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Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product Group Analysis/2

Lot 6: Air-conditioning systems

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TASK 2 – ECONOMIC AND MARKET ANALYSIS

INTRODUCTION

This is the draft report for Task 2 on the economic and market analysis of Air Conditioning Products, as part of the preparatory study on Air Conditioning and Ventilation Systems in the context of the Ecodesign Directive.

This study is being carried out for the European Commission (DG ENTR). The consortium responsible for the study is Armines (lead contractor), BRE and VHK. The subcontractor for this report is BRE.

A Task 2 report has been produced on Ventilation. Some products – notably Air Handling Units – can serve both ventilation and cooling/heating functions. These are reported in the ventilation report.

The products addressed in this report are:
- Air conditioners (with different commercial subtypes: split, split ducted, multisplit, VRF, rooftops)
- Chillers
- Fan coils and other terminal units
- Heat rejection units (cooling towers – closed and opened, dry coolers)

Because this is a new product with not yet established market statistics, the study is missing information on air conditioning condensing units. Market information is only available for refrigeration condensing units.
Stakeholders are invited to supply information on this product.

(Note: required input from stakeholders are noted in the document with the following tag **Information Request issue)**.

1. SUBTASK 2.1 - GENERIC ECONOMIC DATA

This subtask 2.1 is required to provide the following generic economic data:

- EU-27 Production Sold;
- Extra-EU-27 Trade;
- Intra-EU-27 Trade;
- **EU-27 Sales and Trade**: Calculated from EU-27 production sold plus Intra-EU-27 Trade minus Extra-EU-27 Trade

All in physical units.

1.1. PRODCOM DATA ANALYSIS

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Prodcom data categories do not separately identify the air conditioning products covered by this ENTR Lot 6 study. The relevant Prodcom categories are:

- 28251220: Window or wall air conditioning systems, self-contained or split-systems
  - These products are within the scope of the present study if used for comfort cooling and over 12 kW cooling capacity: smaller units were addressed in DG ENER Lot 10
- 28251250: Air conditioning machines with refrigeration unit (excluding those used in motor vehicles, self-contained or split-systems machines)
  - This category includes comfort-conditioning air conditioning chillers but also chillers used for other air conditioning applications, and other products
- 28251270: Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units
  - This category includes air handling units and terminal units – including fan coil units - but also other component parts of central air conditioning systems,.
- 28296030: Cooling towers and similar plant for direct cooling by means of re circulated water
  - Most cooling towers are not used in air conditioning systems

The tables below summarise Prodcom data for these categories. The “apparent production” values are derived from the reported figures and do not take account of possible stock levels (between production or import and sale).

Table 2 - 1 . EU 27 Trade Volumes

Prodcom category 28251220: 1000 of units							
Window or wall air conditioning systems, self-contained or split-systems							
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Sales	1293	1592	1863	2811	3448	3400	2460
Imports	0	12	175	2112	3967	5002	1372
Exports	0	0	1	582	581	283	311
Apparent Production	1293	1580	1689	1281	62	-1319	1399

Prodcom category 28251250: 1000 of units
Air conditioning machines with refrigeration unit (excluding those used in motor vehicles, self-contained or split-systems machines)

	2003	2004	2005	2006	2007	2008	2009
Sales	1378	1853	1672	2490	2489	2384	1593
Imports	0	1	18	244	494	2160	1677
Exports	0	0	0	249	244	548	96
Apparent Production	1378	1852	1654	2495	2238	772	12

Prodcom category 28251270: 1000 of units							
Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units							
	2003	2004	2005	2006	2007	2008	2009
Sales	1919	2200	2341	2582	1837	1716	1284
Imports	0	1	6	124	259	900	533
Exports	0	0	0	766	1565	1405	2242
Apparent Production	1919	2200	2336	3224	3143	2220	2993

Extra EU-27 trade and Intra EU-27 trade are only available in Prodcom at the even more aggregated level of Procom code 28251 Non-domestic cooling and ventilation equipment

The Prodcom data are therefore of very limited value for this analysis, being too aggregated.

1.2. COMPARISONS WITH MARKET RESEARCH DATA

The Prodcom figures may be compared with product sales data from market research, for the year 2008 (all figures rounded). The latter are smaller, as is to be expected from the wider scope of the Prodcom classifications.

Table 2 - 2 . Comparison of Prodcom and Market Research Data

Air conditioning product	Market Research	Prodcom value	Prodcom category
Chillers	85,000	2,384,000	28251250
AHUs for air conditioning and fan coil units	184,000 + 1,140,000 = 1,324,000	1,716,000	28251270

Sales figures used in this report are based on market research (described in more detail later). They are for sales to end-users irrespective of whether they are imported, manufactured within the EU-27 or assembled within the EU-27 from imported components. Import and export is only reported from a national perspective so intra-EU and extra-EU figures cannot be determined from them. Qualitative comments on imports and exports are contained in sections describing the major product suppliers.

Within this report the term “chillers” refers only to chillers used in air conditioning systems. Chillers serving other functions are excluded. Products that are technically similar to those used for (comfort) air conditioning but used in other applications, such as data centres are therefore excluded. The market research data suppliers estimate that about 5% of “air conditioning” chillers may also provide an element of process cooling.

2. SUBTASK 2.2 - MARKET AND STOCK DATA FOR EACH PRODUCT CLASS

2.1. INTRODUCTION AND MARKET OVERVIEW

2.1.1. Market overview

The concept of a “central air conditioning system” covers a wide range of system types, composed of different combinations of components. There are many configurations of systems that fall within the scope of this study, each with its own characteristics in terms of cost, efficiency, control ability etc. The relative importance of each of these characteristics depends on building use, climate and a range of country- and user-specific preferences. Some of the products – notably chillers – can use one of several different engineering technologies to provide equivalent services. Task 1 contains detailed technical descriptions, test procedures etc of different air conditioning products and systems. This overview to Task 2 provides a general picture of their relative importance in the marketplace and in the installed stock. More detailed discussion and analysis for each type of product is provided in the sections following this overview.

The report considers chiller-based systems, ducted split systems, (unducted) single split systems > 12 kW cooling, multi-split systems, Variable refrigerant flow (VRF) systems and rooftop in units.

Figure 2 - 1 . Market Share of Lot 6 Air Conditioning Systems by Type (Shares by Cooling Capacity)

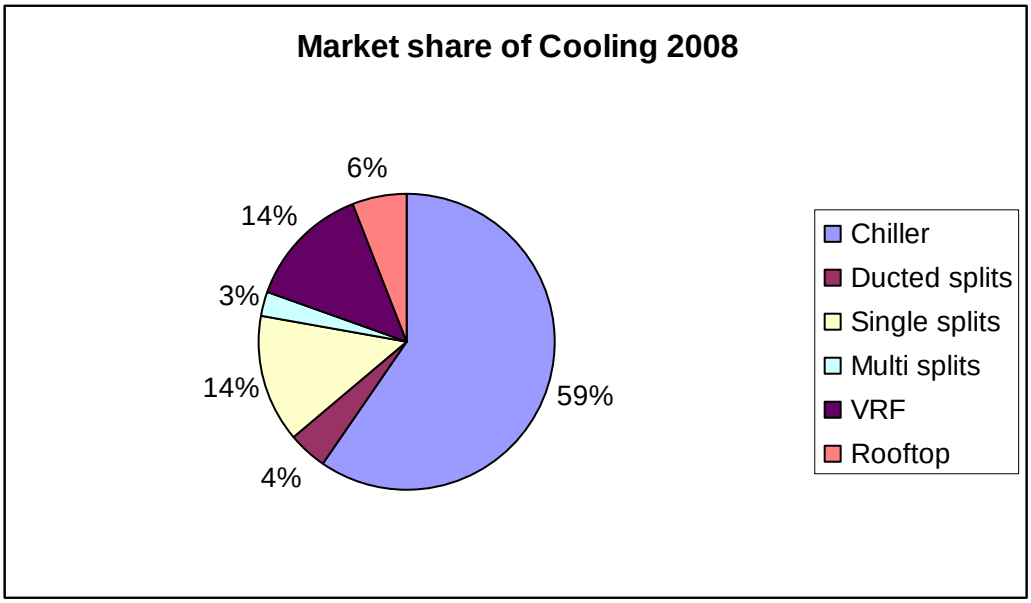


Table 2 - 3 . Sales by GW

Product	Chillers	Ducted Split	Single Split > 12kW	Multisplit	VRF	Rooftop
GW	11.2	0.8	2.6	0.6	2.6	1.1

The most common system is based on packaged vapour-compression chillers producing chilled water. These are usually air-cooled. This type of system accounted for about 60% the estimated 18.9 GW cooling capacity sold in 2008 of systems within the scope defined in Task 1.The most common system configuration consists of a central mechanical ventilation system, providing filtered, cooled and heated air to conditioned spaces, with additional local cooling (and often heating) provided by fan coil units. This report covers all the air conditioning products defined in Task 1 but, because of their importance chillers are considered in more detail. In summary, chillers smaller than about 350 kW usually use scroll compressors and refrigerant R410A or, less commonly, R407C. Large chillers, above 900 kW

capacity generally have centrifugal compressors operating with R134a. Intermediate sizes typically use screw compressors with R134a or R407C. While most chillers are small (below 50 kW), cooling capacity is fairly evenly divided across chiller sizes. The largest end-use sector for chiller-based systems is offices, which account for just over 1/3 of newly-installed cooling capacity. Nearly 2/3 of sales by capacity are in three sectors: offices, retail, and leisure and hotels.

Market shares are not identical in each country; the proportions for the largest markets are shown below.

