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

Introduction to Lot 10 study – products and scope definition August 2007

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Summary

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. In the broadest sense, this encompasses:

– air conditioners,
– ventilation fans,
– comfort fans,
– dehumidifiers,
– humidifiers,
– evaporative coolers,
– air purifiers.

As a consequence, a first part is dedicated to the description of the products likely to answer to the wording "residential room conditioning" appliances.

The screening of the different types of products is then based on the format of the task 1.1 of the MEEuP methodology. Based on the general definitions given before, existing categories are sought in Prodcom codes and in existing test standards.

The functional analysis led afterwards enables to separate products with different primary functions, ending up with groups of products clearly defined by their functional units, the parameters for performance assessment and the testing standards available. These groups and their characteristics are summarised in the following table:

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

Residential room air conditioning appliances, 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
Comfort fans	To move air inside a room	Air flow rate (m3/h)	IEC 60879 (*)	All types of residential comfort fans, table, floor standing, pedestal, wall mounted, ceiling, tower.
Evaporative coolers	To decrease the temperature of a room	Cooling capacity (kW) and temperature decrease	AS 2913-2000	Direct evaporative cooler portable type
Humidifiers	To increase humidity inside a room	Flow rate of added water (L/day)	No	Table and console humidifiers, all technologies
Dehumidifiers	To decrease humidity inside a room	Flow rate of removed water (L/day)	EN 810	Residential dehumidifier, desiccant based and vapor compression type
Ventilation fans	To change indoor air of a room	Air flow rate (m3/h) Static pressure available (Pa)	EN 13141	Individual mechanical fans // Roof , extraction, window, wall, hoods
Air purifiers	To filter the air inside a room	Flow rate of filtered air (m3/h) Size of the smallest particles the device can trap (µm)	EN 779	Filtering type

(*) No test standard covers tower fans.

The scope of the study, as discussed and validated with stakeholders, is then delimited, by focusing the study on the product categories with expected higher environmental impact among the eight categories previously identified.

It leads to four main product categories in agreement with the products referred to as “airco” and “ventilation”:
- cooling only air conditioners,
- reversible air conditioners,
- residential ventilation and
- comfort fans.

Subcategories are presented and limits of scope drawn. This leads to the scope as presented in the following table.

Scope of the study

<table>
<tr><th>Categories</th><th>Products included</th><th>Scope limits</th></tr>
<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">Cooling power <= 12 kW[2]</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>
<tr><td>Ventilation fans</td><td>Fans for decentralized mechanical ventilation
Fans for centralized ventilation</td><td>- Window fans (Elec power < 30 W), Roof fans (Elec power < 100 W), Wall fans (Elec power < 300 W), Range hoods including a fan and rejecting air outside (Elec power < 300 W)
- serving one individual house (Elec power < 80 W), serving various dwellings in the same collective building (Elec power < 500 W)</td></tr>
<tr><td>Comfort fans</td><td>Table-desk fan,
Wall fan,
Floor fan,
Pedestal fan,
Ceiling fan,
Tower fan.</td><td>Elec power < 125 W[3] ?
To be confirmed by the market analysis</td></tr>
</table>

The scope is thus made of 3 very different types of products: air conditioners, residential ventilation fans and comfort fans. As a consequence, it has been decided to split the studies of the three products.

[2] 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.
[3] Cf. Prodcom categories analysis.

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Introduction to Lot 10 study: scope definition

Introduction

The scope indicated by the title of the lot 10[4] 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 Product definitions

In this section ("Product definitions"), all air conditioning appliances are listed and shortly described by main types of commercial products as identified on general commercial documentation (manufacturers, installers, DIY shops online…) :

- air conditioners,
- ventilation fans,
- comfort fans,
- dehumidifiers,
- humidifiers,
- evaporative coolers,
- air purifiers.

1.1 Air conditioners

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[5]. 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.

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

[5] http://www.robur.it

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.
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[6]). 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-

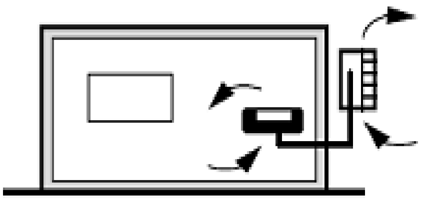
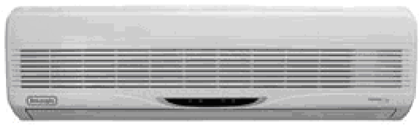
[6] In that case, the air conditioner cannot operate in the reverse cycle to supply heating.

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.

– 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 

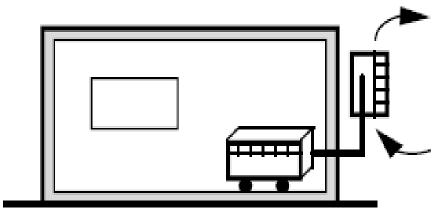
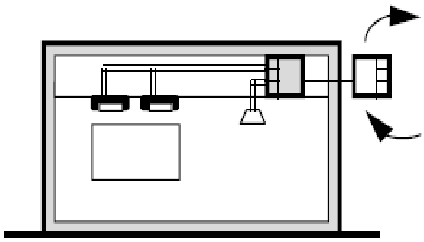
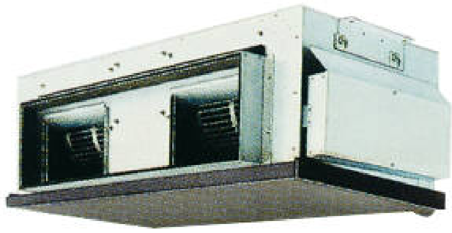
Non-ducted split-packaged unit with mobile indoor unit (mobile split)		Mobile indoor unit 
Ducted split-packaged unit (Ducted split system)		Ducted built-in horizontal indoor unit 

Table 1: 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.

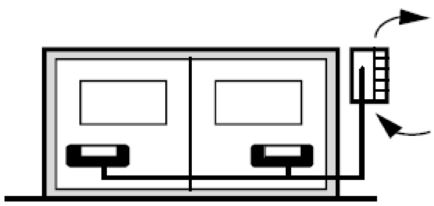
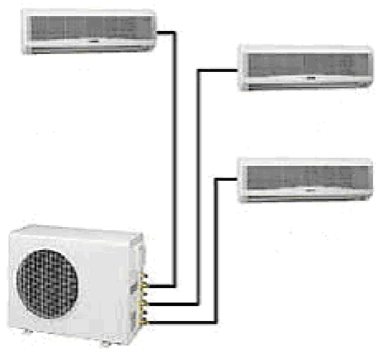
Type of air conditioner	**Operating Scheme**	**Example**
Multi-split-packaged units		

Table 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.

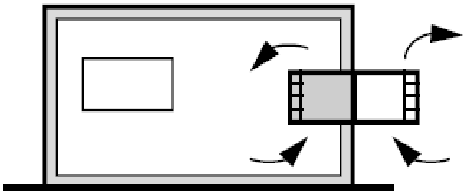
Type of air conditioner	Operating Scheme	Example
Single-packaged unit, through the wall		

Table 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.

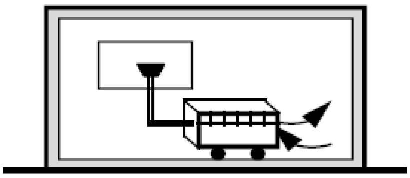
Type of air conditioner	Operating Scheme	Example
Single duct air conditioner		

Table 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.

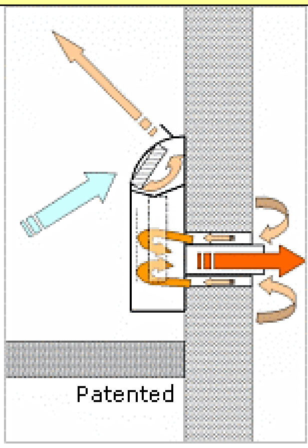
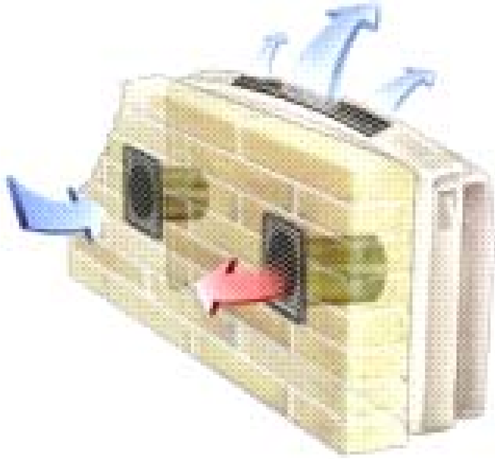
Type of air conditioner	Operating Scheme	Example
Double duct air conditioner (through the wall installation)		

Table 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.

