Product Definition: Air conditioners

January 2010

1 Matrix Definition

This work covers residential air conditioners, defined for this purpose as follows:

> ***'An air conditioner is an appliance for use in dwellings designed to maintain the temperature of indoor air at a given temperature level for a given heat load to be extracted.'***[1]

Note: It is recognised that many air conditioners may be used in both residential and commercial applications – any such units are intended to be included in the performance benchmarking. But their sales numbers into commercial use should not be included – only numbers sold into residential use.

The scope of types of air conditioner is immense and some initial constraints on this are appropriate to focus limited resources in a productive way. These are discussed in the sections below.

Initial step to focus effort:

Only residential air-conditioners will be considered, with a suggested upper capacity limit of 14 kW cooling.
This project aims to address air conditioners intended for use in dwellings (homes). This effectively excludes most central air-conditioner plant (but see also section on page 5 on *Domestic central air conditioners (ducted))*, large packaged systems, VRF systems, close control units (computer cooling) etc. For smaller plant, however, there is no technical distinction between products used in the home and those used in some types of office and other business or public building. Hence an indicative cooling capacity upper limit could be adopted to segregate products of interest. European energy labels and the prevalent European certification scheme[2] adopted 12 kW cooling capacity as their size limit. China uses a market split for labels at 14 kW and also at 7.1 kW; Korea uses 10 kW; Japan 7.1 kW; Canada & US 8 kW and 14 kW; Australia 7.5 and 10 kW[3]. To avoid having to split datasets for many countries, it may seem reasonable to set a size limit at the higher end of the spread and accept data sets that cover a subset of that capacity range for all countries that use lower divisions. I.e. Korea submits products up to 10 kW, Japan up to 7.1 kW etc as their data sets allow. Assuming that capacity data is provided, the benchmarks can be analysed to compensate for varying capacity ranges for products (selecting if necessary a core subset common to all datasets).

[1] From EuP Preparatory study on the environmental performance of residential room conditioning appliances (airco and ventilation), Contract TREN/D1/40-2005/LOT10/S07.56606, Draft of Task 1, version 6, March 2008: Definition of Product, Standards and Legislation, page 7.
[2] Eurovent Certification Programme.
[3] EuP Preparatory Study for residential room conditioning, Task 1 report, section 1.3.4.

Following this constraint, air conditioners can then be broadly categorised by the matrix in Table 1.

Table 1: Initial matrix definition of possible air conditioner sub-categorisation (already reduced by aspects explained above), and subjected to further reduction of scope, see section 2.

		Aspect	**Possible Permutations**							
A	Technology	Refrigeration method	(Electrically driven) vapour compression				Absorption driven			
B		Condenser cooling	Air cooled				Water cooled			
C		Heat transfer fluid	Air (Water chillers excluded)							
D	Functionality	Type	Non-ducted Unitary (‘packaged’, in single mounting)	Non-ducted split units, (single room unit and single condenser linked by pipe-work)	Multi-split (two or more room units and single condenser linked by pipe-work)	Single duct / double duct	Central air conditioners (ducted)			
E		Cooling / heating	Cooling only	Reverse cycle (heat and cool)						
F	Other variables	Mounting	High Wall	Floor mounted	Cassette	Ceiling	Window / thru-wall	Built-in horizontal	Built-in vertical	Mobile
G		Humidity control	Yes	No						
H		Air filtering / purification	Yes	No						
J		Variable speed drive / multi-speed compressor	Yes	No						
K		Refrigerant	R407C, R410A etc							
L		Standby consumption	For controls and crankcase heater(s) etc.							

2 Product Sub-Category Rationalisation

2.1 Technology

Matrix Row A): Refrigeration method

Proposal:

- **Only electrically driven vapour compression cycle units considered.**
  This excludes absorption-based units that constitute a very small proportion of all markets.