Figure 2 - 2 . Cooling Capacity in Selected Countries

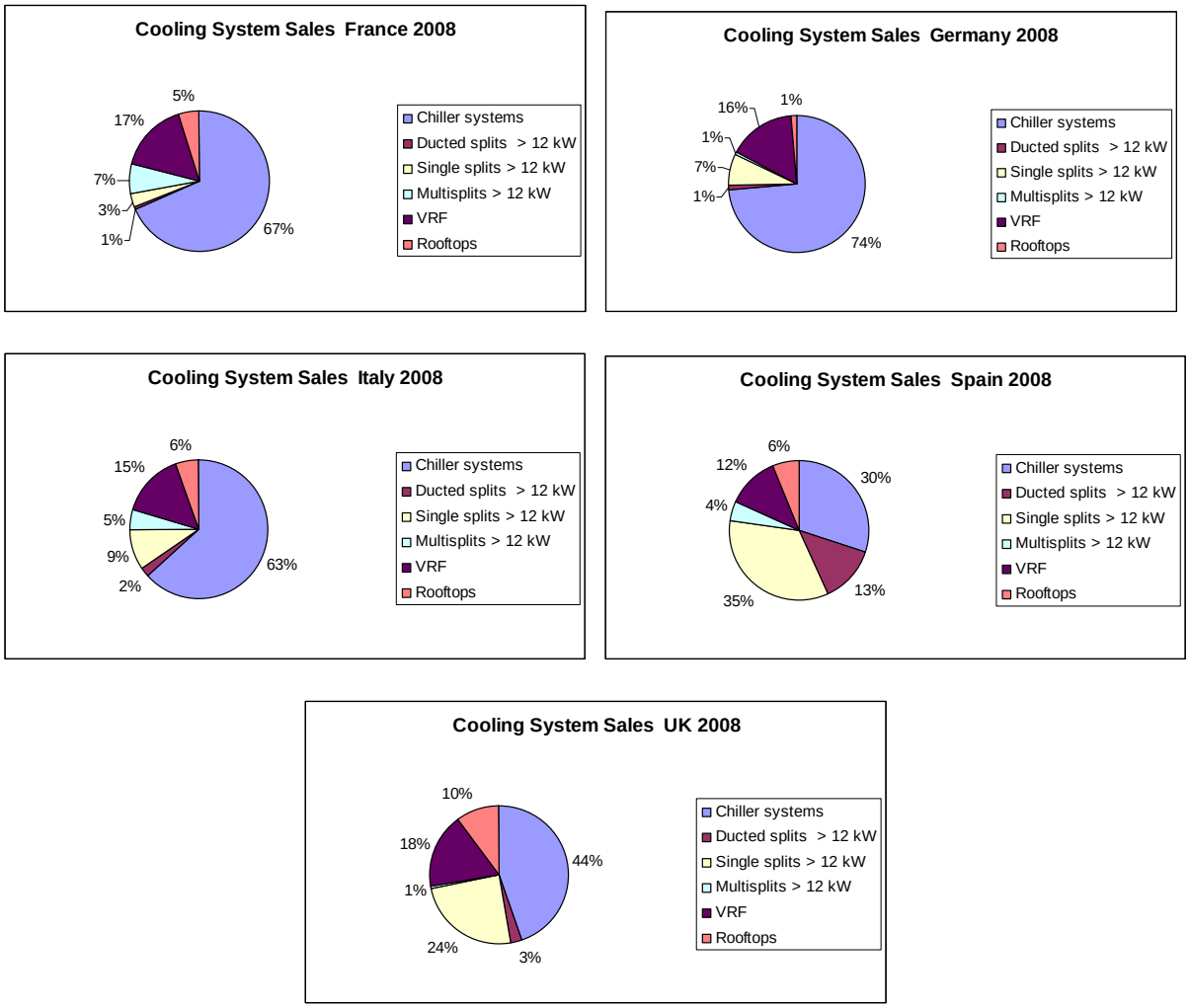


Figure 2 - 3 . EU-27 Stock Trends by Cooling Capacity in GW

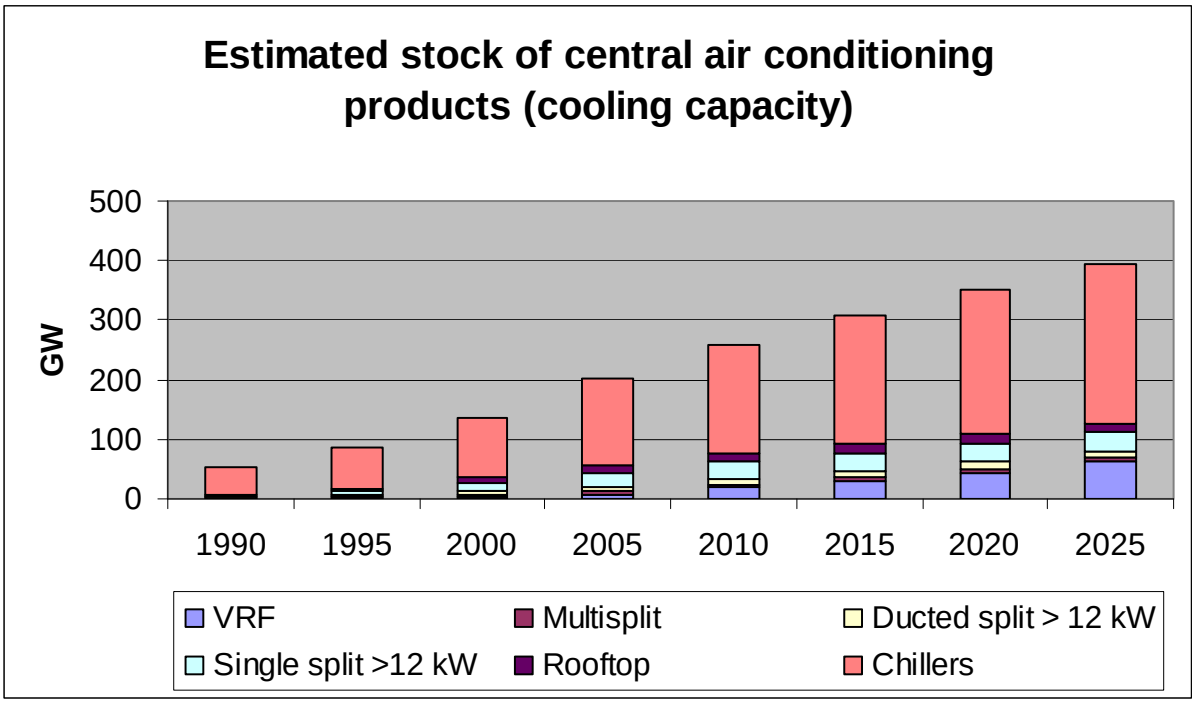
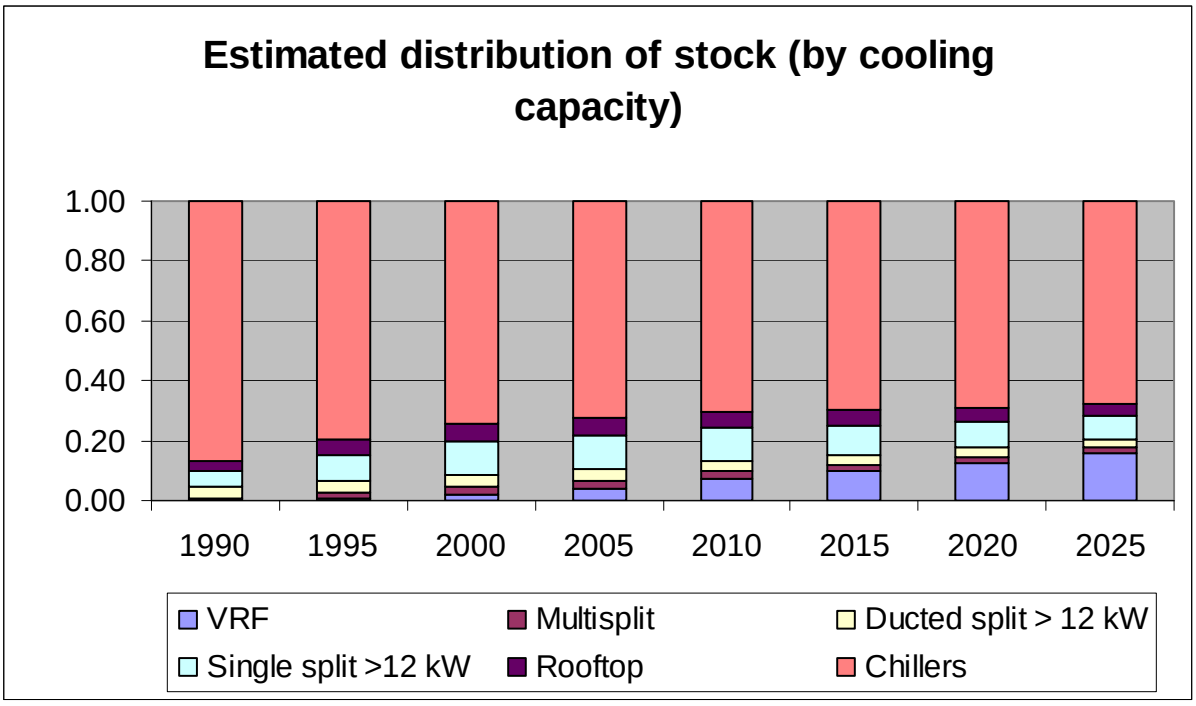


Table 2 - 4 . EU-27 Stock Trends by Cooling Capacity in GW

	GW stock							
Product	1990	1995	2000	2005	2010	2015	2020	2025
VRF	0.0	0.6	3.1	7.4	18.4	30.3	44.5	63.0
Multisplit > 12kW	0.4	1.4	3.4	5.4	6.3	6.6	6.7	6.7
Ducted split > 12 kW	1.9	3.5	5.7	7.9	9.5	10.5	11.0	11.2
Single split > 12kW	2.8	7.4	15.3	23.3	27.9	29.7	30.4	30.6
Rooftops > 12 kW	1.9	4.3	8.0	11.6	14.0	15.1	15.6	15.8
chiller	45.3	67.8	101.8	145.9	181.5	214.7	242.7	267.8

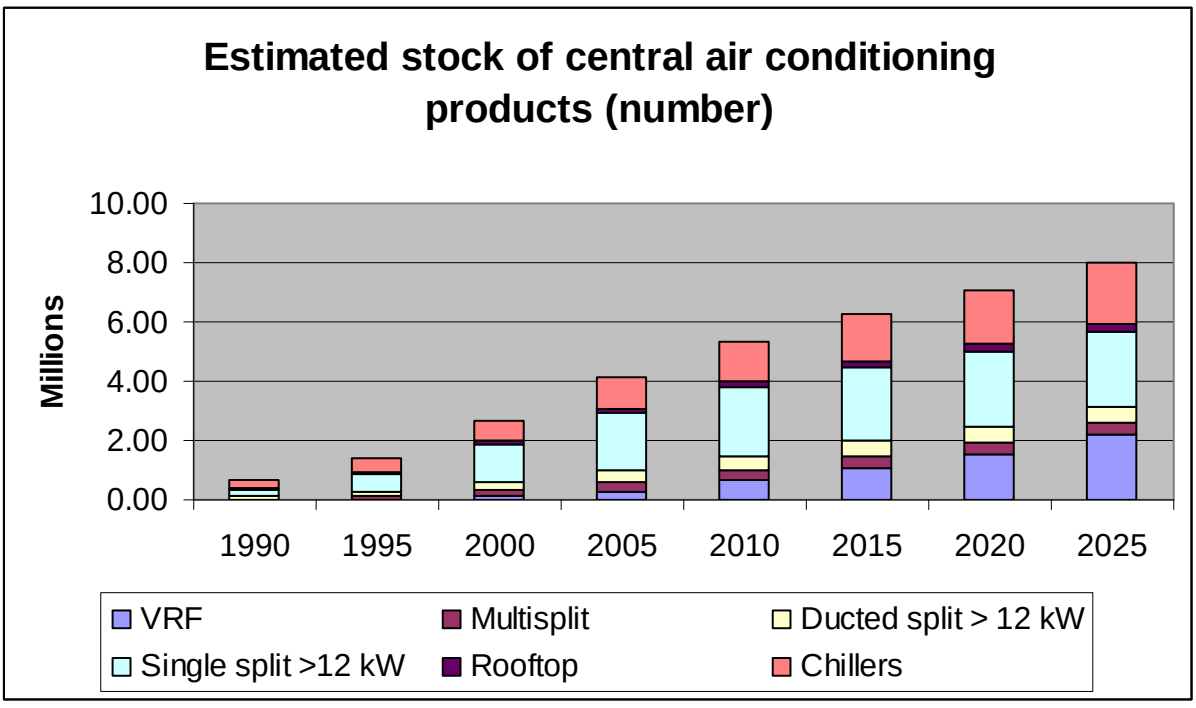
Figure 2 - 4 . Estimated distribution of stock by capacity



The study's estimates are for continuing growth of the stock throughout the period, largely driven by continued new installations of chiller-based systems, augmented by a growth in VRF systems. Within this overall picture of fairly steady growth, there are some markets that are beginning to show signs of market saturation in the sense that the rate of first-time sales is declining, but also younger markets where it is still growing.

Over the period, chiller-based systems dominate in terms of aggregate cooling capacity, but their share falls to 68 % by 2025.

Figure 2 - 5 . Estimated Stock by Number



Because chillers have substantially larger cooling powers per unit than the other system types, the distribution by number is very different, with large single split units and VRF systems representing significant shares.

Table 2 - 5 . Estimated stock of Air Conditioning Units

Estimated Stock of Central Air Conditioning Units (Millions)								
Year	1990	1995	2000	2005	2010	2015	2020	2025
VRF	0.000	0.022	0.107	0.256	0.634	1.046	1.535	2.173
Multisplit > 12kW	0.026	0.086	0.209	0.332	0.392	0.411	0.417	0.418
Ducted split > 12 kW	0.094	0.173	0.278	0.384	0.463	0.511	0.535	0.547
Single split > 12kW	0.233	0.615	1.278	1.942	2.324	2.478	2.531	2.548
Rooftops > 12 kW	0.027	0.061	0.114	0.166	0.200	0.217	0.223	0.226
Chillers	0.268	0.428	0.688	1.028	1.325	1.590	1.824	2.060

2.1.2. Data sources and modelling procedures

Data Sources

The principal sources of data the study has used were:

- product sales data from Eurovent for EU27, mainly for 2008 and 2009 and intermittently for earlier years
- market research reports from BSRIA for six countries: France, Germany, Greece, Italy, Spain, United Kingdom, for year 2007 and 2008 with estimates for 2009. These cover 70% of chiller capacity sold in 2008 and uncertain percentages of repartition by terminal unit type. Most data for systems not based on chillers has been drawn from similar reports for packaged units.
- historical product sales from BSRIA for 14 countries: Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom. Covers 1992 to 2009. These include over 90% of chiller sales capacity in 2008 and uncertain percentages of repartition by terminal unit type. These data have been extrapolated to the whole of Europe by comparisons with Eurovent data for 2008.
- data provided by national associations, researchers and other organisations.

Inevitably there is not complete consistency between data from different sources. Where there is overlap, there is a large measure of agreement[1] for the air conditioning units .The study focuses on 2008 as a base year as it is covered by all three major sources. For those (relatively small) countries for which the study only has data from Eurovent, there could be a degree of under-reporting because if the omission of supply by non-Eurovent members. The numbers are believed to be small, but may include producers of more specialist products aimed at national markets. This could include products using natural refrigerants in countries where these are encouraged – market research data in the major markets does not report significant numbers of such products (like Denmark).

Modelling principles

The study's data is predominantly of annual product sales, but the study needs estimates of installed stock, future first-time sales and present and future replacement rates. The study obtains these by a process of market diffusion modelling, tightly linked to historical sales data. The primary modelling of the market is focused on products and self-contained systems. Estimating the relative proportions of different chiller-based systems is more problematic because of a shortage of data. This process is described in a later section.

The classic market diffusion model is the Bass model [2] , which has been applied to many products and technologies, including air conditioners.