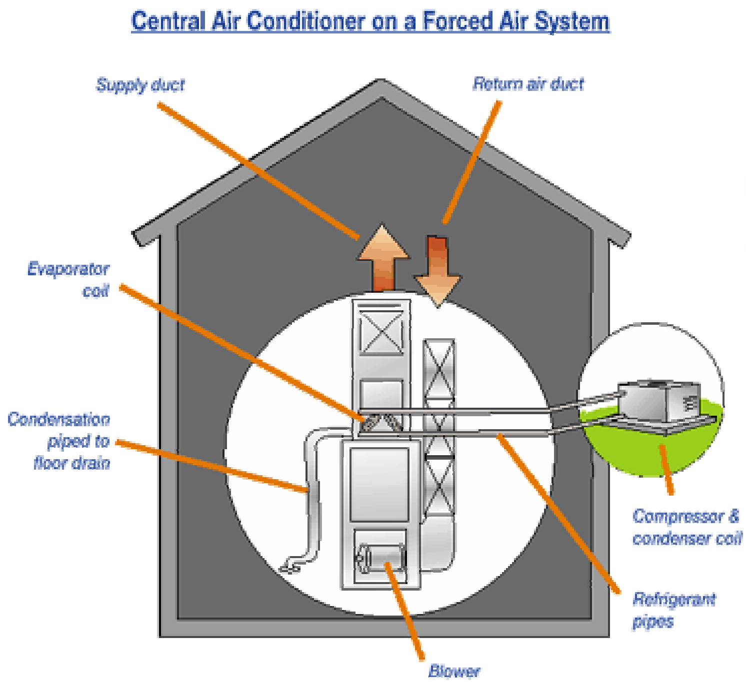


Figure 1: Central air conditioner of the split type[7]

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) while residential sales in kW now accounts for around 37 % (please refer to task 2 of the air conditioners study, Figure 2.6).

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

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

temperature and humidity inside conditions. **Control cabinets** cool down their own contents, mostly computer or electronic controls of other process.

- 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, humidyfying and demudifying, 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.

1.2 Evaporative coolers

Evaporative cooling is an air-conditioning process in which the evaporation of water is used to decrease the dry-bulb temperature of the air.

Evaporative cooling works on the principle of heat absorption by moisture evaporation. It can be divided upon three main types, as follows.

- direct evaporative coolers:
Direct evaporative coolers blow outside air through a water-saturated medium. Thus, outside air is cooled by evaporation and then blown throughout the house. Thus, a direct evaporative cooler is essentially a large fan with water-moistened pads in front of it.
Direct evaporative coolers add moisture to the air stream (coming from outside) until this air stream is close to saturation. The dry bulb temperature is reduced, while the wet bulb temperature does not change. Let's remain that dry bulb is the sensible air temperature and wet bulb is the lowest air temperature achievable by evaporating water into the air to bring the air to saturation.

- indirect coolers:

In indirect evaporative coolers, a secondary air stream is cooled by water like outside air in direct evaporative coolers. The cooled secondary air stream goes through a heat exchanger, where it cools the primary air stream that comes from outside. The cooled primary air stream is then blown throughout the house. Indirect evaporative coolers do not add moisture to the primary air stream. Both the dry bulb and wet bulb temperatures are reduced.

- indirect plus direct

With indirect/direct evaporative coolers, outside air is cooled first by indirect evaporative cooling and then by direct evaporative cooling.

The following psychometric chart summarizes the three types of evaporative coolers. Indirect evaporative coolers enable to change climatic conditions from A to B (both dry and wet bulb temperatures are reduced). Direct evaporative coolers enable to change climatic conditions from B to C (the wet bulb temperature does not change) and the indirect plus direct evaporative coolers from A to C.

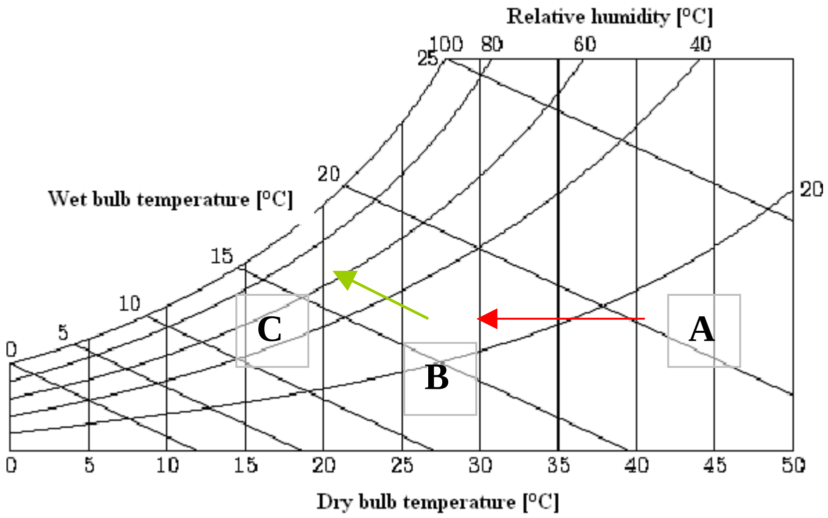


Figure 2: Air enthalpy diagram, illustration of the 3 types of evaporative cooling

A rough thermal comfort zone can be defined as the yellow area on the following chart. From this, it becomes obvious that a direct evaporative cooler is useless when the wet bulb temperature is higher than 20°C or when the dry temperature is about 30°C and humidity is higher than 40%.

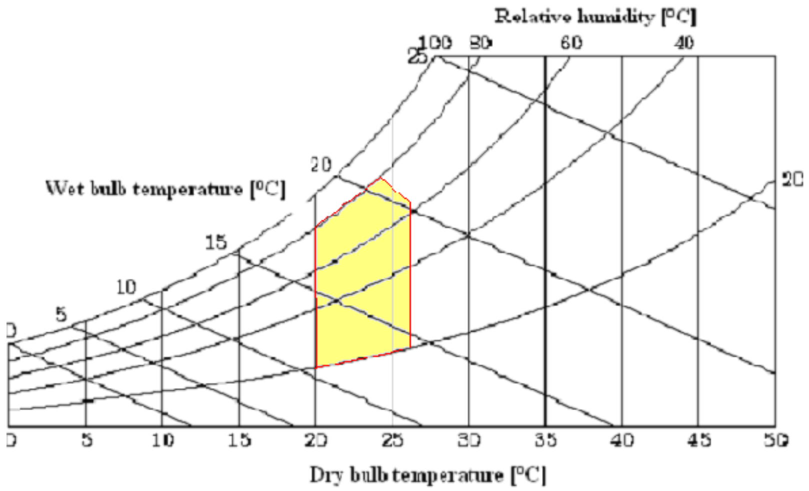


Figure 3: Air enthalpy diagram, comfort zone

Another limitation is that the temperature reduction is directly linked to the difference between the wet bulb temperature and the dry bulb temperature. Evaporative cooling is especially well suited where the air is hot and humidity is low.

Evaporative cooling is often promoted as a green (without refrigerant) and inexpensive way to cool dwellings. Nevertheless, the comfort levels reachable with evaporative coolers greatly depends on the outside climatic conditions and do not always enable to respect satisfactory thermal conditions (such as ones defined in comfort standards for example). Thus, **particular attention must be paid to determine under what range of temperature and humidity an evaporative cooler can deliver the required comfort thermal conditions**.

It can be noticed that in addition to the dropping of the air temperature, evaporative coolers create an additional cooling benefit by moving the air thanks to the blower inside the appliance. This benefit is comparable to small comfort fans effect. On the other hand, on/off evaporative cooler control systems are available that include a low voltage thermostat and fan delay that allows the pads to get wet before the blower turns on.

Portable evaporative coolers found on the European market (or swamp coolers) are mostly of the direct type. Indirect and indirect plus direct types are generally reserved for systems to be included or coupled to air handling units in central air conditioning systems.

Dimensions: 31 x 39 x 76 cm Extraction capacity: 0.4 L/h Electrical supply: 65 W Maximum airflow: 520 m³/h	 Alpatec

Table 6: Evaporative cooler and its typical technical characteristics:

Thus, evaporative coolers can act as air conditioners except they are not able to maintain the indoor air temperature to a required level for a given load. Thus, they cannot be compared to air conditioners since they do not have the same functionality, delivering only part of the cooling needs. Their ability to deliver the cooling capacity to do so is dependant not only on outside and inside temperature, as for air conditioners, but also on outside air humidity.

1.3 Comfort fans

Using fans and moving air in a room is a way people can choose to improve their individual summer comfort. **By generating air movement close to the body, comfort fans increase convection and evaporation and by this way the feeling of comfort.** Thus, using comfort fans improve the individual summer comfort without lowering the room temperature. In fact, the inside temperature is even likely to increase since the comfort fan motor produces heat.

On the other hand, fans should not be used as a primary cooling device during extended periods of excessive heat. Electric fans may provide relief, but when the temperature is above 35 °C, fans will not prevent heat related illness (Adnot, 2007) but on the contrary will contribute to heat exhaustion. Use of summer comfort fans should be guided by an indoor climate stress diagram.

Comfort fans can be used to avoid the use of air conditioners during the summer period and provide an “acceptable comfort”, but it can also be used as a complement to this device. When air conditioning is used, a fan can help to better circulate the cool air through the room, allowing the system to run less often[8].