Matrix Row B): Condenser cooling

Proposal:

- **Only air cooled air conditioners will be considered.**
  This excludes air-conditioners with water-cooled heat exchangers (condensers). Of over 6,200 products in the European Eurovent certification scheme in 2006[4], only 25 were water-cooled – ie less than half of one percent. No data were available for other markets. Whilst water-cooled units will constitute a higher proportion than this in hotter climates, air cooled units are nevertheless far more prevalent.
- **Note:** Data for water spray (or condensate spray) assisted condensers will be accepted, but such data points will be flagged as comparability may be unreliable.

Matrix Row C): Heat transfer fluid

Proposal:

- **Only units that cool air directly will be considered.**
  This excludes units that chill water for the cooling medium. Chilled water units are generally used in larger applications than residential, but mini-chillers are sometimes used in residential systems (chilled water is circulated around the home to fan coil units which cool the air). All of these chilled water units are proposed to be excluded.

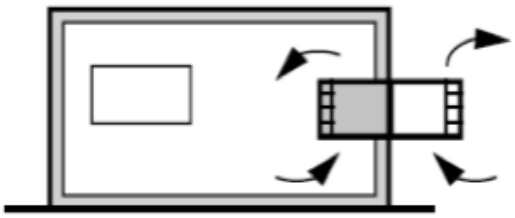
2.2 Functionality

Matrix Row D): Type

How countries sub-divide the market by type varies, as does the terminology used to describe them. Alternative names are suggested in some cases below.

Non-ducted unitary (also called 'packaged', in single mounting)

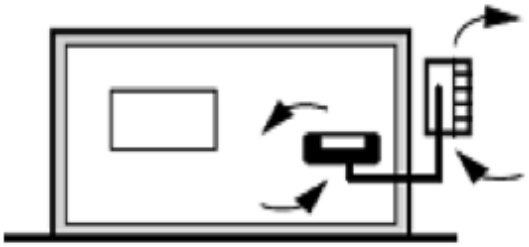
This includes 'window units' and 'through the wall units' (respectively room air conditioners and package terminal air conditioners, PTAC, in the USA). These are factory assembled single housing units designed to be mounted with one part of the housing outside, the other part inside.



[4] EuP Preparatory Study for residential room conditioning, Task 1 report Table 1-49.

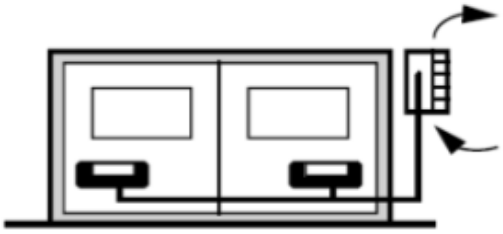
Non-ducted split units (single room unit and single condenser linked by refrigeration pipe-work)

These units are factory assembled in matched pairs – one unit to be mounted in the room to be cooled, linked by refrigerant pipe-work to an exterior condenser unit that expels the heat.



Non-ducted multi-split (two or more room units and single condenser linked by refrigeration pipework)

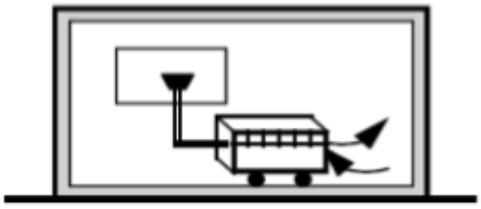
These units are factory assembled in matched pairs, but two or more inside units can be connected to one outside condenser unit that expels the heat. The units are linked by refrigerant pipework. It is challenging to fairly characterise the performance of these units as they can be used in multiple configurations (which is likely to be one reason for their exemption from labels and MEPS in Australia).



