohibit an electronic device from being sold after January 1, 2007, if the electronic device is prohibited from being sold in the European Union, to the extent that Directive 2002/95/EC, prohibits that sale due to the presence of certain heavy metals.

The program outlines strategies to reduce emissions during all stages of production.
www.ciwmb.ca.gov/electronics/act2003/

Does not have a national policy or legislation at present
California; Electronic Waste Recycling Act (2003)
* Reduction in hazardous substances used in certain electronic products sold in California.
* Collection of an electronic waste recycling fee at the point of sale of certain products.
* Distribution of recovery and recycling payments to qualified entities covering the cost of electronic waste collection and recycling.

http://www.ciwmb.ca.gov/Electronics/Act2003/

Energy conservation legislation

10 CFR Part 430: Energy Conservation Program for Consumer Products – Room Air Conditioners and Central Air Conditioners.

Minimum standards of energy efficiency for many major appliances were established by the U.S. Congress in the National Appliance Energy Conservation Act (NAECA) of 1987, and in the National Appliance Energy Conservation Amendments of 1988. Standards for some fluorescent and incandescent reflector lamps, plumbing products, electric motors, and commercial water heaters, heating, ventilation and air conditioning (HVAC) systems were added in the Energy Policy Act of 1992 (EPACT). The US Department of Energy (DOE) is responsible for developing the standards and test procedures for the Appliance Standards Program as well as periodically issuing new standards for specific appliances.

The USA has an extensive MEPS program for air conditioners and heat pumps, that includes the following product types:
- residential room air conditioners (Window/wall),
- package terminal air conditioners (wall units with an air change function included),
- central air conditioners and heat pumps,
- small commercial package air conditioners and heat pumps,
- large commercial package air-conditioners and heat pumps.

Requirements for residential room air conditioners – window/wall single package air conditioners - and central air conditioners are reported hereunder.

Window/Wall air conditioners
The program covers single-phase air conditioners that are not packaged terminal air conditioners. Products with and without louvered sides are defined as distinct categories. The product is required to be tested in accordance with Federal test procedures to meet mandatory efficiency standards. This test procedures can be found in the current U.S. Code of Federal Regulations (CFR, Title 10, Part 430 Appendix F).

Table 1-68: USA MEPS Requirements for Window/wall Air Conditioners

Product Class	Cooling (Heating) Power in Btu/h (kW)	Minimum EER, ratio Btu/h/W (W/W)
	Cooling Only	
with louvered sides	Less than 6000 (1.76)	9.7 (2.84)
	6000 (1.76) to 7999 (2.34)	9.7 (2.84)
	8000 (2.34) to 13 999 (4.10)	9.8 (2.87)
	14 000 (4.10) to 19 999 (5.86)	9.7 (2.84)
	20 000 (5.86) and over	8.5 (2.49)
without louvered sides	Less than 6000 (1.76)	9.0 (2.64)
	6000 (1.76) to 7999 (2.34)	9.0 (2.64)
	8000 (2.34) to 13 999 (4.10)	8.5 (2.49)
	14 000 (4.10) to 19 999 (5.86)	8.5 (2.49)
	20 000 (5.86) or more	8.5 (2.49)
	Cooling and Heating	
with louvered sides	less than 20 000 (5.86)	9.0 (2.64)
	and 20,000 (5.86) or more	8.5 (2.49)
without louvered sides	less than 14 000 (4.10)	8.5 (2.49)
	and 14 000 (4.10) or more	8.0 (2.34)
Casement-Only		8.7 (2.55)
Casement-Slider		9.5 (2.78)

This new standard level is published in the Federal Register (FR), 62FR50121, 24 September 1997 and is effective from 1 October 2000; the original standard was published in 1987 and was effective from 1 January 1990.

Central air conditioners
Central air conditioners and heat pumps manufactured on or after January 23, 2006, shall have Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) not less than:

Table 1-69: USA MEPS Requirements for Central Air Conditioners

Product	SEER Btu/h/W	HSPF (Zone IV) Btu/h/W (W/W)

	(W/W)	
Split system air conditioners	13 (3.8)	-
Split system heat pumps	13 (3.8)	7.7 (2.3)
Single package air conditioner	13 (3.8)	-
Single package heat pumps	13 (3.8)	7.7 (2.3)
Through-the-wall air conditioners and heat pumps – split system	10.9 (3.2)	7.1 (2.1)
Through-the-wall air conditioners and heat pumps – single package	10.6 (3.1)	7.0 (2.1)