[1] This is not the case for Air Handling Units, which are discussed in the ventilation report of this study.
[2] http://bassbasement.org/BassModel/Default.aspx

In its basic form (there are more complex variations), it requires knowledge of four parameters:

- a coefficient of innovation, which reflects the willingness of potential buyers to purchase a novel product. This parameter is important in the early stage of a new market but, in a successful market, its impact is soon overwhelmed by that of the coefficient of imitation
- the coefficient of imitation reflects the propensity of potential buyers to follow the lead set by previous purchasers
- the ultimate number of first-time buyers (as distinct from like for like replacements)
- a reference year (conventionally the “start of market”)

These parameters are not easy to estimate for the products that the study is considering and the study has adopted the following process:

- the study ignores the coefficient of innovation, since the market the study is considering is an established (but not yet saturated) one. The Bass model then becomes the somewhat more manageable logistic curve;
- the study has developed a numerical curve fitting procedure that does not require explicit knowledge of the ultimate level of market saturation. An estimate of the saturation level (for the product being modelled) can be obtained from the “best fit” curve. However, its reliability depends on the goodness of fit of the model and is typically rather uncertain.
- The study then uses this procedure to obtain the “best fit” combination of the other two parameters country by country.

Specific procedures

The historical sales figures are combinations of first-time sales, which increase the installed stock, and replacement sales, which do not. The study separates these two sectors by the following process

- the study first fits the market diffusion model to the historical sales figures,
- for those countries for which the study has detailed market research reports, the study has figures for the proportion of sales that are replacements, installation in new buildings, and refurbishments (new installations in existing buildings). By comparing the number of replacement sales in 2008 with the estimated total sales in previous years, the study can estimate the average replacement age of products (for chillers this is typically between 18 and 20 years),
- the study uses these service life estimates to calculate the number of replacement products in each year,
- the study deducts these from total sales to estimate the number of first-time purchases,
- in order to estimate the current installed stock of products, the key distinction is between replacement and non-replacement sales. The study does not need to explicitly distinguish between first-time installations in new and existing buildings.
- however, the importance of different market drivers for installations in new buildings and in existing buildings are different so for future estimates the study needs to separate them, even though this adds an extra uncertainty.
- the study therefore estimates the number of historical sales into new buildings, anchoring the estimates to reported figures, where these are available.
- the study also estimates the expected growth rate for new buildings with central air-conditioning and refit the model to the (derived) figures for first-time purchases in existing buildings (this is the sector where the concept of market saturation has most meaning)
- this allows the study to estimate first-time purchases in existing buildings, replacement purchases (and assumptions about sales to new buildings) in future years.

For countries where the study has only historical sales data, the study assumes typical values of product life.

For countries for which the study does not have historical sales figures, the study uses parameters derived for countries that the study perceives to have the most similar market conditions, scaled to 2008 sales. The countries for which this process is necessary account for about 10% of 2008 sales.

The historical sales series sometimes include relatively short-lived deviations from the apparent underlying trend. The study ignores years that contain such values when fitting the model (this

improves the curve fit), but add back the short duration deviations when calculating future replacement sales and when estimating the installed stock.

Sales figures for 2008 and 2009 show reductions from the trend lines. The study assumes these to be related to the economic downturn and have excluded them from the curve-fitting. Comparing the model predictions for 2008 and 2009 with the actual sales in those years gives us an estimate of the impact of the economic downturn – this appears to vary substantially between countries.

Historically, including 2008 and 2009, there is an empirical relationship between the growth in EU-27 sales of chillers[3] and EU-27 GDP growth. The study has used this to adjust anticipated sales figures for 2010 and 2011 on the basis of the most recent Eurostat forecasts[4] of EU-27 GDP. There are no Eurostat forecasts for 2012, but extrapolation of the trends suggests that any correction from the underlying trend would be small. The study has not attempted to make country-specific corrections.

Since the historical data is in terms of numbers of sales rather than functional units, so too are the estimates. The study converts the figures to functional units assuming the average product sizes in 2008.

Examples

The charts below illustrate typical results for two countries with different market sizes and histories. Italy represents a long-established market which is showing signs of approaching market saturation – sales are declining (although, in fact, the stock is still increasing). The Czech Republic has a shorter history and, apart from the effects of the economic downturn, sales are still increasing year on year.

Figure 2 - 6 . Example model results – Italy, chillers

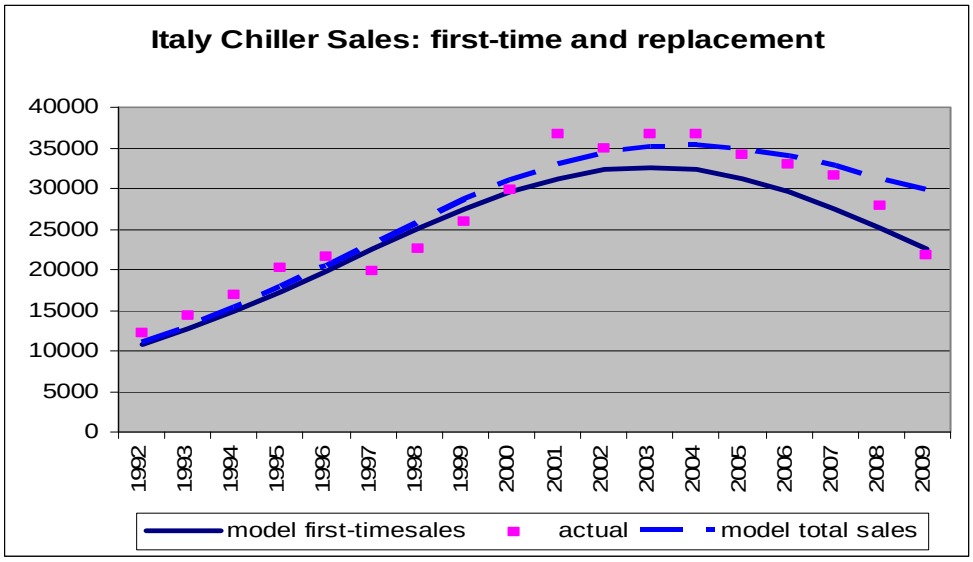
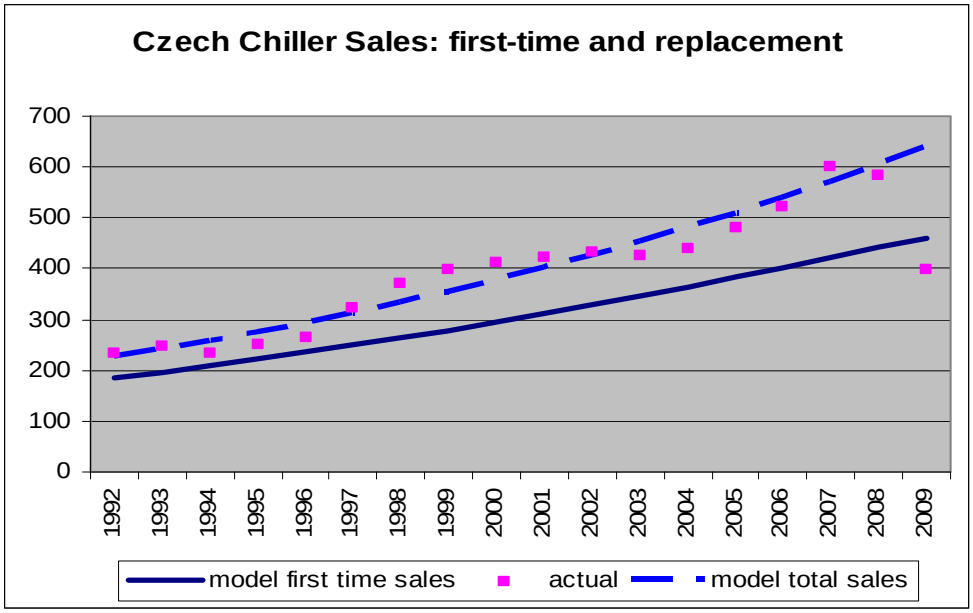


Figure 2 - 7 . Example model results – Czech Republic, chillers

[3] This is also the case for air handling units associated with air conditioning – reported in the ventilation report

[4] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&plugin=1&language=en&pcode=tsieb020 on 16 November 2010



2.1.3. Market history and trends

Historical Sales

The study has historical sales figures relating to central air conditioning only for chillers and fan coil units. These relate to numbers sold, not to functional units (capacity).

Over the 15 years (at least) up to about 2007, the European market for central air conditioning (as indicated by chiller, and fan coil unit sales) grew fairly steadily, as can be seen from the charts for 14 countries. Annual sales of chillers are now (2008) two and a half times greater than they were in 1992. Sales of fan coil units have increased by 65%. Sales of chillers and fan coils all peaked in 2007 and have declined since. The study estimates that the economic downturn reduced chiller sales by 7% in 2008 and 19% in 2009 compared to previous trends.

These generalities mask differences between individual countries, which are sometimes substantial. There was an upsurge in chiller sales in France in 2006 and 2007, which can be linked to the increased competitivity of electricity with higher oil prices and tax rebate for residential heat pumps. This was not matched by growth in the sales of air handling units or fan coils. Greece had a large upturn from 2001 to 2004 coinciding with the run up to the Olympic Games.

We do not have annual sales data on sales of other air conditioning products over this period. Later sections of this report contain estimates based on modelling.

Figure 2 - 8 . Historical chiller sales (14 countries listed above)[5]

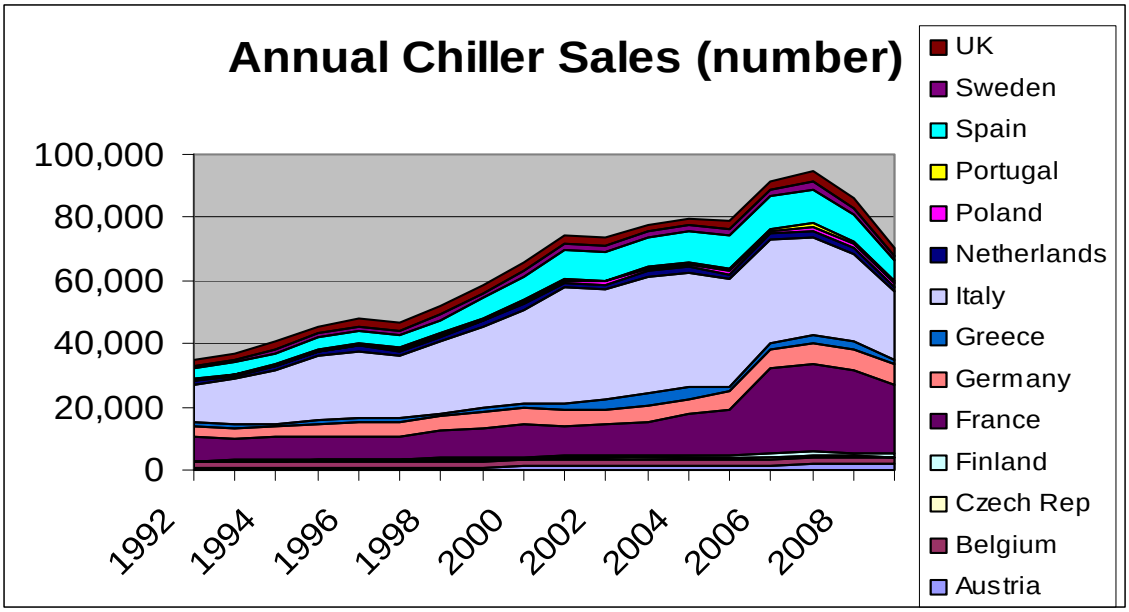
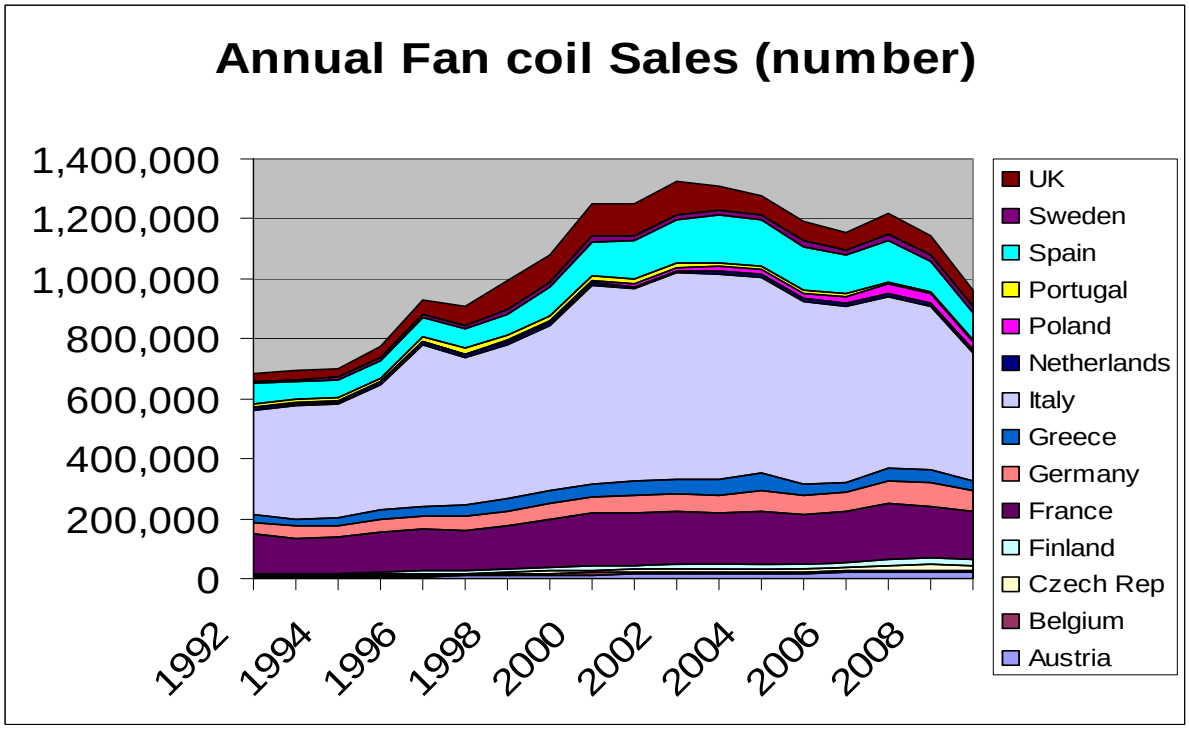


Figure 2 - 9 . Historical Fan Coil sales (14 countries)[6]



Unlike chillers, whose sales continued to increase until 2008, sales of fan coils have been declining since 2002. Italy is the major market.