Single duct / double duct

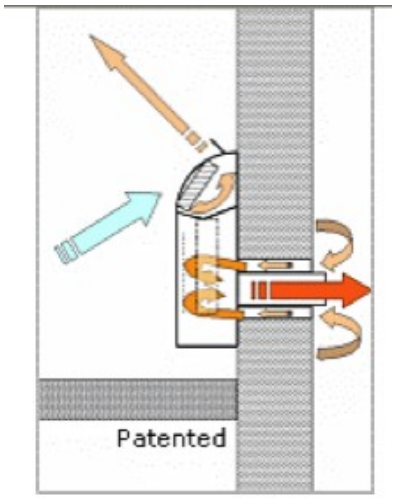
Single duct units are often mobile and take air from the room being cooled to cool the condenser, which is ejected through a pipe to the outside. The test methodology used for these is not ISO 5151, and the test condition is not T1 (see Metrics section 5) and so data for these units would not be comparable to that from other units. *It is therefore proposed to exclude single duct units.*

Note that ‘single duct’ and ‘double duct’ are NOT considered ‘ducted’ air conditioners in the formal sense, since the single or double ducts do not carry conditioned air.



Double duct units are similar to single duct units but take the air to cool the condenser from the outside as well. Sometimes these are wall-mounted, with concentric ducts through a hole in a wall or via a flexible duct (mobile units). Double duct products units are tested using the same standards

as unitary products, since the 'duct' is only an embellishment for condenser air flow. *It is therefore proposed to include double duct units, but analyse them with unitary products.*

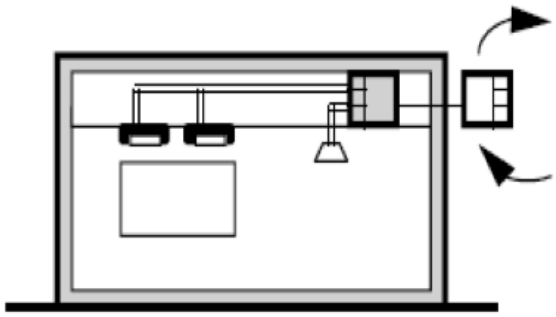


Central air conditioners (ducted)

For these systems, a single split unit cools two or more rooms by means of air ducts to transfer the conditioned air. These units account for around one third of domestic air conditioner sales in Canada (but probably around half of total capacity of sales) and are also common in the US. But they are not common in other countries and regions. This could be due to their more restricted space in dwellings with less room for air ducts.

In addition, there could be doubt over the comparability of efficiency data for benchmarking, since energy consumption will include that for the fan to drive air flow through ducting: EN14511, for example, subtracts that energy from the total, but the resultant figure could be misleading to users (and policy-makers) as the COP/SEER will not include consumption to counter duct losses necessary for their use. How this energy is treated in calculations is likely to vary across regions.

Therefore it is proposed that central air conditioners (ducted) are not analysed in this study.



Proposal (for 'Type'):

- *To exclude central air conditioners (ducted), and to exclude single-ducted units. All other types described above to be included, noting that double-ducted units will be analysed with the unitary products.*

Matrix Row E): Cooling / heating

There are 2 to 3 times as many reverse cycle units on the European market as cooling only, and so data will be collected on both reverse cycle and cooling only units.

The principal focus of this work is proposed to be on cooling efficiency, therefore it is proposed that only cooling efficiency will be mapped and benchmarked at this stage. However, data will also be collected on heating efficiency for later analysis if required, particularly as it is recognised that MEPS are usually introduced for both heating and cooling aspects at the same time.

Proposal:

- *Request efficiency data on cooling only and reverse cycle units, but analyse only cooling efficiency at this stage. Ie to group cooling only units, and cooling phase of reverse cycle units in the same data set for analysis.*

2.3 Other Variables

Matrix Row F): Mounting

The method of mounting is an additional means to subdivide the market, to separate certain types of unit for analysis, but is not considered a primary functionality issue ('type' and cooling / heating are used for that). In addition, mounting is unlikely to be included in all datasets in compatible formats for all mounting types.

The mounting categories used by Eurovent for example are: High Wall, Floor mounted, Cassette, Ceiling, Window / thru-wall, Built-in horizontal, Built-in vertical, Mobile.