There is no direct relation between EER and SEER. The relationship proposed by (EnergyConsult, 2005) may well translate ON-OFF control unit performances but cannot cover all types of control modes, multiple compressor speeds, inverters ...
Building on the analysis of ARI 210/240 standard, with a 2 % EER increase by °C outdoor air temperature decrease, a SEER of 3.8 may translate in a minimum EER of 3.4 (single speed compressor, C_D^C=0.1) or 2.7 for a variable speed unit with average 20 % performance improvement at part load. In heating mode, with 3 % COP decrease by outdoor air temperature decrease, a minimum HSPF of 2.3 may translate in a minimum COP of 2.9 (single speed compressor, C_D^H=0.1) or 2.3 for a variable speed unit with average 20 % performance improvement at part load.

Note on the Energy Star Program for Air conditioners

Increasing SEER minimum thresholds is not a guarantee of improved performance when occurs the peak load for electric utility, because of the increased penetration of inverters and of the analysis led just before. As a consequence, the Energy Star program, in addition of a 14 SEER level, also requires a minimum 11 EER (3.2 EER in W/W) for central air conditioners.

Tolerances

DOE accepts **no tolerance for the SEER and HSPF values**. The procedure to describe compliance is defined in the US DOE CFR 430. The first sample is made of 4 units. In case of non compliance (determined based on a 95 % confidence interval with the t-student distribution), manufacturer can choose to increase the number of units (until 20) in order to reach a statistically significant distribution for a 97.5 % confidence interval. In case of non compliance, the testing cost is at the expense of the manufacturer and the models are banned from the market.

More information:
http://www.eere.energy.gov/buildings/appliance_standards/residential_products.html

1.3.4.8 International comparison

Energy conservation summary

The main goal of this part is to estimate how efficient are the air conditioners on the European market by comparing energy efficiency values of these products to existing MEPS values worldwide. These results are also required for Best Available Technologies analysis in tasks 6 to 8. Minimum EER and/or COP requirements are to be corrected by tolerance values, that are also gathered when available; stand-by energy consumption requirements are also recalled.

Here is a summary of energy conservation legislation in main economies for air cooled air conditioners.

		Split		Package		Tolerances	Specificity of rating
		Cooling	Heating	Cooling	Heating		
Region or country	Stand-by	MEPS	MEPS	MEPS	MEPS		
Australia	Yes	Y	N	Y	N	10 % EER	Full load
China	No	Y	Y	Y	Y	N/A	Full load
Japan	Yes (res.)	Y	Y	Y	Y	20 % EER and (EER+COP)/2 10 (res.) and 15 (com.) % on APF	Moving to seasonal perf
South Korea	Yes (res.)	Y	N	Y	N	20 % EER N/A for seasonal performances	Moving to seasonal perf
USA	No	Y	Y	Y	Y	0 %	Seasonal perf for split
EC	No	N	N	N	N	15 % EER & COP	Full load

Table 1-70: Summary of international energy conservation legislation for air conditioners

MEPS analysis

This analysis is based on the Eurovent-Certification public database (Eurovent-Certification, 2006) for split air conditioners and available MEPS programs in other economies.
The comparison is shown for countries whose legislation is based upon full load standard EER at T1 conditions;

- for Japan, the target for reversible split air conditioners is compared to units in the Eurovent database by computing (EER + COP) / 2 for European units,
- for US and Canada central air conditioners MEPS, it is not possible to apply the same approach since part load performances of European models are not available. As a consequence, we have kept the EER and COP values corresponding to the minimum SEER or HSPF for a default single speed compressor units, as explained in the description of the USA legislation.