Qualitative Comments

[5] Numbers are tabulated in section 2.2.3 on page 23.
[6] Numbers are tabulated in section 2.2.4 on page 37.

Qualitative comments in market research reports, plus some local data, suggest a growing influence of energy efficiency considerations in market trends. This is presumably driven (at least in part) by the impact of EPBD integrated “building + system” energy assessments.

Trends have been noted in several countries towards the use of high-efficiency chillers (and the appearance on the market of some very high performance units).

In Italy, it is reported that specifiers are increasingly likely to propose and install energy efficient solutions, and that initial resistance has weakened to less traditional solutions such as VRF, chilled ceilings and beams and water loop systems. In particular, the last-mentioned has become more common in shopping centres. Sales of VRF and rooftop systems are eating into the (sizeable) small chiller plus fan coil market and chilled ceilings are also replacing fan coils. This is mirrored in the UK, where sales of active chilled beams are now comparable in number and value with fan coils. In Spain, VRF has also increased market penetration but mini-chillers now seem to have stabilised their share.

2.2. AIR CONDITIONING PRODUCTS

2.2.1. Introduction

This part of the report considers specific energy-using air conditioning products, some of which are self-contained systems: others are components of “bespoke” chiller-based systems.

The products identified in Task 1 are:
1) air-conditioners > 12 kW and air conditioning condensing units
2) air-conditioning chillers
3) fan coil units
4) heat rejection units

Of these the last two are components of the various types of chiller-based systems, while the first category consists of several types of self-contained system. Air–to-air air-conditioners compete in the market with chiller-based systems, each having advantages and disadvantages in particular circumstances.

The energy consumption of central systems is not simply determined by the performance of these energy-using components, but also by that of non-energy-using components, including controls. These are not addressed here. For a specific system design, the actual consumption is influenced by building design, building use and climate. This report does not address the importance of these factors but, where possible, presents breakdowns of sales and stock by Member State, and by application (end-use).

2.2.2. Air-Conditioners > 12kW cooling capacity

Scope

This category includes several types of system, which are defined and described in Task 1 and recognised as separate products in the market place, albeit competing in the same market.

These are:
- ducted split units > 12kW
- unducted single split units > 12 kW
- multisplit systems
- variable refrigerant flow (VRF) systems
- rooftop units
- air conditioning condensing units

Data availability is more limited, both geographically and over time than for chillers, and the estimates in therefore rely more heavily on interpolation and extrapolation.

Overview

The charts below provide an overview of the study's estimates of past and future stock and sales, both by cooling capacity and by number, for the EU 27. As noted above, the modelling is based on fewer data than for chillers and therefore has greater uncertainty. Sales figures include both replacements (which do not add to stock) and first-time installations (which do).

The following sections discuss each product type. Apart from VRF systems, the study expects only slow growth in the stock of these systems. The estimated stock numbers are tabulated in section 2.2.1

Figure 2 - 10 . Estimated stock of systems by capacity

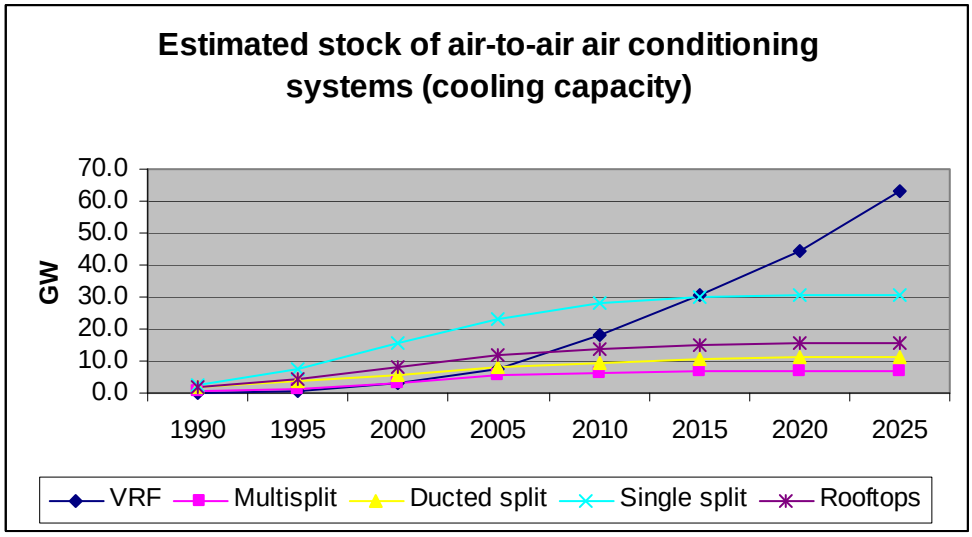


Figure 2 - 11 . Estimated stock of systems by number

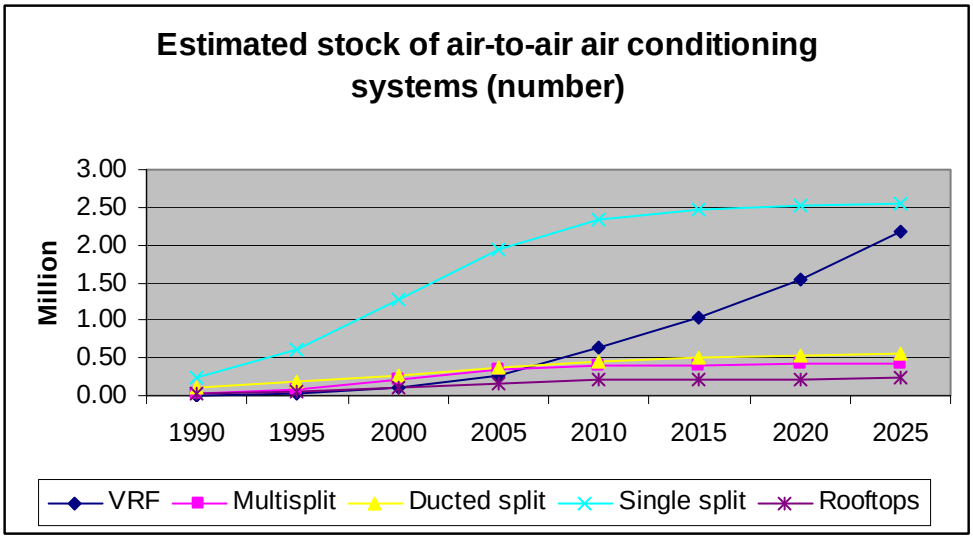


Figure 2 - 12 . Estimated Sales by number

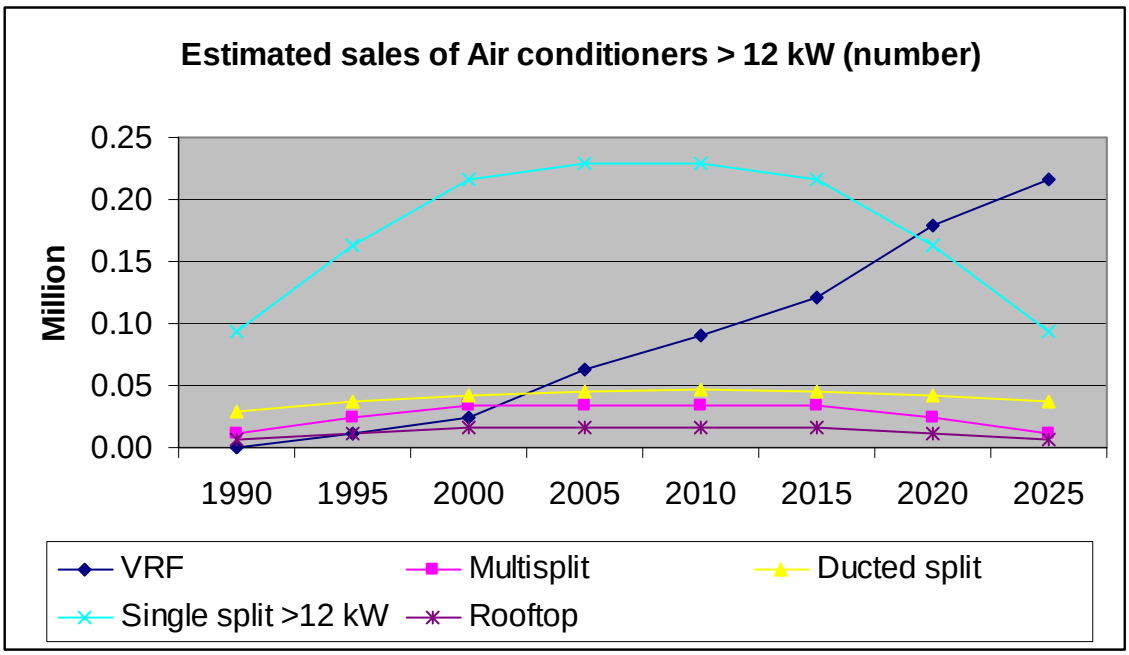
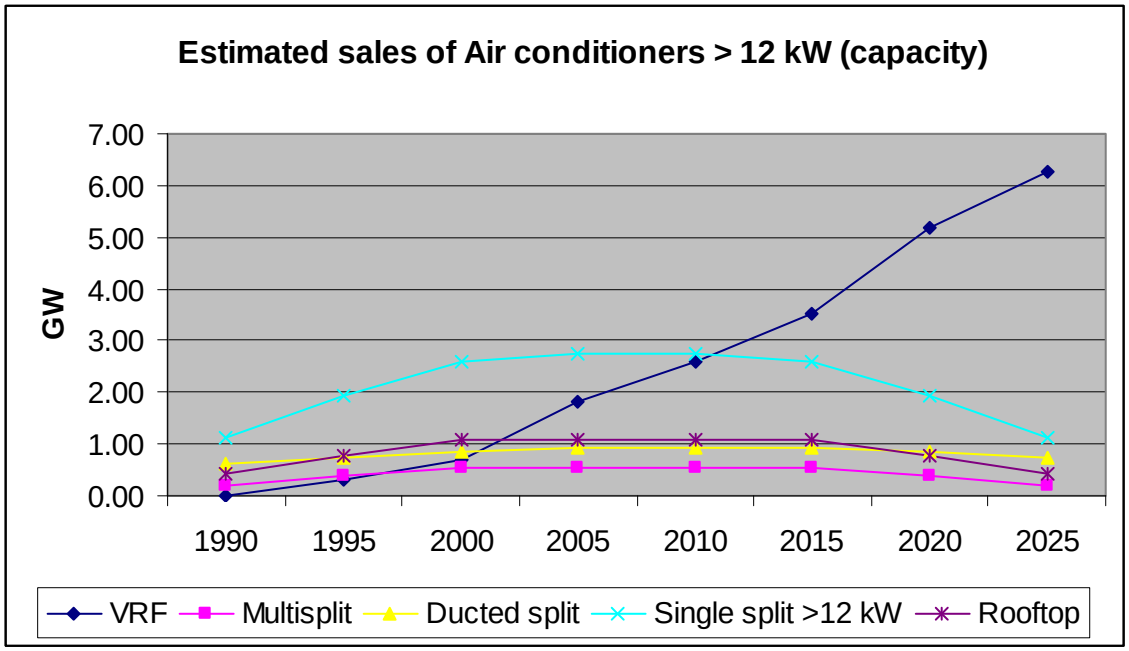


Figure 2 - 13 . Estimated Sales by Capacity

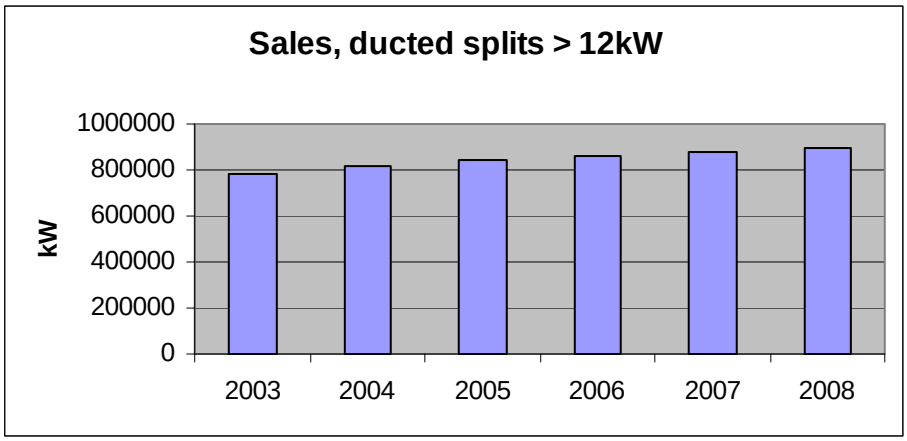


Ducted split systems

Between 2003 and 2008 sales of ducted split systems over 12kW capacity were essentially flat, averaging 0.85 GW per year. The majority (85%) of sales (by capacity) were in Spain, Greece and Italy. Because of the relatively short data run and year to year similarity of sales, it is not feasible to fit a detailed market penetration model. The study estimates the 2010 stock to be approximately 0.46 million units with an aggregate capacity of 9.5 GW. The modelling implies an average growth rate of

the stock of 6.8% pa between 1995 and 2010, which will decline to 1.1% pa from 2010 to 2025. The historical figures represent the trend excluding the effect of the economic downturn. 82% of sales are of reversible products.