The most likely mounting sub-divisions of interest might be:

a) the window-mounted or through-the-wall units (sufficiently high in numbers and widespread geographical use). These products are a subset of the 'packaged unit in single mounting' type.
b) Mobile units. These products are a subset of the single duct / double duct category, but single duct have already been proposed for exclusion, and double duct will be analysed with the unitary products.

Due to the variability of terminology and categorisation, it is proposed not to attempt to sub-divide mounting types any further than this.

Proposal:

- *To tag 'window' and 'through the wall' data for separate analysis later if required, but no analysis or data presentation will be done on mounting methods at this stage.*

Matrix Row G): Humidity control

For the majority of products, and for most datasets, efficiency with humidity control is unlikely to be separately noted. Hence, such units will not be excluded, but this feature will be assumed as not operating in the efficiency tests. Humidity levels during test will, however, be taken into account when analysing data.

Proposal:

- *To ignore humidity control functionality of the products.*

Matrix Row H): Air filtering / purification

In most substantial datasets this is unlikely to be noted as a feature. Standard test methods will not include this function anyway. Hence, such units will not be excluded, but this feature will be assumed as not operating in the efficiency tests.

Proposal:

- *To ignore air filtration aspects.*

Matrix Row J): Variable Speed Drive / multi-speed compressors

Variable speed drives and multi-speed compressors improve matching of the cooling load to the unit capacity, and so give improved efficiency in the field (although efficiency under standard test conditions may not show such substantial savings). It could be useful to policy makers to distinguish such units, to understand their penetration into the market (anecdotal evidence indicates this may be growing rapidly).

Proposal:

- *To note whether units have variable speed control, if it is included in the dataset. No specific analysis of these units to be undertaken, other than to note indicative market penetration (%).*

Matrix Row K): Refrigerant

There is a limited range of refrigerants that can be used in this type of equipment and refrigerant type is unlikely to be the most dominant factor influencing efficiency. It is proposed not to analyse for refrigerant at this stage, however, this can be requested as a secondary data item for possible future analysis.

Proposal:

- *To request refrigerant type in the dataset, as an item of secondary interest (lower importance), with no data analysis of refrigerant to be carried out at this stage.*

Matrix Row L): Standby consumption

Some air-conditioners will have a standby consumption when no cooling is being carried out. This could be supporting controls awaiting a start signal, or could also be for crankcase heaters in outdoor units. When these same items consume power during cooling/heating operation, the consumption is included in the EER or COP assessment. However, standby consumption could account for a significant annual proportion in moderate or cool climates.

Since hours of use / in standby of the products will not be determinable, standby consumption can only be plotted as an overall characteristic of products, and not as an annual consumption figure.

Proposal:

- *To request data on standby consumption for plotting as a characteristic of the products.*

3 Revised Categorisation

Based on the proposals made, Table 2 provides a rationalised Product Definition Matrix. This rationalised matrix may then be rearranged to provide a simplified view of the product categorisations for which data should be sought, see Table 3.

Table 2: Rationalised Matrix Definition of air conditioners Sub-Categorisation

		Aspect	**Possible Permutations**		
A	Technology	Refrigeration method	Electrically driven vapour compression (Absorption units excluded)		
B		Condenser cooling	Air cooled, including spray assisted (Water cooled units excluded)		
C		Heat transfer fluid	Air (Water chillers excluded)		
D	Functionality	Type	Unitary ('packaged', in single mounting, including double duct units)	Split units, (single room unit and single condenser linked by pipe-work)	Multi-split (two or more room units and single condenser linked by pipe-work)
E		Cooling / heating	Cooling only units and reverse cycle units (which heat and cool) will be analysed together in the same dataset. O*nly data for cooling phase to be analysed at this stage.*		
F	Other variables	Mounting	Data to be invited, but not analysed at this stage (Window / thru-wall; other fixed mounting; mobile)		
G		Humidity control	(ignore)		
H		Air filtering / purification	(ignore)		
J		Variable speed drive / multi-speed compressor	(record if present or not)		
K		Refrigerant	Record refrigerant type (using ASHRAE refrigerant numbers, Rxyz etc)		
L		Standby consumption	Invite submission of standby consumption		

This final set of variables has been simplified into the definition and sub-categorisation shown in Table 3 below.