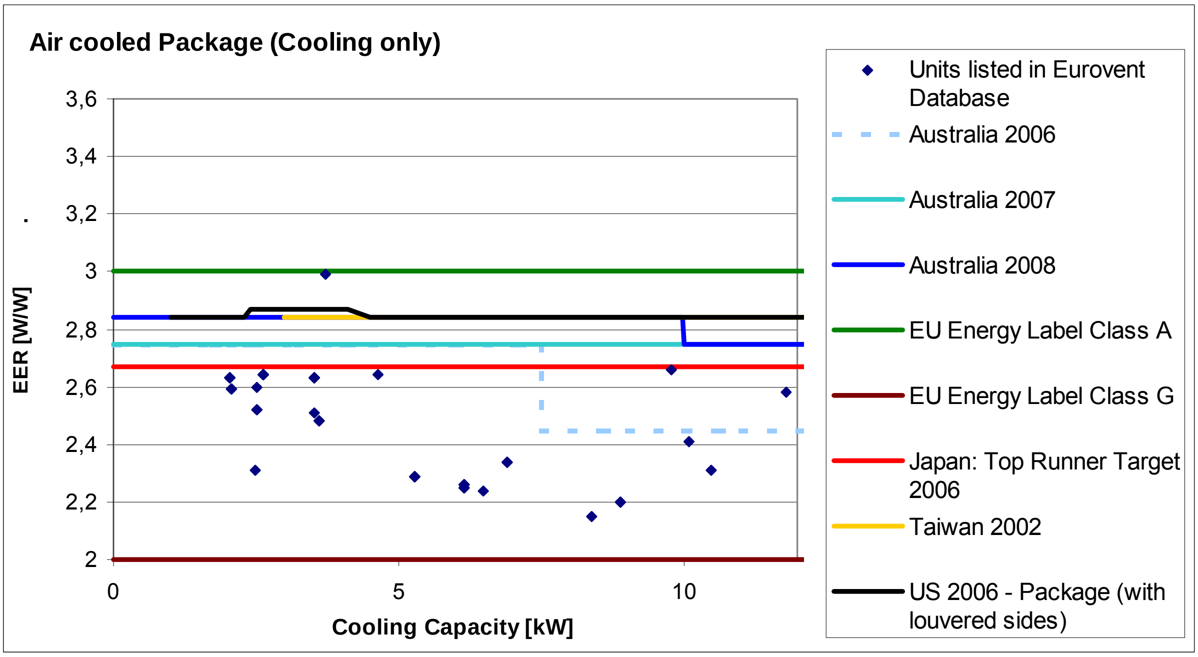


Figure 1-15: International comparison of Air cooled Package MEPS (Cooling only)

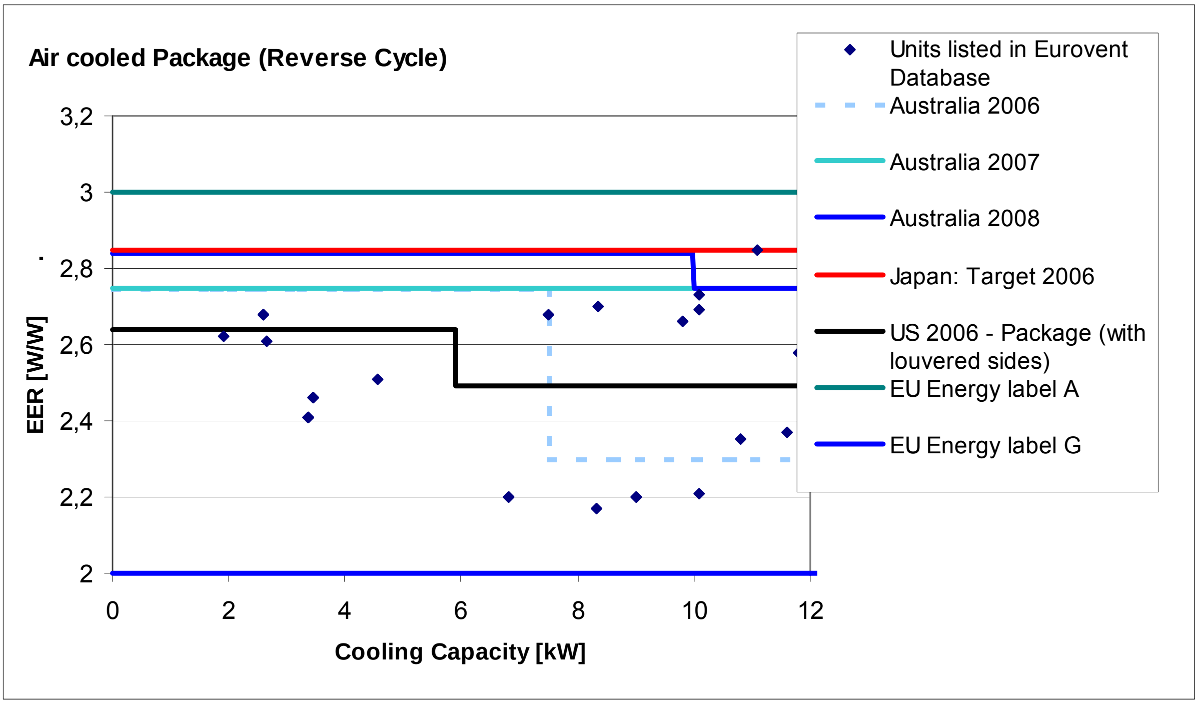


Figure 1-16: International comparison of Air cooled Package MEPS (Reverse Cycle)