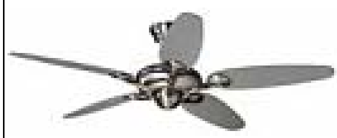
Type	Typical characteristics	Example
Table fan – Desk fan	Propeller diameter: 250-400 mm Air flow: 1300-3600 m^3/h Electrical supply: 35-60W	 Delhongi
Pedestal fans	Propeller diameter: 250-450 mm Air flow: 2000-4500 m^3/h Electrical supply: 40-70 W	 Alpatec
Floor standing fans	Propeller diameter: 300-500 mm Air flow: 3000-6000 m^3/h Electrical supply: 40-120W	 Alpatec
Wall mounted fans	Propeller diameter: 250-400 mm Air flow: 1300-3600 m^3/h Electrical supply: 35-60W	
Ceiling fans	Propeller diameter: 900-2000 mm Number of blade: 3-5 Electrical supply: 50-150W (without lights)	 Coolandwarm
Tower fans	Height: 350-1400 mm Air flow: 400-2200 m^3/h Electrical supply: 35-50W	 Alpatec
Box fans	Propeller diameter: 250-400 mm Air flow: not specified Electrical supply: 35-60W Louvers available to orientate the flow	 Rovex

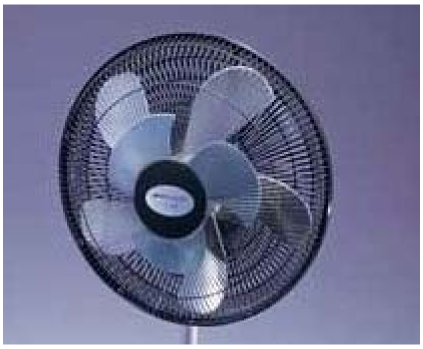
Table 7: Different types of comfort fans and their technical characteristics

8 http://www.energystar.gov

Most fans have various speeds. Part of the fans are oscillating horizontally (if the user demands it) and a few even oscillate vertically.

We have observed the existence of a new type of fan (called “2cool” by Bionaire) with a higher electricity consumption than usual products (90 W) using two “fans”: higher velocity in the center (25 cm), large coverage of sides (40 cm). Hereunder the appearance of that product :

Figure 4: “2cool” fan by Bionaire



As soon as there is a remote control, there is a standby consumption. It’s infrequent except for ceiling fans, and this stand by consumption is never indicated in commercial offers.

In Taiwan there is a so called “autorevolving hanging fan” that we have not observed on the EU market.

1.4 Humidifiers

Humidifiers primarily aim at increasing humidity in a single room or in the whole house. Water is vaporized into the air in order to increase the absolute humidity of the air, hence increasing the relative humidity. Several types of humidifiers are sold in Europe:

- Warm mist humidifier: In this kind of humidifier, water is heated to the boiling point and the resulting stream is then dispersed in the room after mixing it with cool air to minimize scalding risk. Boiling water kills bacteria but consumes a lot of energy.
- Impeller humidifier: In this kind of humidifier, a pad absorbs water from the water tank and a fan mechanism blows air through the filter throwing out tiny water droplets in the room to be humidified.
- Ultrasonic humidifier: This kind of humidifier produces high-frequency vibrations that creates water droplets and throws them into the air.

In the residential sector, portable humidifiers can be found in two basic styles. Small tabletop models can humidify a room or two, and can easily be carried from place to place as needed. Console humidifiers are about the size of a laundry hamper, and depending on their capacity, can humidify the whole house. Most of the humidifiers include a built-in humidistat, a device that allows to set the desired relative humidity level for the room and maintain it.

Type	Typical characteristics	Example
Tabletop model	Dimensions: 22 x 29 x 29 cm Capacity: 15 L/day Electrical supply: 400 W	 Delonghi
Console humidifiers	Dimensions: 30 x 50 x 70 cm Capacity: 45 L/day Electrical supply: 1100 W	

Table 8: Two types of humidifiers and their typical technical characteristics:

Sometimes, they can also be advertised as an inexpensive and ecological mean to cool a room (impeller, ultrasonic), by the same effect as evaporative coolers – reducing dry bulb temperature by increase of humidity inside the room. On the other hand, hygienic aspects are also very important when purchasing a humidifier because allergic reactions are likely to occur when the air is dry. They are also often criticized because for example bacteria can proliferate in pads (impeller humidifiers) and dead bacteria can cause allergic reactions (warm mist humidifiers).

1.5 Dehumidifiers

Dehumidifiers are used to remove humidity from a room. They remove water from air, and hence reduce absolute humidity to reduce relative humidity. Relative Humidity (RH) is the quotient of the actual vapor pressure by the saturation vapor pressure. It can be characterized by the amount of water vapor actually present in the air compared to the greatest amount of water vapor the air can hold at that temperature. An optimum RH level for buildings is usually between 30 % and 50 %. Maintaining such a level of RH prevents bacteria growth and improves thermal comfort. In fact, regarding humidity, the comfort zone is quite large, between 30 and 80 %, (Givoni, 1976). As a result, at least in Europe, most dehumidifiers are used to protect the room (from moulds) rather than to improve the thermal comfort.

In South-East Asia and other very hot and humid zones, dehumidifiers are commonly used in summer, alone or together with an air conditioner.

In Europe, dehumidifiers are more likely to be used in rooms where the humidity content of the air is high because of vapour production (laundry for example – (Stem, 2006)).

(DéLonghi, 2006) states that there are two different types of dehumidifiers on the European market:

- Mechanical dehumidifiers:

Mechanical dehumidifiers are based on a refrigerating circuit (the system is similar to air conditioners). A small fan drives the air to be dehumidified to a refrigeration coil. Since the saturation vapor pressure of water decreases when the temperature decreases, the water contained in the air condenses and is recovered in a collecting tank. Then, the air can be reheated by the warmer side of the refrigeration coil.

- Desiccant dehumidifiers:

Desiccant dehumidifiers are based on materials that have a high affinity for water vapour (desiccant materials). These materials absorb humidity from air and then need to be dried by a heat source to discharge the absorbed humidity (generally by a thermal resistor).

Dehumidifier capacity is usually measured in litres of absorbed water per 24 hours (or litres per day) and is determined by two factors: the size of the space that needs to be dehumidified and the conditions that exist in the space before dehumidification. The extraction capacity depends on the climatic conditions (humidity and temperature). In Europe, according to information supplied by manufacturers on the technical manuals of products, domestic dehumidifiers can absorb from 5 to 30 litres of water a day (inside air conditions of temperature and humidity are rarely known) consuming from 150 W to 700 W. Most dehumidifiers include a built-in humidistat, a device that allows to control the desired relative humidity level in the room.

Type	Typical characteristics	Example
Mechanical dehumidifiers (refrigerating circuit)	Dimensions: 23 x 31 x 50 cm Extraction capacity: 9 L/day Electrical supply: 210 W	 Alpatec

Mechanical dehumidifiers (refrigerating circuit)	Dimensions: 30 x 35 x 80 cm Extraction capacity: 26 L/day Electrical supply: 670 W	 Danby
Desiccant dehumidifiers (absorbing materials)	Dimensions: 17 x 30 x 47 cm Extraction capacity: 6 L/day Electrical supply: 495 W	 Delonghi

Table 9: Three dehumidifiers technical characteristics

1.6 Ventilation fans

Ventilation fans ensure air renewal in occupied dwellings; it is necessary for three reasons:

- **comfort and hygiene for occupants (fresh air…),**
- **durability of the building (avoid moisture condensation on surfaces inside dwelling),**
- **safety (face to combustion devices for example),**

Minimum air flow rates are the result of Member States national building codes. These minimum hygienic requirement for fresh air flow has important energy consequences because of forcing cold air inside in winter and hot air inside in summer. Nevertheless, the thermal consequences and energy consequences is faced by different measures at building thermal envelope level implemented by Member States national building codes and the Energy Performance of Buildings Directive 2002/91/EC. Following the Article 15, alinea 2.c of the EuP directive 2005/32/EC, it can be said that the Community addresses this issue. As a consequence, the heat or coolness consequence of residential ventilation seems beyond the scope of the study. We will so focus only on the efficiency of residential ventilation fans regarding their main duty, which is to provide fresh air for hygienic purpose.

A ventilation fan consists of a bladed rotor that is connected to an electric motor through a shaft or a belt. The rotor can be preceded or followed by a stationary blade row and the ventilator can be linked to inlet and outlet ducts. In the domain of ventilation the fan and the motor are sold together, whether they are linked by a shaft or by a belt. Ventilators performances are characterized by the pressure and the airflow they can provide along with the required inlet power. These performances vary importantly among the vast amount of existing ventilators, a first segmentation (technical) is usually performed regarding how the air flow is deviated by the device, (Cory, 1992). Generally speaking, axial and centrifugal fans are the most frequent technical types.

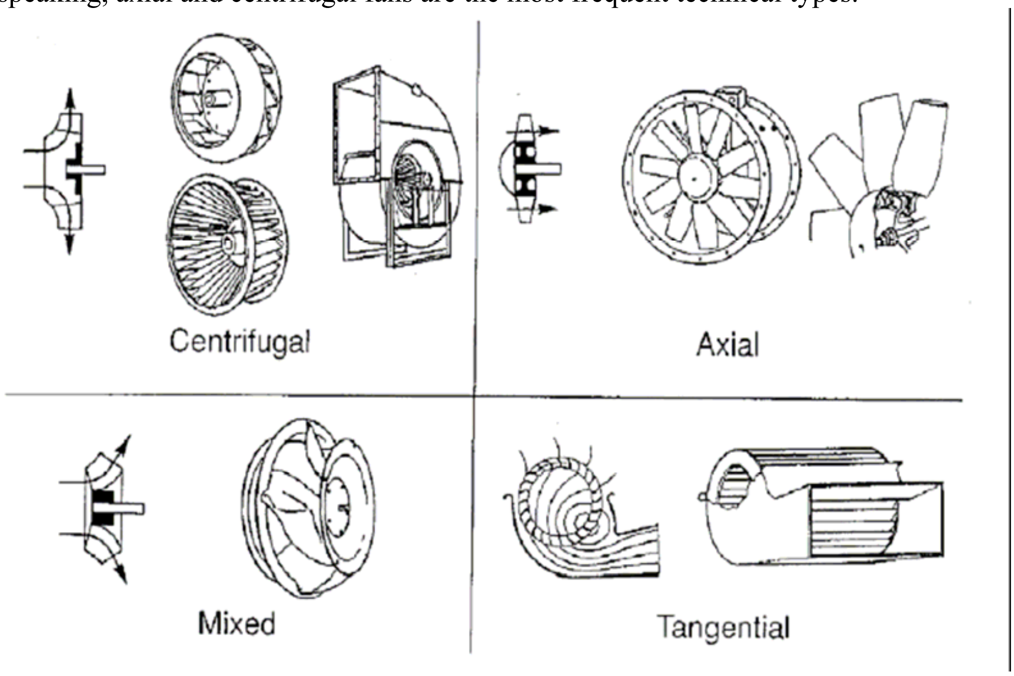


Figure 5: Different types of fans according to fluid mechanics, from Cory (1992)

Building ventilation can be roughly divided into three categories: **natural ventilation, individual mechanical ventilation and centralized mechanical ventilation**. Each kind of ventilation requires specific energy using products. Mechanical ventilation means all the motorized devices used to renew the indoor air. The required energy using products for ventilation are shortly described hereafter respecting the three main types of ventilation.