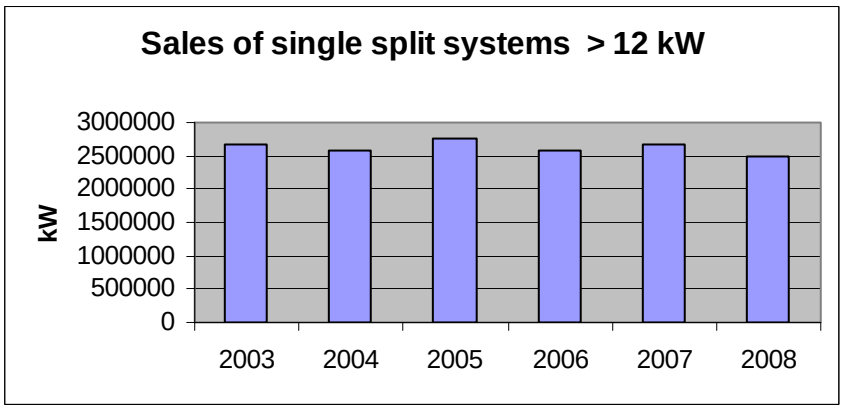
Figure 2 - 14 . Sales – Ducted splits over 12 kW by cooling capacity



Unducted single-split systems > 12 kW

As with ducted splits, between 2003 and 2008 sales of single split systems over 12kW capacity were essentially flat, averaging 2.62 GW per year. The majority (64%) of sales (by capacity) were in Spain, and the UK. Because of the relatively short data run and year to year similarity of sales, it is not feasible to fit a detailed market penetration model. The study estimates the 2010 stock to be approximately 2.32 million units with an aggregate capacity of 27.9 GW. The modelling implies an average growth rate of the stock of 9.3% pa between 1995 and 2010, which will decline to 0.6%pa from 2010 to 2025. (The historical figures represent the trend excluding the effect of the economic downturn.) 66% of sales are of reversible products.

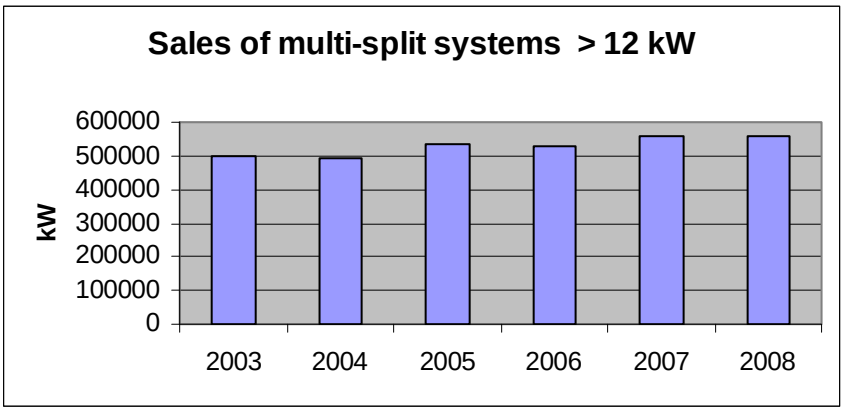
Figure 2 - 15 . Sales - single-splits over 12 kW - by capacity



Multi-split systems

As with ducted splits, between 2003 and 2008 sales of multisplit systems over 12kW capacity were essentially flat, averaging 0.53 GW per year. The majority (86%) of sales (by capacity) were in France, Italy and Spain. Because of the relatively short data run and year to year similarity of sales, it is not feasible to fit a detailed market penetration model. The study estimates the 2010 stock to be approximately 0.39 million systems with an aggregate capacity of 6.3 GW. The modelling implies an average growth rate of the stock of 10.6% pa between 1995 and 2010, which will decline to 0.4%pa from 2010 to 2025. (The historical figures represent the trend excluding the effect of the economic downturn.) 64% of sales are of reversible products.

Figure 2 - 16 . Sales - multisplits over 12 kW by capacity



Variable Refrigerant Flow Systems

Published market data on sales of VRF systems are rather sparse and this section is the result of a mixture of analysis and comments from stakeholders.

From market entry in the early 1990s, sales increased rapidly up to 2008. The study estimates the 2010 stock to be approximately 0.63 million systems with an aggregate capacity of 18.4 GW. The modelling implies an average growth rate of the stock of 25.1% pa between 1995 and 2010, which will decline to 8.6%pa from 2010 to 2025. (The historical figures represent the trend excluding the effect of the economic downturn.) 88% of sales are of reversible products (this includes heat recovery systems that can transfer surplus heat removed from one space into other spaces with heating needs).

Rooftop units over 12 kW capacity

Between 2003 and 2008 sales of rooftop units over 12kW capacity were also essentially flat, averaging 1.1 GW per year. Because of the relatively short data run and year to year similarity of sales, it is not feasible to fit a market penetration model. The study estimates the 2010 stock to be approximately 0.20 million units with an aggregate capacity of 14.0 GW. The modelling implies an average growth rate of the stock of 8.2% pa between 1995 and 2010, which will decline to 0.8%pa from 2010 to 2025. The historical figures represent the trend excluding the effect of the economic downturn. 62% of sales are of reversible products. In addition 11% of sales provide a heating service using fossil fuels (usually gas).

Figure 2 - 17 . Sales: Rooftop units by capacity

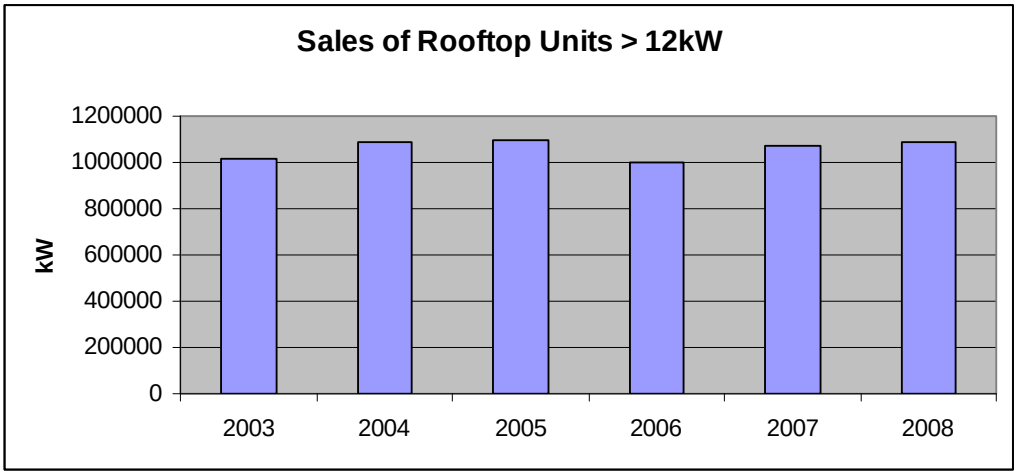
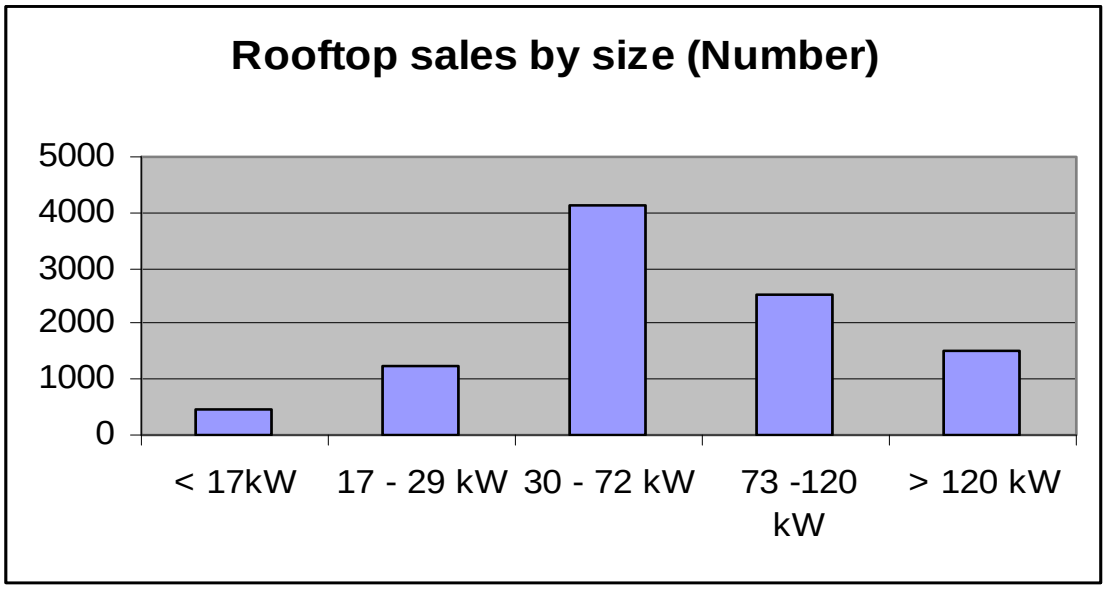
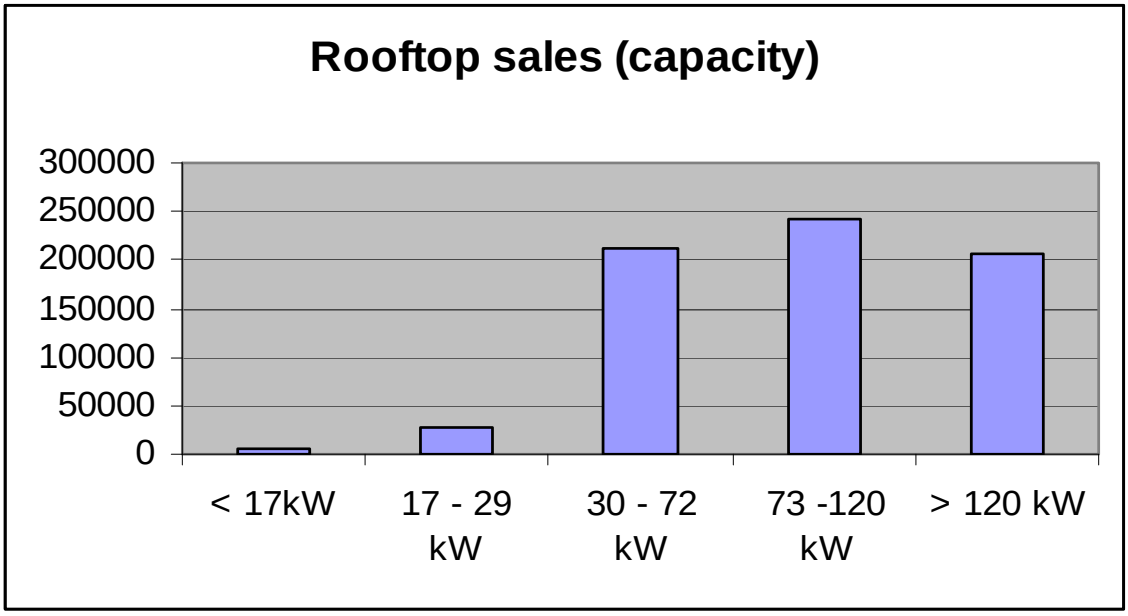