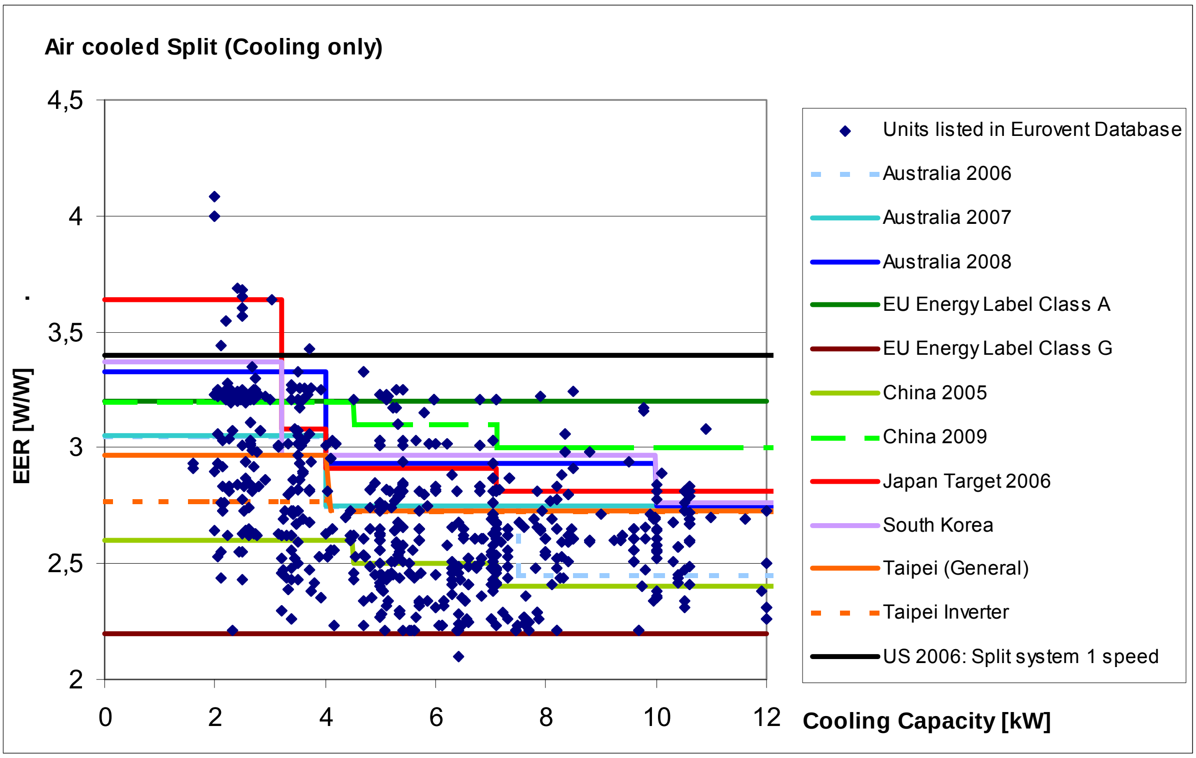


Figure 1-17: International comparison of Air cooled Split MEPS (Cooling only)