1.6.1 Natural ventilation

The air enters the dwelling through cracks, windows, slots and exits through vertical ducts. Each room of the dwelling is equipped with vertical ducts and no ventilation device is required. Air motion is due to the difference between indoor and outdoor temperatures and to the wind pressure on the building shell. As a result, air renewal varies with climatic conditions and can be very insufficient in summer when the temperature difference between indoor and outdoor temperature is low or when there is no wind. Further status of natural ventilation depends on national building construction codes; UK offers the possibility to design natural ventilation whereas mechanical ventilation is mandatory in France[9]. Natural ventilation is not an EuP, nor a performance option since the choice between two types of ventilation is regulated by Member States through national building codes, hygiene regulations, etc.

1.6.2 Mechanical ventilation as opposed to natural ventilation

According to most countries building codes, the electricity consumption of a well balanced and tuned mechanical ventilation is limited compared with thermal energy saved by avoiding the direct effect of the wind in a poorly designed natural ventilation. Thermal energy used in buildings as a result of artificial or natural ventilation represents 30 to 40 % of heating demand in residential buildings (CFP, 2006) (as much as 80 % in some non residential buildings). Ventilation related electricity, heating and cooling demand calculation has been improved in each country in the EPBD frame.

A study by Ademe/ATEE (ATEE, 2006) indicates the magnitude of yearly thermal energy gains obtained by introducing a simple mechanical ventilation with “self regulating by special exhausts” instead of “natural ventilation”: from 2894 kWh to 1154 kWh in individual houses (1740 kWh savings), from 1838 kWh to 733 kWh in flats (1105 kWh savings), in both cases 60% of initial consumption expressed in “useful energy”. The associated yearly electricity consumption, assuming an old 50 W extraction unit is about 437 kWh. This means a significant final energy saving, but not so much when translated in “primary energy” with the factor 2.5. For instance with an efficient boiler in a flat the saving is 1381 kWh primary and the additional consumption is 1092 kWh primary. The more efficient the extraction is, the more savings can be attributed to mechanical ventilation, either in final or primary energy.

From now on, we will speak only of the EuP under consideration, the fan in charge of mechanical ventilation, and of its electricity consumption.

1.6.3 Decentralised mechanical ventilation

The ventilation system can be designed as such as to generate underpressure in the rooms (general case) or over pressure.

Decentralised mechanical ventilation means that several extraction ventilators are used to renew the air of a complete house. Three configurations are possible: a natural air supply with mechanical exhaust with fans, a mechanical air supply with natural exhaust, a mechanical air supply with mechanical exhaust.

[9] Mechanical ventilation is mandatory in France in all new dwellings since 1982 and in case of retrofit since 1969 in France according to (Ebm-Papst, 2006) and (Uniclima, 2006)

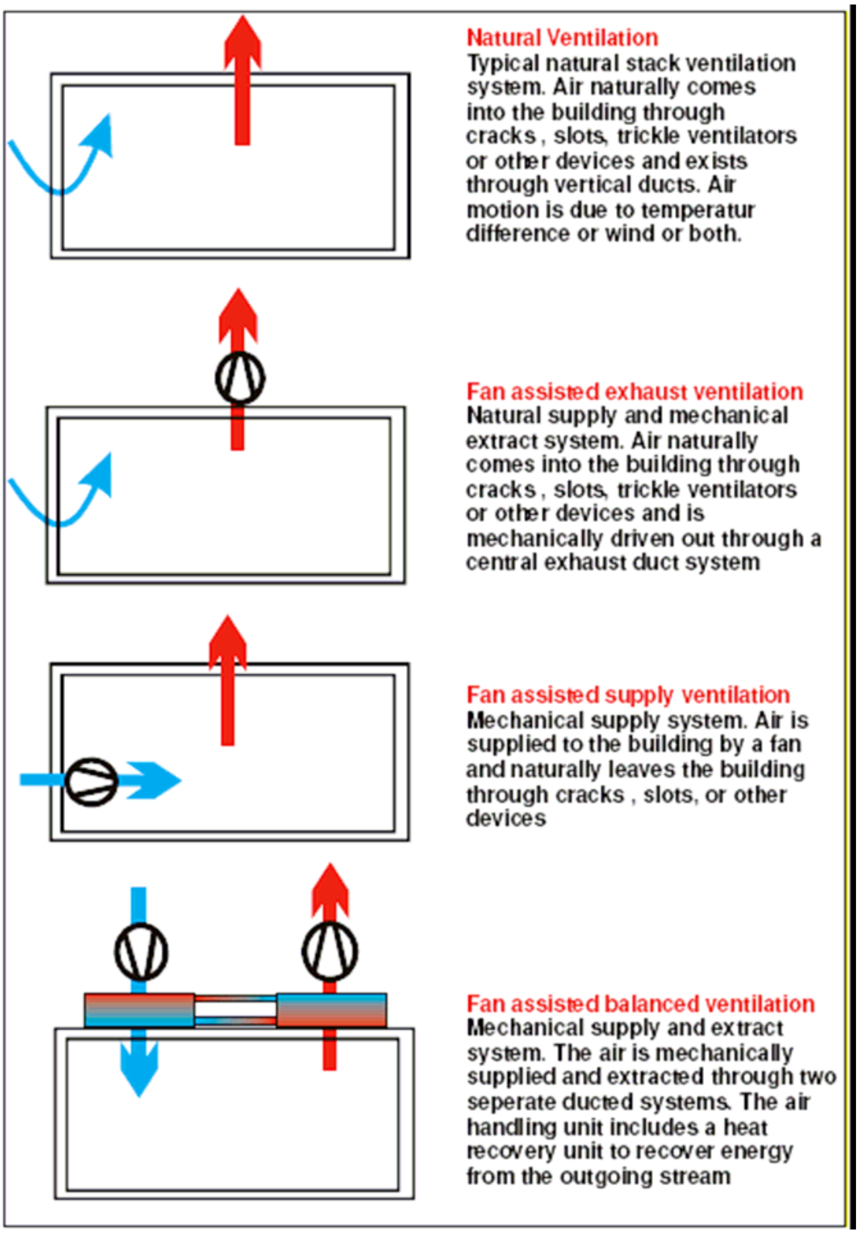


Figure 6: Different types of building ventilation, extract from Lot 11 study on ventilation in non residential buildings (Radgen, 2007)

The first configuration is by far the more common in Europe. The air comes into the room through cracks, windows, slots (natural air supply) and the exhaust air is evacuated by small sized ventilators that can be located on the roof, the ceiling, the walls or in the windows. These fans also generate a depression enabling the outside air to naturally come into the room. For other configurations, ventilators can also be used for direct introduction of outside air inside, the ventilators used in this case are similar to the others.

As a result, in terms of energy using products, individual mechanical ventilation requires several kinds of fans:

- **Roof fans** are located on the roof of the room or may be linked to a ducted system.
- **Extraction fans** can eject the air through the walls or the ceiling directly or through a short duct. Extraction fans are located inside whereas roof fans are located outside.
- **Window fans** are embedded in a window glass. They can also be located in the frame of the window (see Table 10).

- In the residential sector, **hoods** are located close to pollution sources (mainly in the kitchen). The user can turn it on or off when he wants, this kind of device is not taken into account in the dwelling air renewal rate calculation (which is being regulated at Member State level). Three different types of hoods can be found. The hood is simply a filter to be plugged on a decentralized or centralized ventilation system ; in that case, there is no specific consumption for this product, which is not considered in this study. The hood can be plugged directly outdoor: polluted air is extracted inside and rejected directly outside; this is a ventilation system to be considered in this study. The third type is the assembly of a fan and a filtration system that filters indoor air and rejects it in the same room, typically above the hood, to be classified in the category air purifiers.

Among decentralised systems, we find the very common roof fans, window fans, etc. A roof fan is represented in the figure below.

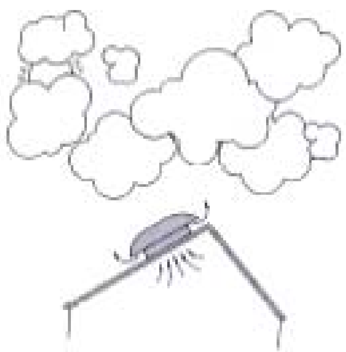


Figure 7: Roof fan implantation scheme

The figure below shows that internally, it combines the motor and the fan itself.