Table 3: Simplified Product Categorisation Matrix

Definition & scope	*'Air conditioners used in dwellings and designed to maintain the temperature of indoor air at a given temperature level for a given heat load to be extracted.'* Including only (at this stage): • Products of up to 14 kW cooling capacity (indicative, to exclude products used only in commercial premises) • Electrically driven vapour compression (Absorption units excluded) • Cooling only units, and • Cooling function of reverse cycle units (data for heating cycle / heat pumps to be collected but not analysed) • Air cooled condensers, and water/condensate spray assisted (water cooled units excluded) • Only air to air units (water chillers excluded)		
Type	Unitary ('packaged', in single mounting, including double duct units)	Split units, (single room unit and single condenser linked by pipe-work)	Multi-split (two or more room units and single condenser linked by pipe-work)
Other variables to be noted (but not analysed)	Mounting (Window / thru-wall; Other fixed mounting; Mobile) Variable speed drive / multi-speed compressor (yes / no) Refrigerant (designated according to ASHRAE refrigerant numbering system) Standby consumption (plotted as a characteristic of the products)		

Note: Both ducted air conditioners (central) as used in US and Canada, and single-ducted (portable) units are excluded.

4 Participating Country Requirements

To be determined following feedback.

5 Metrics

The key metrics to be used in mapping graphs are:

Unit Energy Efficiency, Cooling: *a) EER (Energy Efficiency Ratio) (broadly the kW cooling per kW electrical input at a known rating point)*
b) Seasonal EER (SEER, EU / US), or Cooling Seasonal Performance Factor (CSPF, Japan)

This will require detailed information on how seasonal efficiencies are calculated as they may differ around the world.

Data to be collected, but not analysed at this stage:

Unit Energy Efficiency, Heating: *a) COP (Coefficient of Performance)*
b) Seasonal COP, or Heating Seasonal Performance Factor (HSPF, Japan)

Similarly, this will require detailed information on how seasonal efficiencies are calculated.

In each case, the most important data set for comparison will be EER (SEER for one product cannot be compared with EER for another).

Noted for completeness, but challenging to compare due to significant variation in climate, building thermal characteristics etc:

Unit energy consumption:	*kWh/year* Typical equivalent full load hours will vary depending on the ambient conditions in each climate region of each country i.e. the proportion of the year for which cooling is required, and consumption will depend on many other factors including building characteristics, so practical value of this data is questionable.

Note: Latent cooling ratio will not be recorded nor analysed.

Full load versus seasonal efficiency assessment

Performance data for air conditioners has historically been based on full load performance. However, very few units will spend much time at full load. Hence units are often selected on their efficiency at a non-representative output level compared to how they are used in the field. Therefore seasonal efficiency methodologies have been developed in several countries /regions in which tests are carried out typically at 25%, 50%, 75% and 100% of full load. The seasonal average performance is calculated from these data based on what proportion of a typical year would be spent in each of these load conditions. The EuP preparatory study for air conditioners indicates that the USA, Japan and Korea already have seasonal efficiency test methodologies in use. A formal seasonal test methodology is being developed under ISO, and for Europe a mandate to CEN is expected requiring CEN to develop a methodology for use with EuP measures.

Most data is likely to be available only for full load performance. But seasonal efficiency (SEER) is a more valuable metric for optimising equipment selection. Since there is a variety of test methods and test conditions in use to determine SEER, the data will have to be carefully analysed to ensure comparability, and this is dependent upon having details of the test and calculation methods provided with the data.