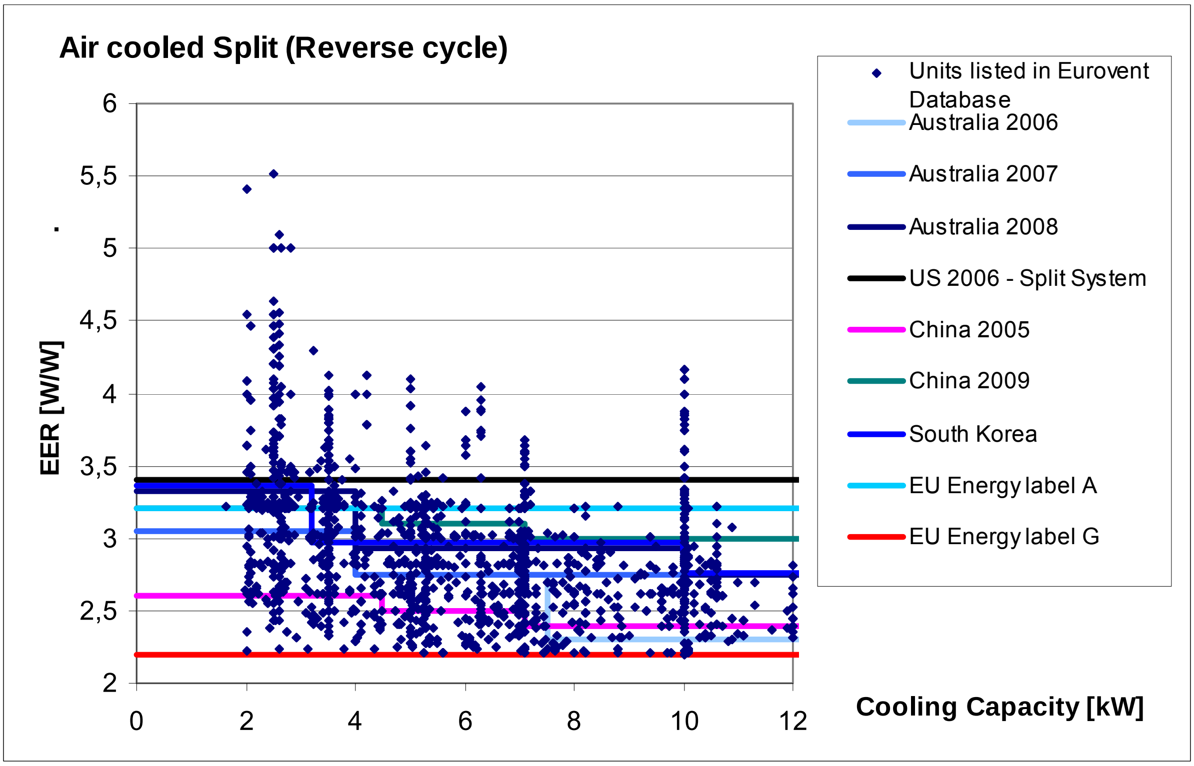


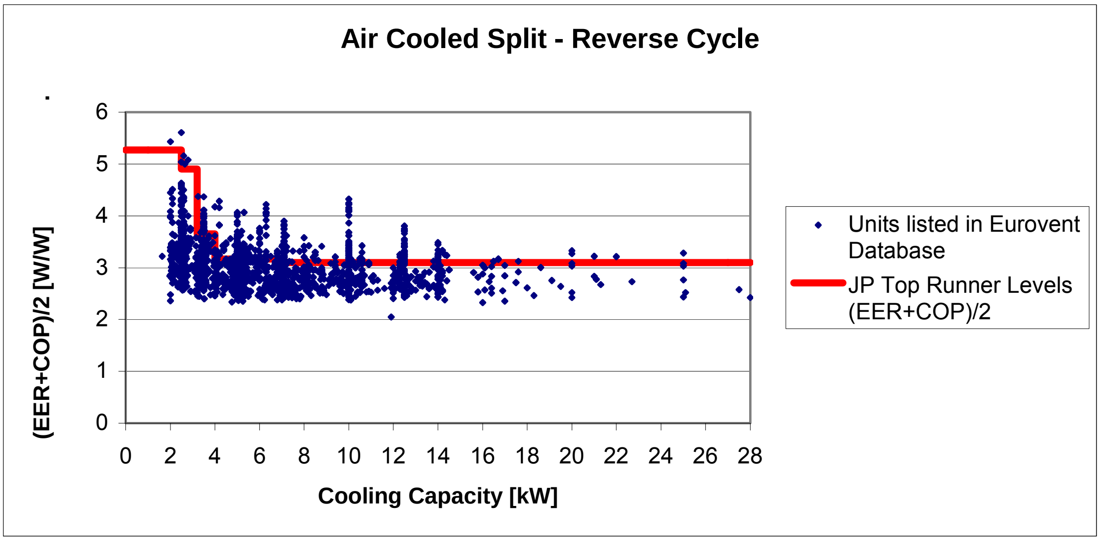
Figure 1-18: International comparison of Air cooled Split MEPS (Reverse cycle)

The graphs show that most of the European market EER declared would not comply with abroad legislation. To illustrate the gap, Korean or Japan MEPS scheme applied tomorrow to

European cooling only split air conditioners would remove more than 90 % of the Eurovent database products.

For reversible units, we report hereafter the comparison of Eurovent database reversible air conditioners with Japanese top runner targets. Conclusions are similar. The broadest gap appears for small capacities, until 4 kW, where Japan concentrates energy efficiency efforts (most sold products in dwellings in Japan).