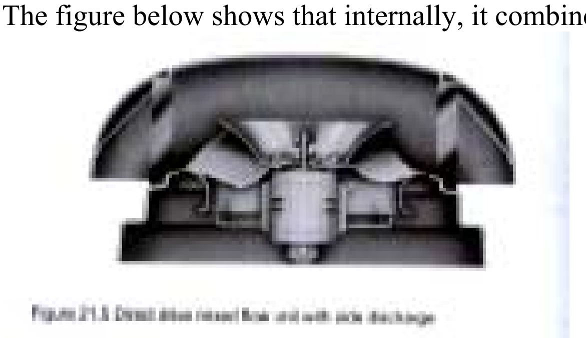


Figure 8: Roof fan figures from (Cory, 1992)

For decentralised systems, the ducts are short, as shown in the figure below, if any.

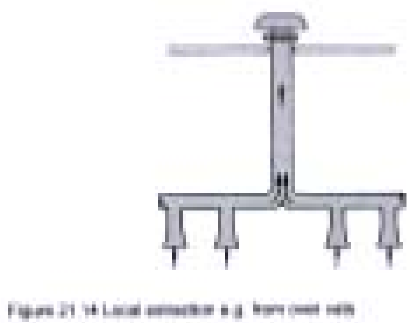


Figure 9: Constant flow extraction from (Cory, 1992)

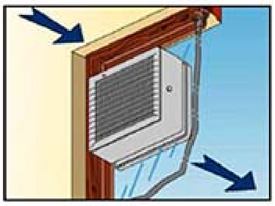
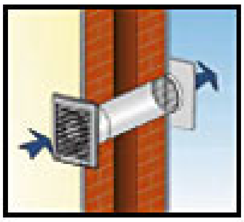
Type	Operating scheme	Typical characteristics	Example
Hoods	Air extraction in kitchen and rejection outdoor	Consumption: 100 – 300 W Airflow: 200 – 700 m³/h Ducted Fix	 Atlantic
Window glass		Consumption: 20 – 100 W Airflow: 200 – 1400 m³/h Non ducted Fix	 Helios
Window (Inside the frame)	Another type of window fan, located in the frame of the window	Consumption:120W Reversible air flow Non ducted Movable	 Honeywell
Wall/ceiling		Consumption:10 – 50 W 100 – 400 m3/h Connected to a short ducted system Fix	 Atlantic
Roof		Often connected to a ducting system Centrifugal or mixed fan Outside the building	

Table 10: Different types of decentralised ventilation fans and their technical characteristics

1.6.4 Centralized mechanical ventilation

Centralized mechanical ventilation means that one extractor and a ducted system are used to renew the air of a whole dwelling (made of several rooms).

Three configurations can be found in the residential area: a natural air supply with mechanical exhaust, a mechanical air supply with natural exhaust and a mechanical air supply together with a mechanical exhaust.

The configurations described hereunder will be often shown with drawings representing individual houses, but they are applied to buildings made of various dwellings as well (called hereunder collective buildings).

Simple flow centralized mechanical ventilation (Natural air supply and mechanical exhaust)

Because of the depression generated by the extractor, the air comes through the dwelling from the less polluted rooms (bedrooms, living rooms) to the most polluted ones (kitchen, toilets) by spaces around the doors. The air comes into the dwelling through cracks, windows, slots. exhaust air is sucked by the extractor, evacuated by grilles in the most polluted rooms. In terms of energy using products, this kind of ventilation requires an extractor larger than small sized fans (as defined in the previous subsection "decentralized ventilation"). An extractor consists in a centrifugal fan driven by an asynchronous motor.

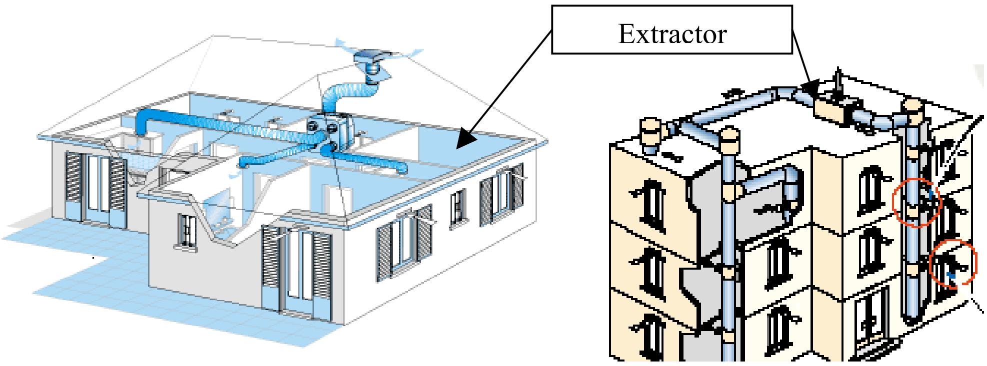


Figure 10: Centralized ventilation with natural air supply and mechanical exhaust fans, Atlantic (left: individual house, right : collective dwellings)

Figure 11: Simple flow extractor, Atlantic (left: individual house, right : collective dwellings)

Usually the electric power is under 80 W for individual houses and under 500W for collective dwellings ventilation.

In mechanical ventilation systems, the air supply is sometimes made through a **ground coupled air to earth heat exchanger**, also called Canadian well, which allows partial cooling of the air in summer. In that case, mechanical ventilation can help to decrease room temperature by a few degrees in summer. This system is designed by specialists on a case by case basis, built and buried on site.

Simple flow centralized mechanical ventilation (Mechanical air supply and natural exhaust)

Air is supplied centrally by a supply fan. Because of the overpressure generated by the air supply inside the dwelling, the air exits the dwelling through cracks, windows, slots.

Balanced double flow ventilation system

The double balanced system is made with (following the flow): air collection (outside the building), one fan, air inlets into the room, exhausts for air extraction, another fan, air rejection device, with typically the addition of a heat exchanger and some filters, and ducts to conduct air flows (inlet and exhaust). The flow becomes almost independent from outside pressure conditions. The internal pressure balance becomes even more important.