Figure 2 - 18 . Rooftop sales by size in numbers



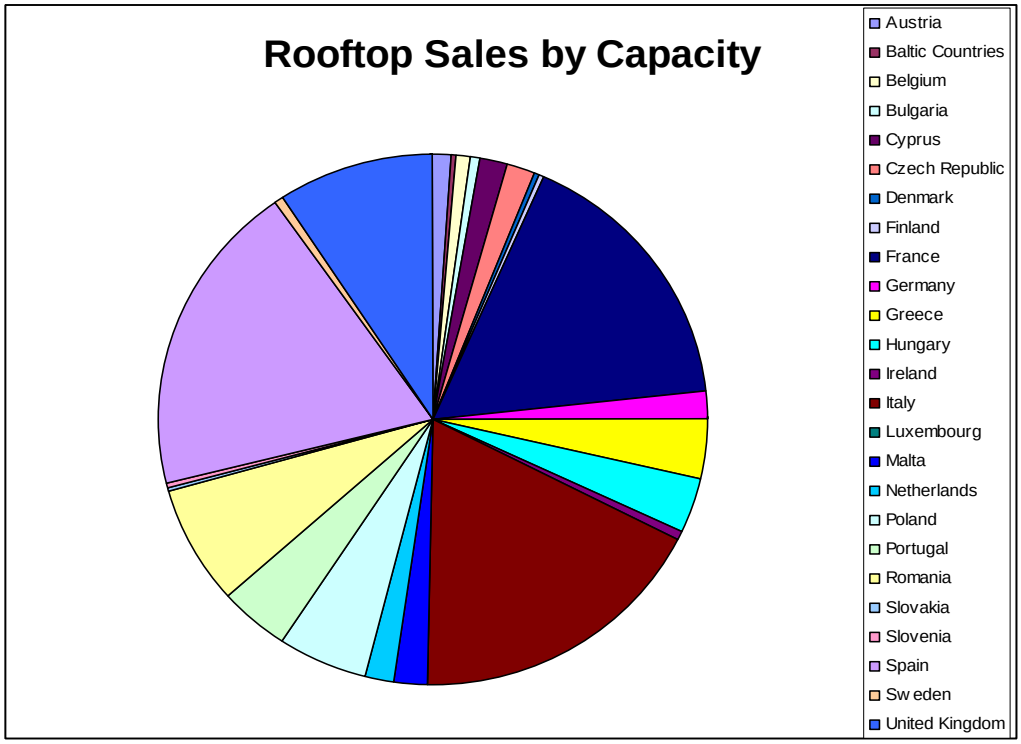
Most sales are of mid-size units of between 30 and 120 kW cooling capacity. This translates into a distribution by installed capacity that is fairly evenly split across sizes above 30 kW.

Figure 2 - 19 . Rooftop Sales by capacity



Two thirds of sales were in Spain, UK, Italy and France.

Figure 2 - 20 . Rooftop Sales by country (capacity)



Air conditioning condensing units

There is a clear lack of market information regarding air conditioning condensing units **Information Request issue**.

Stakeholders have indicated to the study team a potential market size of about 30 000 units but this figure is uncertain, as well as the average capacity of these products. In ENTR Lot 1 study on refrigeration, statistics are available on condensing units for refrigeration. It is mentioned in the Task 2

of ENTR Lot 1 study[7], that "*Condensing units for high evaporating temperature (+5°C) are used in air conditioningsystems whereas, in commercial refrigeration, only medium (-10°C) and low (-35°C) temperatures are used."* With this hypothesis, and using the Task 2[8] figures of ENTR Lot 1 for positive temperature units, this would lead to 200 000 units, of unknown capacity. More information is required on sales to improve the estimate.

2.2.3. Air conditioning chillers

Introduction

Measured by cooling capacity, chiller-based systems account for about 60% of the market (for air conditioning products and systems that provide cooling and are covered by this study). Since chillers are generally of much larger capacity than the other products, their importance by number of products is much lower. In 2009 about 95600 air conditioning chillers were sold – about 18% of sales measured by number.

Distribution of sales by country

Figure 2 - 21 . Chiller sales (capacity) by country

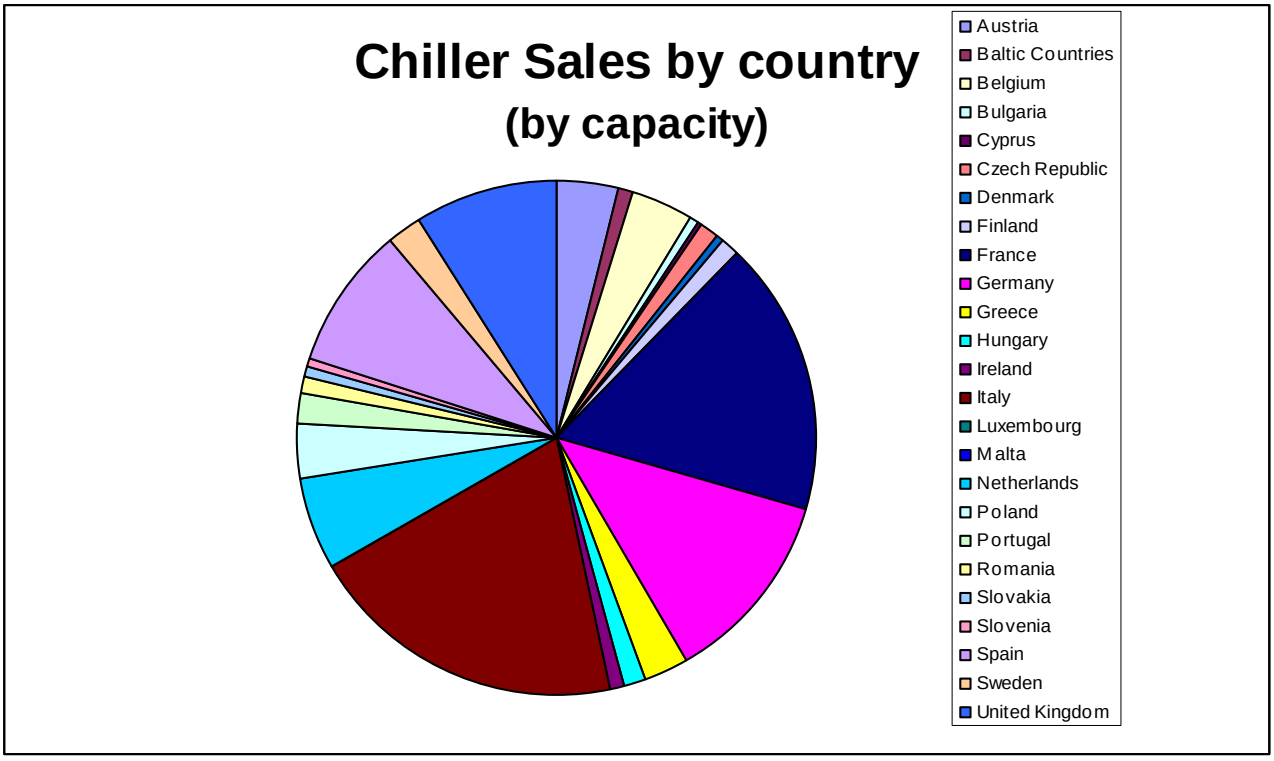


Table 2 - 6 . Chiller Sales

[7] ENTR Lot 1 study, Draft report of Task 1, September 2010, p 52.
[8] ENTR Lot 1 study, Draft report of Task 2, September 2010, p 28.

Estimated Chiller Sales 2008		
Country	**GW cooling**	**Number**
Austria	0.45	1898
Baltic Countries	0.09	365
Belgium	0.44	1527
Bulgaria	0.06	334
Cyprus	0.02	98
Czech Republic	0.13	651
Denmark	0.06	820
Finland	0.14	851
France	1.94	33570
Germany	1.39	8604
Greece	0.29	1658
Hungary	0.18	837
Ireland	0.09	275
Italy	2.25	27668
Luxembourg	0.01	66
Malta	0.00	17
Netherlands	0.66	2405
Poland	0.37	1370
Portugal	0.21	1177
Romania	0.15	701
Slovakia	0.06	276
Slovenia	0.04	367
Spain	1.01	5712
Sweden	0.25	1396
United Kingdom	1.01	2948
TOTAL	**11.29**	**95591**

As can be seen in the chart and table, almost half of the total sales of 11.3 GW were in three countries: Italy, France and Germany. These countries plus Spain and the UK account for two-thirds of sales. There is a wide disparity of average chiller sizes with France, Italy and Denmark[9] having low values and Ireland and the UK particularly large ones. The average size across the whole of Europe is 118 kW, reflecting the importance of the French and Italian markets. This results in larger market shares by number of these countries (as represented in the historical data).

Table 2 - 7 . Chillers: national indicators (EU-27 average chiller size 118kW)

[9] It should be mentioned that there is a tradition to use ammonia in bigger chillers, and a ban on HFC for chillers with a refrigerant charge > 10 kg has been in effect in Denmark since January 2007 (see the statutory order: http://www.hfc-fri.dk/_root/media/19348_HFC-bekendtg%F8relsen%20ENG.pdf). The chillers with ammonia and hydrocarbons are not included in the data from Eurovent Certification, and this means that only small chillers sold in Denmark are part of the statistics from Eurovent Certification. Consequently, chiller data for Denmark are certainly underestimated.

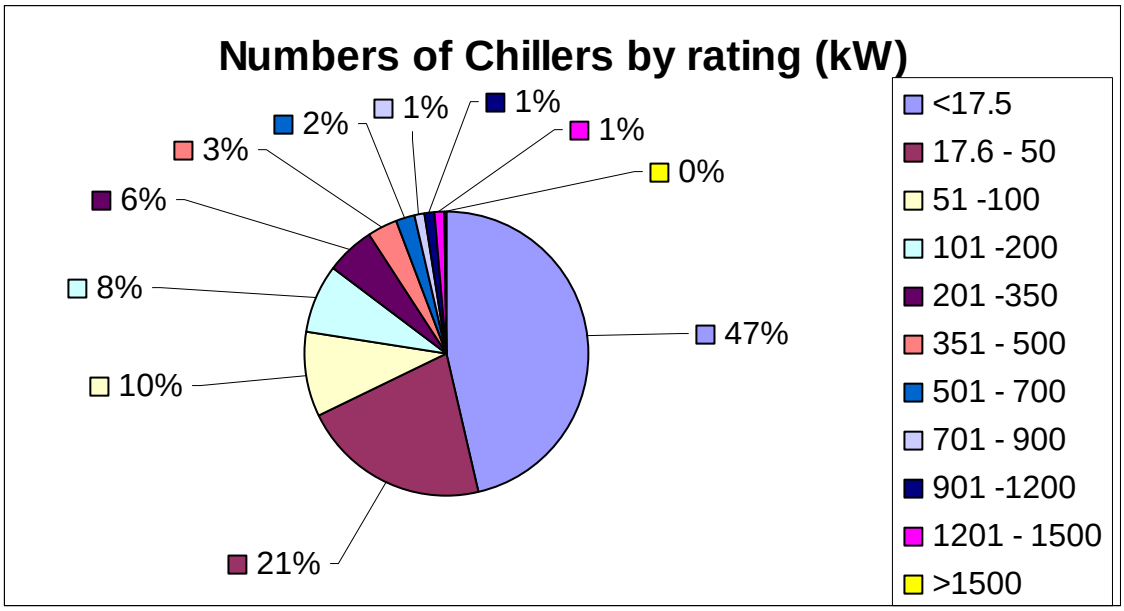
Country	Average Chiller Capacity	Percentage of Market (by capacity)	Percentage of Market (by number)	Apparent underlying sales trend
Austria	237	4%	2%	upwards
Baltic Countries	250	1%	0%	
Belgium	285	4%	2%	downwards
Bulgaria	178	1%	0%	
Cyprus	197	0%	0%	
Czech Republic	205	1%	1%	upwards
Denmark	74	1%	1%	
Finland	159	1%	1%	upwards
France	58	17%	35%	upwards (but recent off-trend bubble)
Germany	162	12%	9%	slow growth
Greece	177	3%	2%	upwards (but recent off-trend bubble)
Hungary	217	2%	1%	
Ireland	322	1%	0%	
Italy	81	20%	29%	downwards
Luxembourg	99	0%	0%	
Malta	230	0%	0%	
Netherlands	272	6%	3%	downwards
Poland	269	3%	1%	upwards
Portugal	178	2%	1%	flat to down
Romania	209	1%	1%	
Slovakia	217	1%	0%	
Slovenia	122	0%	0%	
Spain	177	9%	6%	flat to down
Sweden	178	2%	1%	downwards
United Kingdom	344	9%	3%	flat to down

The “apparent sales trend” column in Table 2 - 5 is drawn from fitting a market diffusion curve to the historical sales data but excluding sales in 2008 and 2009. It therefore represents the underlying trend before the economic downturn.

In the cases of France and Greece, recent sharp increases in sales that have since declined have also been ignored. These inferences therefore represent a pre-2008 view of “business as usual” trends. Upwards expectations represent countries where the inferred current market saturation is low (below 30%), downwards expectations correspond to relatively high implied saturation (over 70%) and “flat to down” intermediate saturation levels.