Figure 1-19: Comparison of Japanese MEPS and reversible split air conditioners and reversible split in the Eurovent database



This comparison cannot be led for moveable appliances, first because no database is available at the moment in Europe and second because there is no specific MEPS programs for single ducts and double ducts in other economies. Moveable split could be compared on the basis of existing split air conditioners MEPS programs.

For reversible units, for COP in the heating mode, only the USA and Canada have MEPS programs (in Japan, the target is a single value for both modes, here the average of (EER+COP)/2). When compared for European split units. Average full load standard H1 conditions gives an average COP of 2.9.

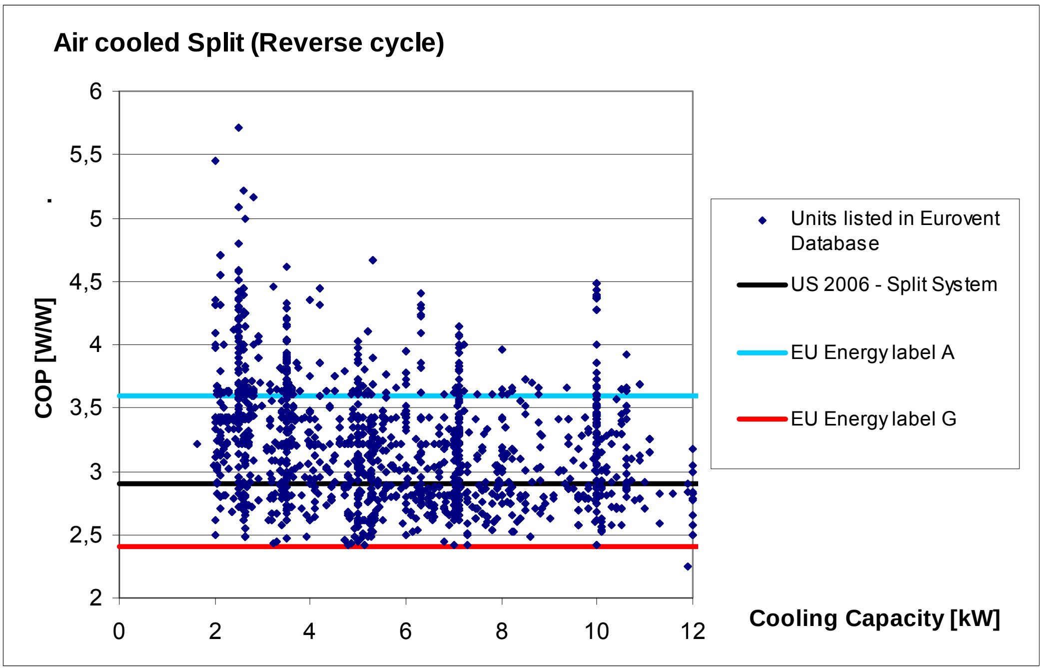


Figure 1-20: USA average COP (heating mode) of reversible central air conditioners with HSPF=7.7, source (ARI, 2007) and COP of reversible split air conditioners in the Eurovent database

The average COP of USA central air conditioners minimum HSPF is lower than the average COP in Eurovent Database. It also appears that the EU labelling scheme for COP of reversible split air conditioners is no longer adapted for current COP values, at least in terms of models in the Eurovent database.

1.3.5 Conclusion on legislation

Most interpretations of the WEEE and ROHS directives (countries, manufacturers' association) seem to limit its scope to that part of air conditioners that not installed. If this is confirmed, this will have consequences in our technical study later, by introducing a distinction between products to which WEEE applies and products to which it does not apply. However, stakeholders indicate that part of WEEE is spontaneously implemented for air conditioners due to the value of the specific waste (copper, e.g.). Directive 2000/2037/EC on Ozone Depleting Substances (ODS) and Regulation 2006/842/EC fluorinated greenhouse gases have an influence not only on the choice of fluid to be used but also on the way they are contained and recovered, with important constraints on the design of the products. Other legislation like EPBD, machinery, pressure, EMC and low voltage directives seems to have a more limited effect on products energy and environmental performance.

Directive 2002/31/EC energy labelling of household air-conditioners has initiated market transformation in the direction of energy efficiency. The comparison of the energy efficiency of air conditioners sold in Europe and of the Minimum Energy Performance Standards for air conditioners in other economies, mainly Japan and South East Asia shows that Europe is lagging behind in terms of energy efficiency for residential air conditioners. The use of full load performance in Europe as a basis for selection of efficient products is also under the best international standards as well as large tolerances for labelling the energy performance.

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