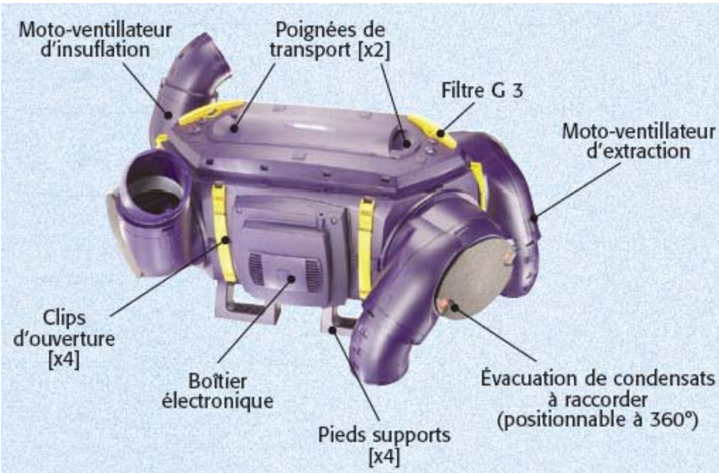


Figure 12: Balanced double flow ventilation unit, Courtesy France Air-CFP

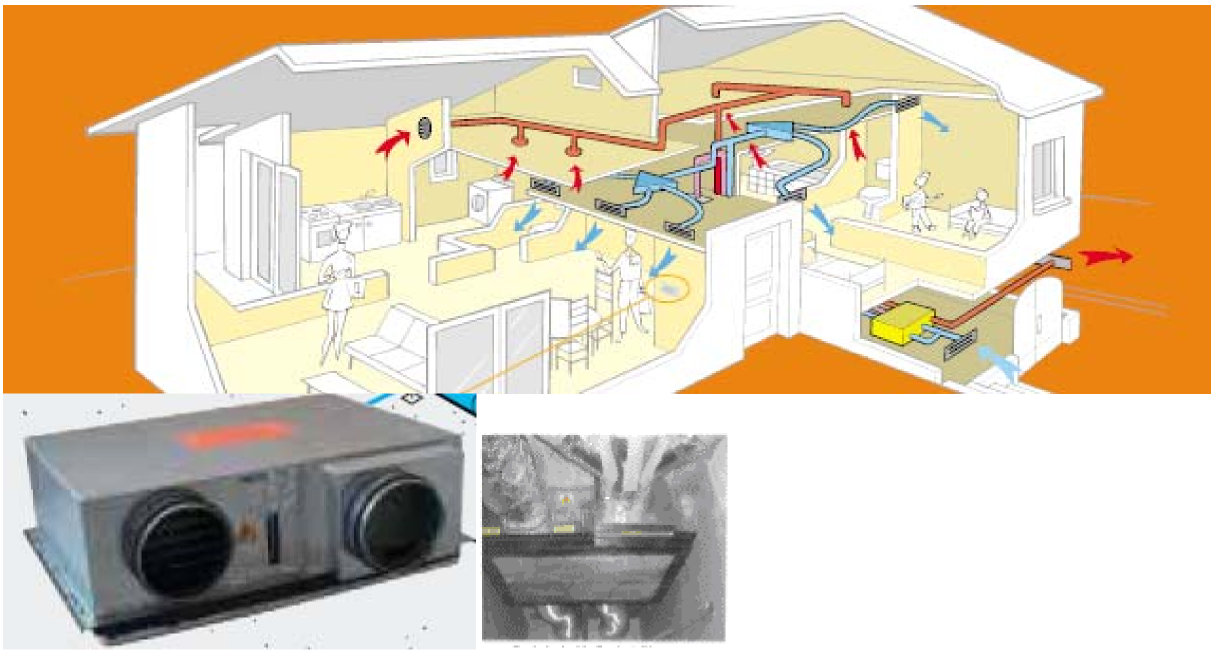


Figure 13: Balanced double flow ventilation system and unit, Courtesy Aldès -CFP

- **Double flow centralized mechanical ventilation**: the exhaust air is extracted in the kitchen, the toilets and the bathrooms. New air is introduced in other rooms with another network but the same extractor block.
- Centralization allows to process the new air (filtration, heating, humidification…) and by gathering the two networks (extraction of exhaust air and extraction of new air) to preheat the new air by recovering heat on the extracted air thanks to a plate heat exchanger. As a result, double flow ventilation coupled **with heat recovery** heat exchanger enables to economize heating energy. This system enables to recover an important part of the energy lost because of the introduction of fresh air for ventilation need in winter but increases electricity use in the product. Double flow heat recovery ventilation is generally a stand alone product to be installed on the ventilation network in dwellings. The head losses being different, the electricity use cannot be compared directly with the other products.
- Centralized mechanical ventilation systems can also be coupled with a reversible heat pump that uses exhaust air as the cold source in winter and as the hot source in summer. In France this system is called "**double flow thermodynamic ventilation**". It supplies both cooling in summer and heating in winter but the heating and cooling energy does not enable to cover all the heating and cooling needs because ventilation air flow rates are quite small. As for plate heat exchanger, heat or cool recovered will depend on outside conditions. This system enables to recover from 50 % to 200 % of the energy lost because of the introduction of fresh air for ventilation need in winter and in summer according to (Promotelec, 2006). Both in cooling and heating modes, this system can only supply part of the thermal requirements of a standard dwelling. It is covered by EPBD prescriptions and should be compared with other heating equipment like boilers.

Fan assisted natural ventilation[10]

Natural ventilation may fail to deliver proper air renewal all year long particularly when wind outdoor is low. In those conditions, assisted natural ventilation makes use of a fan to maintain required hygienic flow rates. Typical flow rates of 300 m3/h and 10 to 20 W are common for these products. The design of fan assisted natural ventilation as a passive stack fan is showed on the figure below.

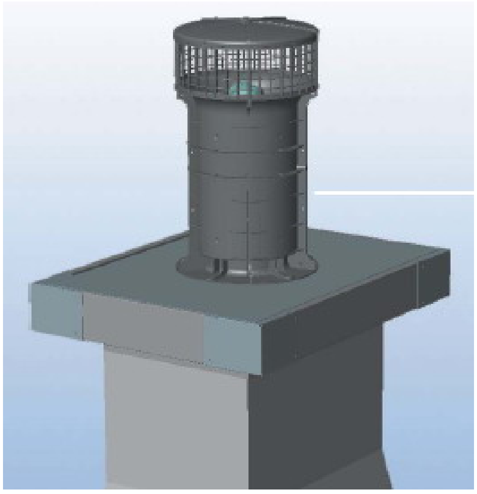


Figure 14: Passive stack fan assisted natural ventilation, Courtesy Aereco www.aereco.fr

[10] "Natural ventilation" is used here specifically to mean ducted natural ventilation systems, while natural ventilation usually encompasses (in the UK anyway) window opening.

1.7 Air purifiers

An air purifier is an energy using product that aims at removing contaminants, often solid particulates such as dust, pollen, molds, and bacteria from air.
In the European residential sector, air purifiers essentially use three types of filters (sometimes at the same time):
- Activated charcoal filters enable to capture some particles in the air by adsorption. Particles become fixed to the irregular and cracked surface of charcoal (1 g of charcoal has a surface about 600 to 1000 m2). This filter traps odours, gases and particles with a theoretical efficiency of 90 % at 10 μm.
- Theoretically, the HEPA (High Efficiency Particulate Air Filter) filter captures 99.97% of all dust and particles as small as 0.3 μm (1 human hair = 150 μm). Particles are attracted by the filter fibres by electrostatics.
- The "washable" foam filter captures up to 25% of airborne pollutants of 1 micron and more, depending on the model.

Amount of filtered air: 140-250 m³/h Electrical supply: 80-185 W Filter up to 0.01 microns	 Delonghi
Amount of filtered air: 242 m³/h Electrical supply: 60 W Filter up to 0.3 microns	 Alpatec

Table 11: Air purifiers and their technical characteristics:

Ionisation is another means proposed to as air purification but is generally proposed in other products rather than alone, in evaporative coolers or air conditioners for instance.

2 Existing product categorisations

The first place where to look for information is Prodcom. Prodcom is a unified terminology for products resulting from industrial activity (see Eurostat, 1998). Segmentation existing in the EU custom code are also investigated as well as test standards and MEPS in Europe and in third countries.

2.1 Air conditioners

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 12: 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 13: 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**[11].

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:
    - Split and multi-split appliances, Packaged, Single-duct and Double Duct
– Water-cooled air-conditioners:
    - 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 14: Segmentation applied to air conditioners in the European labelling directive

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

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
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 15: 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, 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>

Table 16: Eurovent segmentation

2.2 Evaporative coolers

Not included in **Prodcom**, see part on dehumidifiers.
No additional segmentation was found for **evaporative coolers** because of the inexistence of test standards.

2.3 Comfort fans

The Prodcom categorization clearly distinguishes the comfort fans (NACE 29.71.15.30) from ventilation fans (the extraction ones: NACE 29.23.20.30, NACE 29.23.20.70…). There is **no category for comfort fans with an electrical power higher than 125 W and tower fans are not mentioned**.

Fans covered by NACE 29.23 ("Manufacture of non-domestic cooling and ventilation equipment")	
29.23.20.30	Axial fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)
29.23.20.70	Centrifugal fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)
29.23.20.70	Fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)
Fans covered by NACE 29.71 ("Manufacture of electric domestic appliances")	
29.71.15.30	Table, floor, wall, window, ceiling or roof fans, with a self contained electric motor of an output <= 125 W
29.71.15.33	Roof ventilators
29.71.15.35	Other ventilators

29.71.15.50	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side <= 120cm

Table 17: Prodcom segmentation for ventilators

Technical description of comfort fans is given to specify the content of NACE 29.71.15.30. Testing standard in other economies[12] consider these different types as categories (table fan, wall-mounted fan, floor table fan, floor standard fan and ceiling fan).

The column (tower) fans (whose market share is growing nowadays) are not mentioned but could be considered as table fans. However they are not covered in existing test standards and legislation abroad.

The box fans (whose market share is growing nowadays) are not mentioned but could be considered as table fans. Practically they seem to be covered in existing test standards.

2.4 Humidifiers

Not included in **Prodcom**, see part on dehumidifiers.
No additional segmentation was found for **humidifiers** because of the inexistence of test standards.

2.5 Dehumidifiers

Within the **Prodcom** inventory, humidifiers, dehumidifiers and evaporative coolers are covered by NACE 29.23 ("Manufacture of non-domestic cooling and ventilation equipment") and gathered in the same category. As a result, residential humidifiers, dehumidifiers and evaporative coolers are not covered by Prodcom.

Humidifiers, dehumidifiers and evaporative coolers	
29.23.12.70 (Prodcom)	Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units
8415.83.00 (EU custom code)	Air conditioning machines comprising a motor-driven fan, not incorporating a refrigerating unit but incorporating elements for changing the temperature and humidity (excl. of a kind used for persons in motor vehicles, and self-contained or "split-system" window or wall air conditioning machines)

Table 18: EU custom code and Prodcom segmentations for humidifiers, dehumidifiers and evaporative coolers

Regarding **dehumidifiers**, **Canada** has mandatory a MEPS program that applies to electrically operated, mechanically refrigerated dehumidifiers with a daily water-removal capacity of up to 30 liters. Desiccant dehumidifiers, compressed air dehydrators, and dehumidifiers used in skating rinks, indoor swimming pools and other commercial and industrial applications are excluded. This clearly aims at dehumidifiers used in the residential sector. Desiccant dehumidifiers are not included.

To qualify for the **ENERGY STAR** label, a segmentation is made between standard-capacity dehumidifiers (i.e. with a water removal capacity up to 35 liters per day) and high-capacity dehumidifiers (i.e. with a water removal capacity of 36 to 57 liters per day). Desiccant based dehumidifiers are not covered.

[12] See Task 1.2 on test standards in third countries and Task 1.3 Legislation in Third countries.

Dehumidifiers		
Water removal capacity	Up to 35L/day	From 36L/day to 57L/day
Energy Star appellation	Standard-capacity dehumidifiers	High-capacity dehumidifiers

Table 19: Energy Star categorization for dehumidifiers

2.6 Ventilation fans

In the **Prodcom** inventory, ventilation fans are covered both by NACE 29.23 ("Manufacture of non-domestic cooling and ventilation equipment") and NACE 29.71 ("Manufacture of electric domestic appliances"). Categories within NACE 29.23 are meant for non residential products and mainly rely upon the type of fan (as presented in the first section of this study: centrifugal, axial…) with an electrical input limit of 125 W. Categories within NACE 29.23 are thus not useful in our study of residential ventilation.