Proposal:

- *To collect full load data and analyse that as the primary data stream.*
- *To invite seasonal data with test method and calculation method details, for analysis at a later stage. The availability of seasonal data is in itself a useful indicator for policy-makers on progress on this issue.*

Additional notes on metrics:

There is a variety of test methods used, with different climate classes, humidity levels etc. Analysis of the test method will have to be undertaken for each data set submitted to ensure comparability.

In practice the T1 test condition[5] indicating performance under a moderate climate is the world standard condition for rating air conditioners[6] and will be adopted for this comparison as far as

[5] From ISO 5151: *Non-ducted air conditioners and heat pumps - Testing and rating for performance.* T1 conditions are : indoor 27ºC / outdoor 35ºC dry bulb.

[6] EuP Preparatory Study for residential room conditioning (Lot 10), Task 1 report, page 28.

practicable. Participants should also be asked if any modification was made to T1 conditions for local testing.

The relative efficiency of small air-conditioning units will have a proportionately smaller impact on the overall national efficiency levels compared to the efficiency of large units. Hence, it is proposed to weight the efficiency of the unit according to its capacity when deriving an overall market efficiency. This is in addition to any sales weighting that may be possible.

6 Data requirements

To enable the most effective analysis of data and comparison between countries, we would like to collect the following data:

Information on new products on sale

For all years available between 1996 and 2008 and for all categories as defined in Table 3,

1. Ideally this will be in the form of **individual model information** including (in approximate order of priority)**:**
   a. EER (calculated by dividing cooling capacity given in kW by power input given in kW cooling, at known rating conditions as per 7. below)
   b. Cooling capacity, in kW (preferably, data in BTU/hour will be converted).
   c. Any standby consumption in watts, including any crankcase heater.
   d. Type of unit
   e. Any information on models that are anticipated to enter the local market within two years that are more efficient than anything currently on the market
   f. Whether the unit has variable speed drive or not (yes/no)
   g. Mounting method – in particular whether a window unit / through the wall, mobile unit, or 'other fixed unit'
   h. Seasonal energy efficiency ratio (SEER), also known as Cooling Seasonal Performance Factor (CSPF) in Japan
   i. Refrigerant (designated according to the ASHRAE refrigerant numbering system)

   And if product is a reverse cycle unit:

   j. COP (heating)
   k. Heating capacity, in kW or BTU etc
   l. Seasonal COP, also known as Heating Seasonal Performance Factor (HSPF) in Japan.

2. Where this is not possible, other information that allows the identification of best, worst and sales weighted average consumption of products available on the local market.

Information on stock and sales

For all years available between 1996 and 2008, for dwellings / household / residential / domestic products (not commercial)

3. The country / regional stock of air conditioners in use at that time:
   a. Overall number of products installed in homes (or average number per household), ideally by type.
   b. Indicative sales weighted average cooling capacity
   c. Indicative sales weighted average heating capacity (for reverse cycle units)
   d. Average product lifetime
4. Where this is not possible, other available information on stock, eg overall average energy consumption etc.
5. Total annual sales volume, by type and/ or capacity if possible.

Additional Information Required for Data Processing

6. Test methodology(ies) used to derive the data, and any relationship to known international standards (e.g. clone of test standard [ABC112233], clone with amendments [X Y and Z], etc.)
7. Climate class of test (class T1 ideally), and any other information to determine the test conditions used for that product, and any modifications made to the standard class conditions.
8. Calculation method for seasonal efficiencies and seasonal COP.
9. List of local regulations that define and affect product efficiency

Additional Information Required for Other Planned Analysis

10. Summary of all major policy actions affecting air conditioners over the period data is available including whether voluntary or mandatory, the year when policy was first considered, the year of formal announcement of the policy plans, and the year when the policy came into force. Also whether it applies to cooling only, or to cooling and heating modes.
11. Summary of any major cultural or other issues that are thought to affect this product at the local level (housing quality / age, trends in proportion of house volume that is cooled etc).