Distribution of sales by rated cooling capacity

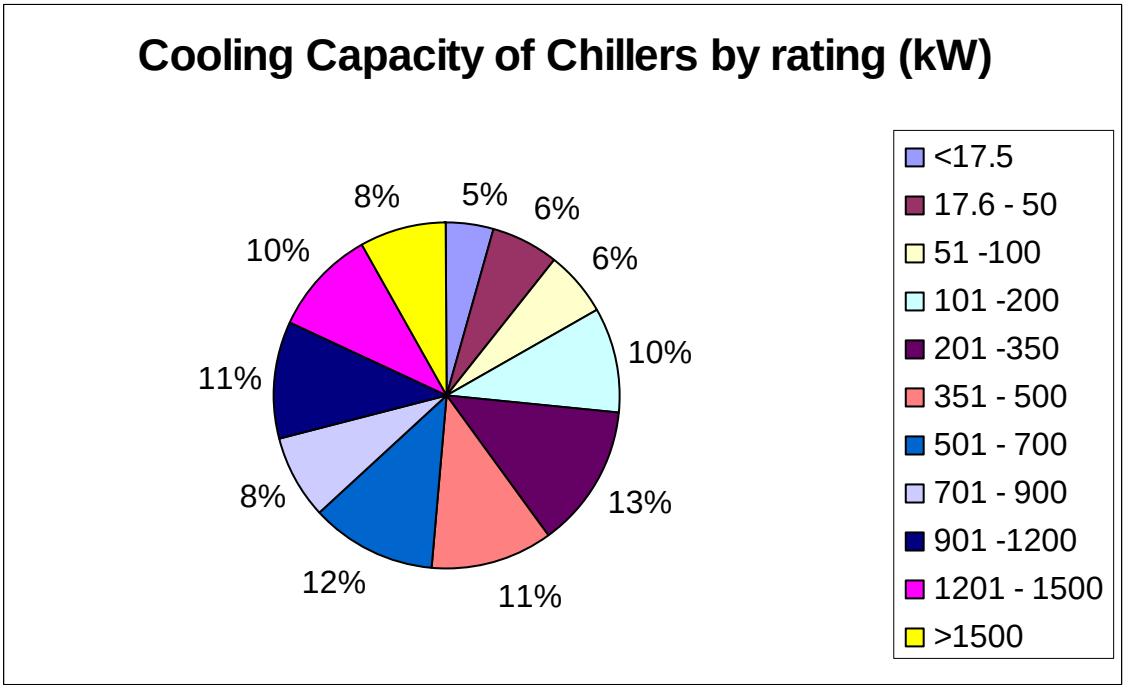
Figure 2 - 22 . Numbers of chillers by rated cooling capacity



[

Two-thirds of chillers are smaller than 50kW cooling capacity and 47% are smaller than 17.5kW.

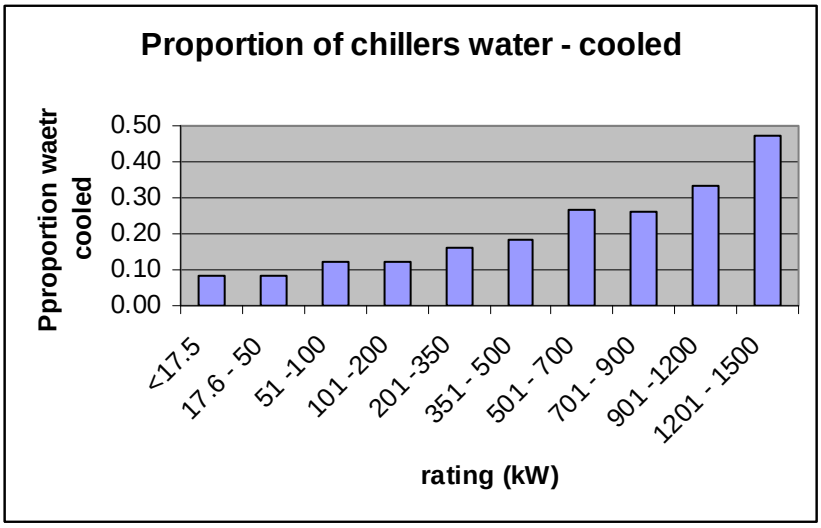
Figure 2 - 23 . Cooling capacity of chillers by rating



In terms of the functional unit – kW of cooling capacity – the market is very evenly split between different ranges of capacity. No single range accounts for more than 13% of sales and the range that dominates numbers of sales (<17.5 kW) accounts for only 5% of total capacity.

Chiller heat rejection method

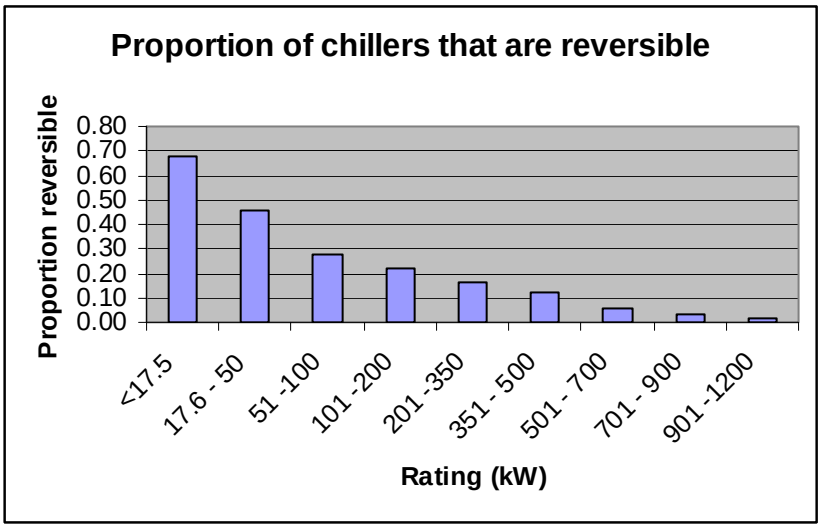
Figure 2 - 24 . Proportion (kW cooling) of chillers that are water cooled



Overall, 23% of chillers are water cooled, but the proportion increases with the size of chiller.

Chiller reversibility

Figure 2 - 25 . Proportion (kW cooling) of chillers that are reversible



Overall, 16% of chillers by capacity are reversible, but the proportion decrease markedly with the size of chiller.

Chiller compressor technology

Compressor Technology Shares Sales

Figure 2 - 26 . Chiller technology by cooling capacity

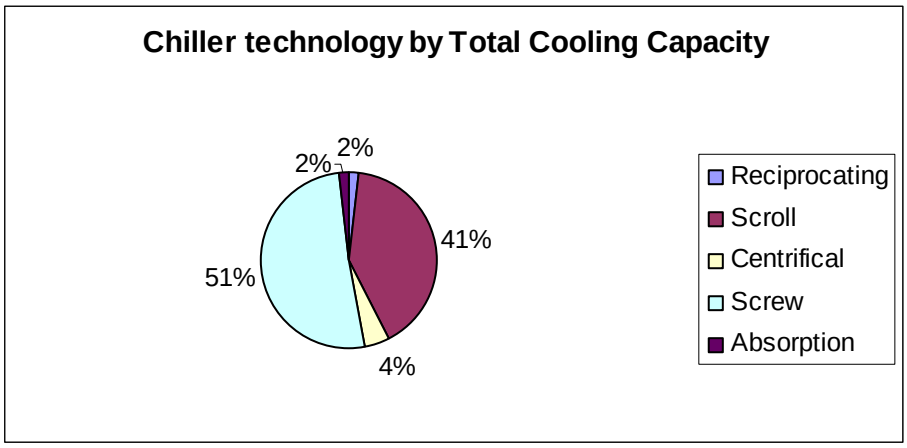
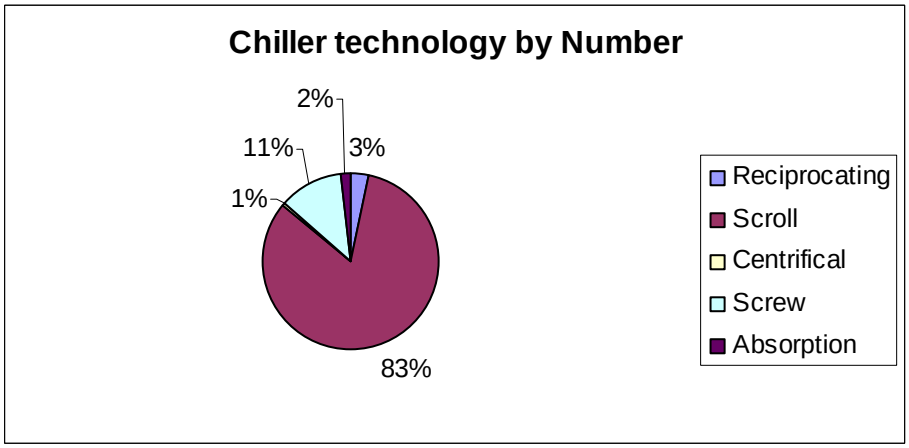


Figure 2 - 27 . Chiller Technology by Number

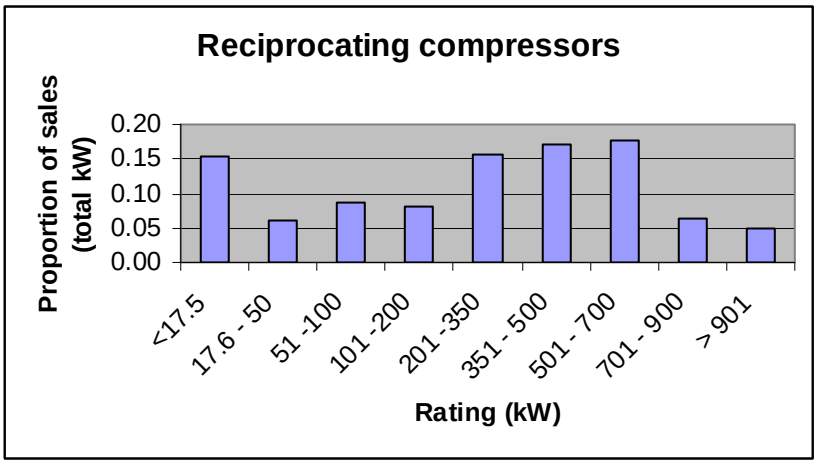


Chillers can use several alternative compressor technologies. Based on the six countries for which the study has detailed data, scroll and screw compressors dominate the market in terms of newly installed cooling power. Because screw compressors have large capacities and scroll compressors smaller ones, the latter dominate in terms of numbers

Different technologies are more common in products of different capacities. The charts below show proportions of sales (expressed in kW cooling)

Reciprocating compressors

Figure 2 - 28 . Reciprocating compressors: sales (kW) by rated cooling capacity

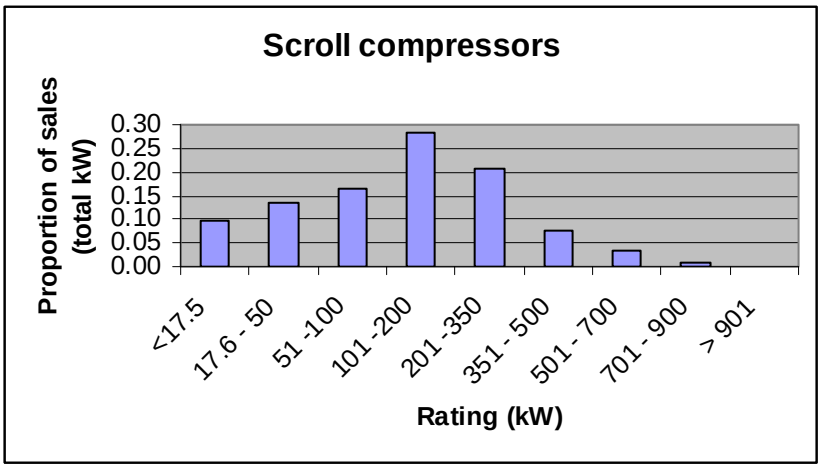


The few chillers with reciprocating compressors that are sold are predominantly of smaller sizes, but the smaller numbers of larger reciprocating chillers results in these sizes representing most of the cooling capacity.

Slightly over half the compressors use R410A refrigerant, with the remainder being split between R407C and R134a. Surprisingly, a few sales of R22 compressors were reported – possibly sold within the EU-27 for export elsewhere.

Scroll compressors

Figure 2 - 29 . Scroll compressors: sales (kW) by rated cooling capacity

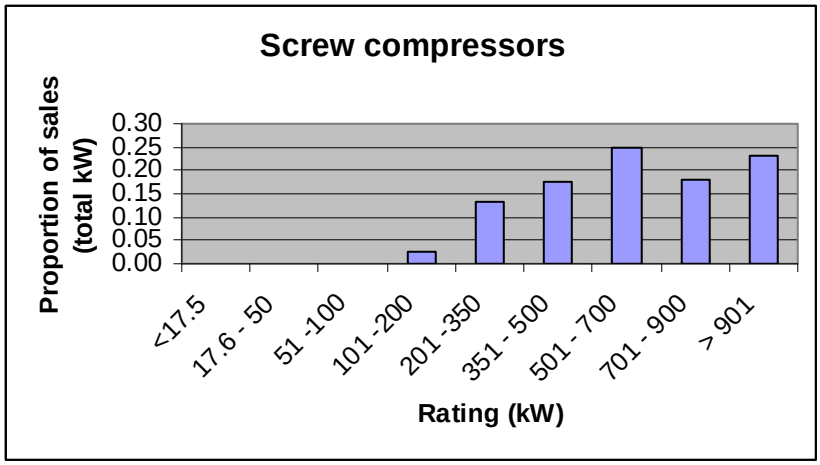


Scroll compressors are widespread in smaller chiller sizes, typically below about 300 kW rating.