Fans covered by NACE 29.23 ("Manufacture of non-domestic cooling and ventilation equipment")	
29.23.20.30	Axial fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)
29.23.20.70	Centrifugal fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)
29.23.20.70	Fans (excluding table, floor, wall, window, ceiling or roof fans with a self-contained electric motor of an output <= 125 W)

Fans covered by NACE 29.71 ("Manufacture of electric domestic appliances")	
29.71.15.30	Table, floor, wall, window, ceiling or roof fans, with a self contained electric motor of an output <= 125 W
29.71.15.33	Roof ventilators
29.71.15.35	Other ventilators
29.71.15.50	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side <= 120 cm

Table 20: Prodcom segmentation for ventilators

Within NACE 29.71 we find the residential products. We eliminate here 29.71.15.30, because we treat separately the comfort fans and we finally recognise the products under study in the present report under the three remaining categories.

Categories according to EN- standards, namely testing standard EN 13141 (CEN, 2006a)

Part 4 is applicable to encased ventilation fans having several inlets, as well as ducted and non ducted fans, without defining them more precisely.

Part 6 defines Exhaust ventilation system packages used in a single dwelling
A package is perfectly defined in the standard (two extents):

ventilation system package (for a single dwelling)
Combination of compatible components which are tested, delivered and installed as specified by the manufacturer to complete a residential ventilation system when sold as a single product.

exhaust ventilation system package
System package comprising all components necessary to complete at least the exhaust part of a ventilation system in a dwelling.

Part 7 defines a mechanical supply and exhaust ventilation unit (including heat recovery) for mechanical ventilation systems intended for single family dwellings as
In general such a unit contains:
- supply and exhaust air fans;
- air filters;
- air to air heat exchanger with/without air to air heat pump for exhaust air heat recovery;
- control system.

Such equipment can be provided in more than one assembly, the separate assemblies of which are designed to be used together.

Part 8 defines an un-ducted mechanical supply and exhaust ventilation unit (including heat recovery)
for mechanical ventilation systems intended for a single room
In general, such a unit contains:
- supply and exhaust air fans;
- air filters;
- air to air heat exchanger for exhaust air heat recovery;
- control system.

Such equipment can be provided in more than one assembly, the separate assemblies of which are designed to be used together.

2.7 Air purifiers

Within the Prodcom inventory, air purifiers are only covered by NACE 29.23 (“Manufacture of non-domestic cooling and ventilation equipment”). It refers to non-domestic appliances, machinery and apparatus for “filtering and purifying air”, it does not seem to apply to residential air purifier products described in the definition and that are therefore not explicitly covered by Prodcom.

Air purifiers covered by NACE 29.23 (“Manufacture of non-domestic cooling and ventilation equipment”)	
29.23.14.10	Machinery and apparatus for filtering or purifying air (excluding intake filters for internal combustion engines)

Table 21: Prodcom segmentation for air purifiers

3 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.

3.1 Air conditioners

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.

3.1.1 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.**

1.6.1 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 to increase the refrigeration cycle capacity when starting by evaporative cooling on the condenser. It does not seem necessary to create a specific technical characteristics 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 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 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.

1.6.2 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.

3.2 Evaporative coolers

Evaporative coolers, as air conditioners and comfort fans, are used to improve summer comfort. Evaporative coolers can compete, within certain climatic conditions, with air conditioners.

Nevertheless, because of their physical principle, they cannot maintain the temperature of the indoor air temperature of a room at a given set point for a given heat load to be extracted; it depends on outside climatic conditions. End users are generally aware the product will consume less but will not be able to supply the same level of summer comfort as air conditioners. They could be included in the air conditioner category if the functional unit had been defined in terms of comfort.

It is feasible to define a performance parameter in terms of cooling capacity for evaporative coolers only if it is accompanied with a climatic chart indicating the real limitations of the product in function of outside air conditions and when, for instance a required indoor temperature of 25 °C cannot be reached. This type study has been realized in France to establish a design guide for low energy cooling solutions in offices[13]. By the past, SAVE projects as URBACOOL and PASSYS have also explored favorable European climates for evaporative cooling[14].
Then it is proposed to keep evaporative coolers as a distinct category. The functional unit is to cool the air of a room. There should be two performance parameters to translate that functional unit, the cooling capacity and the temperature decrease available as a function of air conditions.

3.3 Comfort fans

The primary function of comfort fans is **to increase air speed in such a manner the end user may feel more comfortable**. Since air speed must not be increased too much to get acceptable comfort conditions and that comfort is likely to be increased if the air stream attains a larger part of the body, the functional unit would then be "**to move air inside a room"** and the performance parameter to be kept is the air flow rate supplied by the fan.

Different categories have been identified but do not correspond to secondary functions.

About comfort fans, a secondary functionality consists in lighting up a room (ENERGY STAR program). This functionality only concerns ceiling fans that can be associated with a lighting system. This has no direct link with residential room conditioning appliances but changes the environmental impact of the product. Indeed, there are many cases when compatibility is only between light kits and ceiling fans under the same brand. Then some ceiling fans must not be promoted if their associated lighting system is not efficient enough even if the fan is efficient.
This functionality will be taken into account in the environmental impact analysis but will not lead to a specific category.

3.4 Humidifiers

The primary function of humidifiers is to **increase humidity** in a room. The product performance parameter is then defined as the water flow rate that can be added to the indoor air.
Air handling and filtering, elimination of odours or bacteria are some features offered by some dehumidifiers (air-plasma purifier, active carbon filters…). This secondary functionality may be taken into account in the environmental impact analysis but will not lead to a further segmentation.

3.5 Dehumidifiers

The primary function of dehumidifiers is to **remove humidity** from a room. The product performance parameter is then defined as the water flow rate that can be removed from the indoor air.
Air handling and filtering, elimination of odours or bacteria are some features offered by some dehumidifiers (air-plasma purifier, active carbon filters…). This secondary functionality may be taken into account in the environmental impact analysis but will not lead to a further segmentation.

3.6 Ventilation fans

The primary function of ventilation fans is generally to **change indoor air** of a room or dwelling and the corresponding **functional parameter is the air flow rate**. Nevertheless, double flow

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[13] (Ecoclim, 2002)
[14] (Santamouris, 2004)

systems with heat recovery or thermodynamic double flow systems, have respectively two and three primary functions:

- double flow with heat recovery: change indoor air, recover heat;
- thermodynamic double flow: change indoor air, recover heat, recover coolness.

Given that we already mentioned that the thermal consequences of residential ventilation were already addressed by other Community legislation, we will not consider further the other (thermal) functions of double flow mechanical ventilation and thermodynamic double flow ventilation. However, the product displaying those thermal aspects will have more head losses, and two fans, which will lead to higher electricity use. We shall try to base our calculations on the ventilation function, by correcting for the other functions.

For this study, we are interested in products, motor, shaft or belt, fans, including the packaging if any, but not in the system, fresh air grilles and connecting ducts for instance for centralized systems; they will affect the product environmental impact but are not considered inside the EuP product in the rest of the study.

Thus, the product to be considered are individual mechanical exhaust fans for centralized or decentralized residential mechanical ventilation as defined previously:

- Fans for decentralized mechanical ventilation:
    - Roof fans,
    - Window fans,
    - Wall fans,
    - Hood fans.
- Fans for centralized ventilation
    - Extract fan,
    - Supply fan,
    - Extract and supply (balanced or double flow),
    - Extract and supply (balanced or double flow) with heat recovery.

In Appendix 2 of lot 11 interim report many variables and parameters that can be considered are listed. From the physical point of view common to lot 10 and lot 11, there are two characteristics that can be considered as the primary functional parameters of a fan :

• the increase in pressure of the gaseous flow (Δp)

• the velocity of the flow (m3/s).

Apart from the two characteristics mentioned above there are a lot of other technical issues that have to be considered when selecting an appropriate fan. However they are clearly secondary.

The most important ones are:

• Diameter of the fan (m)

• Volume and weight of the fan

• Type of the fan (axial/centrifugal, backward/forward-inclined etc.)

• Type of drive and electrical supply

• Noise level and vibration

• Control systems

• Mounting arrangements and inlet/outlet sizes.

Can we choose between the two characteristic parameters? For the fans used in residences (present study), the rate of air moved (m3/h) is usually the decision parameter as the requested pressure increase (typically 100 Pascal in individual houses and 150 Pascal in collective dwellings) is reached easily by all products. However we shall see that the pressure influence cannot be neglected, and we will keep both.

The air flow rate and the pressure difference generated will be kept as main functional parameters. They are related by a curve that is obtained through testing and giving the air flow rate for a certain level of pressure difference, and vice versa.

3.7 Air purifiers

The primary functionality is to remove contaminants and pollutants, or **to purify air**. Then the performance parameters are first the air flow rate that can be treated and second the size of the smallest particle that can be filtered.
Regarding air purifiers, no additional functionality has been found.

3.8 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. In some case, test standards are not available…

Table 22: Residential room air conditioning appliances, 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
Comfort fans	To move air inside a room	Air flow rate (m3/h)	IEC 60879 (*)	All types of residential comfort fans, table, floor standing, pedestal, wall mounted, ceiling, tower.
Evaporative coolers	To decrease the temperature of a room	Cooling capacity (kW) and temperature decrease	AS 2913-2000	Direct evaporative cooler portable type
Humidifiers	To increase humidity inside a room	Flow rate of added water (L/day)	No	Table and console humidifiers, all technologies
Dehumidifiers	To decrease humidity inside a room	Flow rate of removed water (L/day)	EN 810	Residential dehumidifier, desiccant based and vapor compression type
Ventilation fans	To change indoor air of a room	Air flow rate (m3/h) Static pressure available (Pa)	EN 13141	Fans for decentralized mechanical ventilation: Roof fans, Window fans, Wall fans, Hood fans. Fans for centralized ventilation: Extract fan, Supply fan, Extract and supply (balanced or double flow), Extract and supply (balanced or double flow) with heat recovery.
Air purifiers	To filter the air inside a room	Flow rate of filtered air (m3/h) Size of the smallest particles the device can trap (µm)	EN 779	Filtering type

(*) No test standard covers tower fans.

In addition to the primary functions the secondary functions will be considered throughout the study when they may explain some environmental performance differences. In this subsection, we summarized the functions common to several products.
X: primary functionalities
x: secondary functionalities

Table 23: Residential room air conditioning appliances, functions summary

Functions	Reversible air conditioners	Cooling only air conditioners	Evaporative coolers	Comfort fans	Humidifiers	Dehumi-difiers	Ventilation fans	Air purifiers
To maintain air temperature inside a room (cooling and heating)	X							
To maintain air temperature inside a room (cooling)	X	X						
To decrease the temperature of a room			X					
To move air inside a room	x	x	x	X				
To increase humidity inside a room	x	x	x		X			
To decrease humidity inside a room	x	x				X		
To change indoor air of a room	x	x					X	
To filter the air inside a room	x	x	x		x	x	x	X
To be ductable (available static pressure)	x	x					x	
To light up a room				x				

4 Scope of the study

The scope of the study should be defined on the basis of the MEEuP methodology 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 different seven 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.

4.1 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)[15] 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.

4.2 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 cooling capacity of 12 kW (as in the labelling directive 2002/31/EC).

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

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

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 (*)	Around 6 millions (VHK, MEEuP) (Sales figures 2005)	Average power: 1 kW ? Nb of use: 500 h (2002/31/EC) Yearly consumption: 500 kWh Total Yearly Consumption of pieces sold in 2005 >[16] 3 TWh
Reversible air conditioners	Single duct Double duct Window and through the wall package Split package Multi-split package Central air conditioners (US type)		

Table 24: Energy impact estimate of air conditioners and reversible air conditioners sales, EU 25.

(*) 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[17], 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.

4.3 Evaporative coolers

Thanks to the Australian Greenhouse Office, existing test standard and existing legislation (in Iran only) has been identified. No market data has been identified or supplied by stakeholders at the moment for Europe. Nevertheless, Australian conclusions, that decided not to build a legislation on this product are of interest here. The largest benefit of evaporative coolers is waited if this product may enter in competition with air conditioners. However, as explained beforehand, air conditioners cannot compete for all climatic conditions with air conditioners (they cannot maintain a given required

[16] 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.

[17] VHK, 2006, Ecodesign of Energy Using Product, Lot 1, Report of Task 2, Draft 2, December.

temperature for all outdoor conditions). That is the reason why we had to define two distinct functional units for air conditioners and evaporative coolers.
Whether enough information was supplied on the real performances of these units according to climate so that an application index may be developed and included in the product documentation evaporative coolers could compete with air conditioners and become a BAT for air conditioners in some well defined cases (hot and arid climate, low cooling needs). For hot and arid climates, (Mark Ellis & Associates, 2001) notes that consumption, as compared to a classical air conditioner may be divided by 5. In that direction, it seems a priority to define a harmonised performance test standard for evaporative coolers that includes this variable cooling ability.

As a separate product, their environmental impact is likely to be very low because of supposed small market shares. Further quantitative information on the European market and environmental impact (bills of material), whether made available by interested stakeholders, could help screening the Article 15 of the Directive 2005/32/EC in order to consolidate the decision to include it or not in the study.

4.4 Comfort fans

The scope is limited to **residential** comfort fans.
Commercial names of the products identified are the following ones:
- Table-desk fan,
- Wall fan,
- Floor fan,
- Pedestal fan,
- Ceiling fan,
- Tower fan,
- Box fans.

The existing limit of 125 W found in the Prodcom categories may correspond to the residential range of products. This point will be analyzed in the following tasks. At the moment, no power or air flow rate limitation is put.

Categories	Products included	Approx numb of appliances sold / year	Gross estimation of average energy consumption / year
Comfort fans	Table-desk fan, Wall fan, Floor fan, Pedestal fan, Ceiling fan, Tower fan, Box fans.	Around 3 millions (CECED, 2006) (Sales figures 2005)	Average power: 40 W ? Nb of use: 500 h ? Yearly consumption: 20 kWh Total Yearly Consumption of pieces sold in 2005 0.06 TWh

Table 25: Energy impact estimate of comfort fans, EU 25.

4.5 Humidifiers

Certainly a capacity limitation in terms of humidity that can be added in L/day would have to be defined to limit the scope to **residential** humidifiers.
There is no market data available. Individual electric power advertised by manufacturers give unitary electric power of the same order of magnitude as for dehumidifiers. A priori, energy impact is supposed to be of the order of magnitude of the one of dehumidifiers.

4.6 Dehumidifiers

The scope is limited to **residential** dehumidifiers. According to CECED (2006), this includes two technologies, vapor compression (refrigeration cycle) and desiccant based dehumidifiers. Desiccant based dehumidifiers being also used in air handling units of central air conditioning systems, a capacity limitation to translate the wording residential would have to be defined.

Categories	Products included	Approx numb of appliances sold / year	Gross estimation of average energy consumption / year
Dehumidifiers	Based on the refrigeration cycle Desiccant based	Around 500 000 units (Sales figures 2005) (CECED, 2006)	Average power: 250 W ? Nb of use: 250 h ? Yearly consumption: 62.5 kWh Total Yearly Consumption of pieces sold in 2005 0.03 TWh

Table 26: Energy impact estimate of comfort fans, EU 25.

4.7 Ventilation fans

Ventilation fans group gathers several different product types.

- Fans for decentralized mechanical ventilation:
    - Roof fans
    - Window fans
    - Wall fans
    - Hood fans
- Fans for centralized ventilation serving various rooms, which can be differentiated between fans serving one individual house (Elec power < 80 W) and fans serving various dwellings in the same collective building (Elec power < 500 W); those products are also called encased fans and may be sold as packages with the exhausts and/or supply grilles, the roof outlets and/or inlets.
    - Extract fan
    - Supply fan
    - Extract and supply (balanced or double flow)
    - Assistance fans for hybrid ventilation.

Based on what is in the scope of Lot 11, roof fans under 100 W, extractors under 300 W, window fans under 30 W, hood fans under 300 W and wall fans under 30 W can be considered as used in the residential sector.

Categories	Products included	Approx numb of appliances sold / year	Gross estimation of average energy consumption / year
Ventilation fans	Small window fans Wall fans Roof fans Hoods fans Extract fan Supply fan Extract and supply (balanced or double flow) Assistance fans for hybrid ventilation.	Around 800 000 in France (Uniclima, 2006) (Sales figure 2005) 4 millions in Europe ?	Average power in use: 25 W ? Nb of use: 8760 h Yearly consumption: 220 kWh Total Yearly Consumption of pieces sold in 2006: 0.9 TWh

Table 27: Energy impact estimate of ventilation fans, EU 25.

For ventilation fans, specific care should be taken concerning information on national legislation at Member State level because of possible interaction with national building codes. For instance, UK and

France have already implemented minimum energy efficiency requirements for mechanical ventilation.

4.8 Air purifiers

There is no market data available. Individual electric power advertised by manufacturers give unitary electric power of the same order of magnitude as for dehumidifiers but average product is not known.

4.9 Final scope for lot 10

We referred until now to the wording "Residential room conditioning appliances" and have identified 8 product categories:

- air conditioners,
- reversible air conditioners,
- comfort fans,
- evaporative coolers,
- humidifiers,
- dehumidifiers,
- ventilation fans,
- air purifiers.

Amongst these categories, the functional analysis showed that humidifiers, dehumidifiers and air purifiers cannot be identified as "airco" or "ventilation" appliances. As a consequence, they are thought to be out of the scope of Lot 10.

Moreover, if we attempt to classify product categories by the energy impact of the appliances sold on the EU market in 2005, we find the following four main energy consumer product categories, cooling only air conditioners, reversible air conditioners, residential ventilation and comfort fans. These product groups are explicitely included in 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", at least for air conditioners and residential ventilation.

Dehumidifiers, evaporative coolers, air purifiers, are thought to have electricity consumption (of sold units per year in 2005, as in the table above) **under around 30 GWh for each category**, i.e. **less than 1% of the consumption of air conditioners**. We have presently no figures concerning humidifiers but we expect the same order of magnitude as for dehumidifiers. These four product categories then seem of lower importance, then in good agreement with the lot targeted products.

However, information on the excluded product categories that could help to make better evaluations in the light of the article 15 criterias as market sales and stock information, environmental impact and potential for improvement, in order to avoid missing any important Energy Using Product, is welcome.

Scope of the study

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[18]
Reversible air conditioners	Single duct Double duct Window and through the wall package Split package Multi-split package Central air conditioners (US type)	
Ventilation fans	Fans for decentralized mechanical ventilation Fans for centralized ventilation	- Window fans (Elec power < 30 W), Roof fans (Elec power < 100 W), Wall fans (Elec power < 300 W), Range hoods including a fan and rejecting air outside (Elec power < 300 W) - serving one individual house (Elec power < 80 W), serving various dwellings in the same collective building (Elec power < 500 W)
Comfort fans	Table-desk fan, Wall fan, Floor fan, Pedestal fan, Ceiling fan, Tower fan, Box fans.	Elec power < 125 W[19] ? To be confirmed by the market analysis

Table 28: Scope of lot 10 study

[18] 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.
[19] Cf. Prodcom categories analysis.

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