Two thirds of sales used R410A refrigerant and the remainder R407C.

Screw compressors

Figure 2 - 30 . Screw compressors: sales (kW) by rated cooling capacity

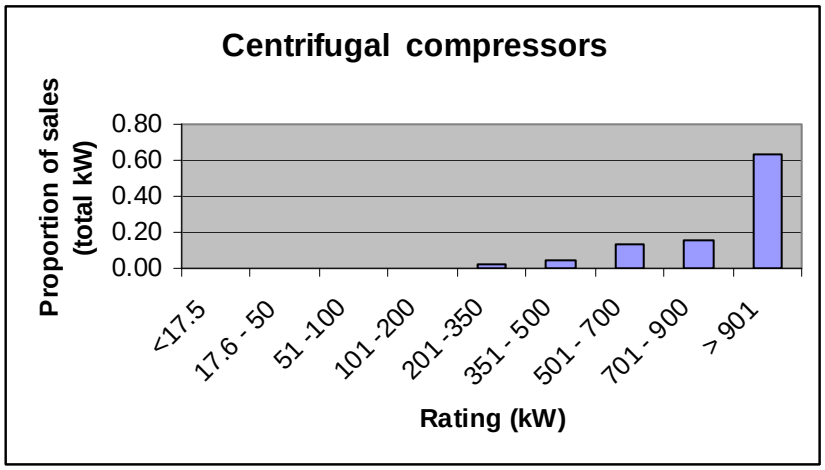


Larger sizes – above 300 kW or so - account for all the cooling capacity provided by screw compressors.

70% of sales used R134a refrigerant with the remainder reported to be split fairly evenly between R407C and R410A. R410A not being available for screw compressors, this must certainly be a mistake from statistics.

Centrifugal compressors

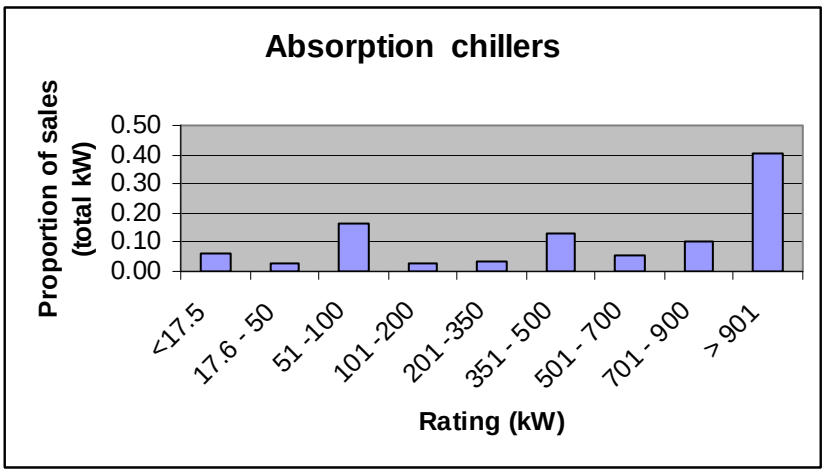
Figure 2 - 31 . Centrifugal compressors: sales (kW) by rating



Centrifugal compressors are predominantly used at very large sizes of over 900 kW rating. Even so, they account for only a small proportion of total cooling capacity. All used R134a refrigerant.

Absorption chillers

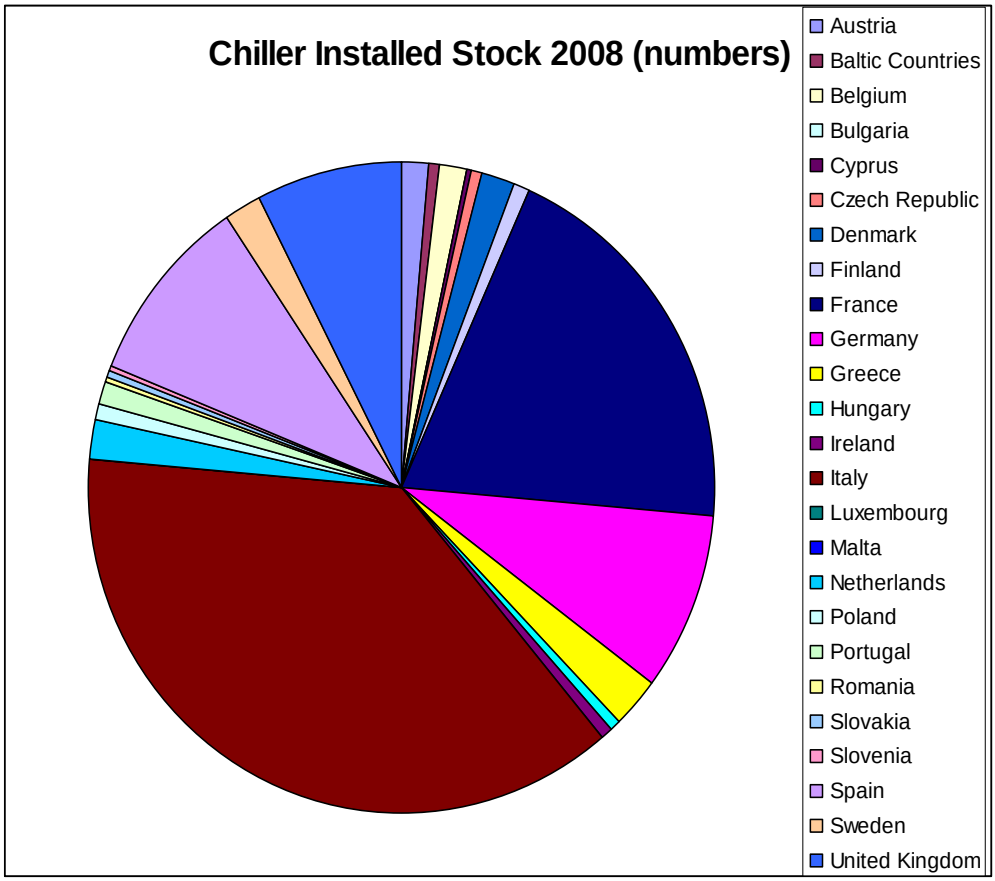
Figure 2 - 32 . Absorption chillers: sales (kW) by rating



The absorption chiller market comprises relatively large numbers of small units and much smaller numbers of much larger ones. The latter account for the greater part of newly installed capacity. The larger installations are believed to be mainly associated with the use of waste heat – from CHP systems, for example, the smaller units are typically used where there it would be expensive to obtain an adequate electricity supply for vapour compression chillers.

2008 chiller stock

Figure 2 - 33 . Chillers – 2008 stock (numbers)



The study has estimated the size of the chiller stock using the modelling methods described earlier. Italy has the largest stock (measured by numbers). Together with France it accounts for 57% of chiller stock. Three other countries – Germany, Spain and the UK – together account for another 26%. The total chiller stock in 2008 is 1.17 million (which is equivalent to just over 12 years of 2008 sales, including replacements).

Figure 2 - 34 . Chillers – 2008 stock (capacity)

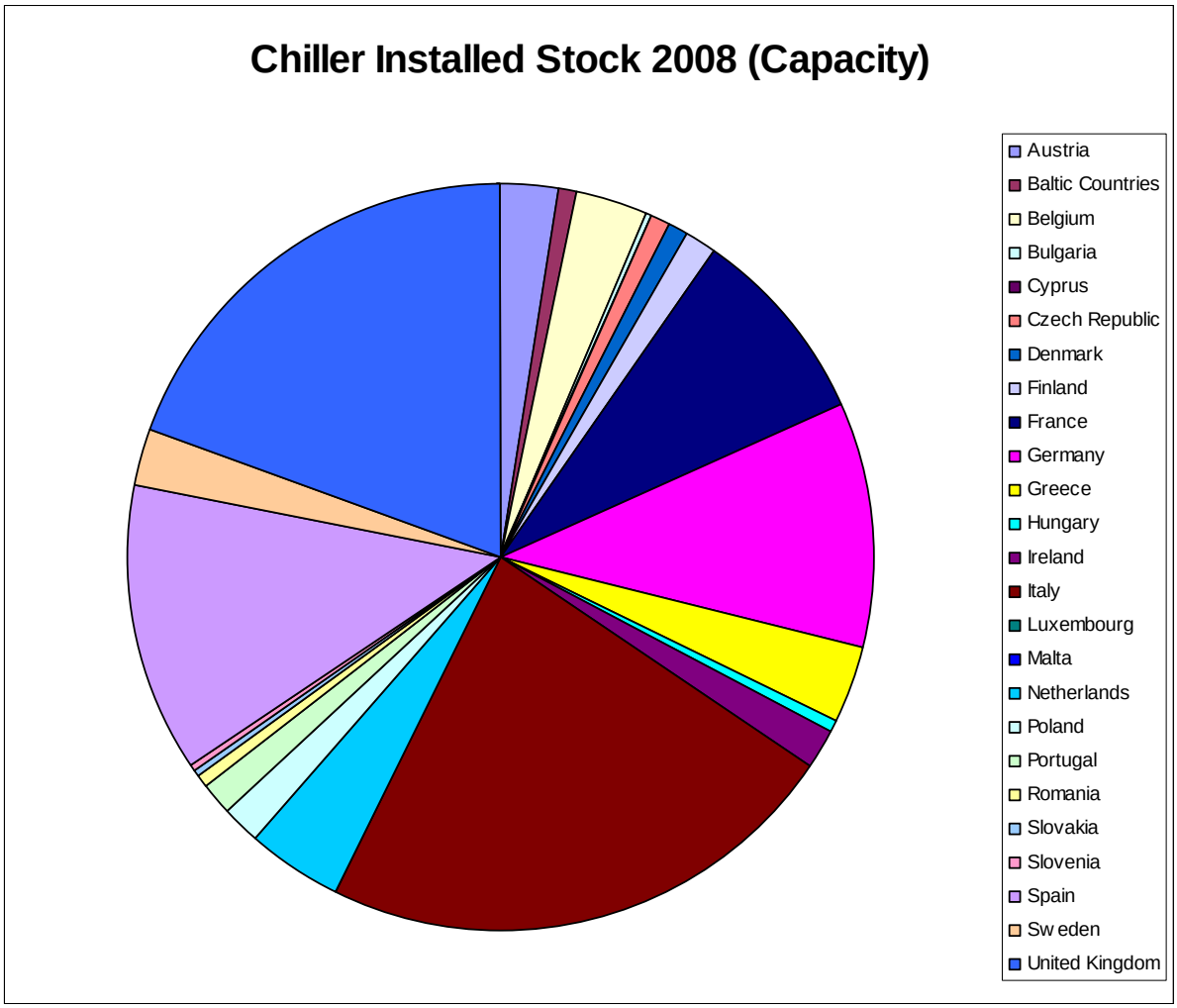


Table 2 - 8 . Chillers: national indicators

Chiller stock: 2008		
	Number	Capacity GW
Austria	16754	3.97
Baltic Countries	3222	0.81
Belgium	16195	4.62
Bulgaria	8309	1.48
Cyprus	2438	0.48
Czech Republic	16195	3.32
Denmark	8697	0.64
Finland	9323	1.47
France	198938	11.54
Germany	101784	16.49
Greece	21653	3.83
Hungary	20822	4.52
Ireland	8486	2.73
Italy	444961	36.04
Luxembourg	781	0.08
Malta	423	0.10
Netherlands	24000	6.53
Poland	7537	2.03
Portugal	10714	1.91
Romania	17439	3.64
Slovakia	6866	1.49
Slovenia	3240	0.40
Spain	116180	20.56
Sweden	20898	3.72
UK	90966	31.29
TOTAL	1176819	163.68

The distribution by capacity was obtained by multiplying stock numbers by the average size of chillers sold in each country in 2008. There is an implicit assumption that this distribution of chiller sizes also reflects past sales.

Because the average chiller size sold in France and Italy is relatively small, and that in the UK (and to a degree Germany) is large, there is a redistribution of market shares from that for numbers. Between them, five countries: Italy, the UK, Spain, Germany and France account for nearly three-quarters of installed capacity. Total installed capacity in 2008 is 164 GW of cooling.

The study can compare these estimates to the estimated total tertiary floor area in most countries as shown below. The study would expect these ratios to reflect a mixture of climate, market maturity and the mix of building types and the relative share of chiller-based system in the air conditioning market. This seems to be the broad picture, but the study does not have sufficient reliable data to analyse the ratios in detail.

Future chiller sales and stock

Projections from the study's modeling show a continuing growth in sales of chillers. However this is increasingly driven by the replacement market (chillers having a typical life of 18 years), with sales for first-time installation slowly declining. Thus the installed stock continues to increase, but the rate of

increase declines slightly from recent values. Sales for the five year period 2005 to 2010 are close to those of the previous five years. This reflects the economic downturn at the end of the interval combined with above-trend sales at its start.

Figure 2 - 35 . Projected chiller sales

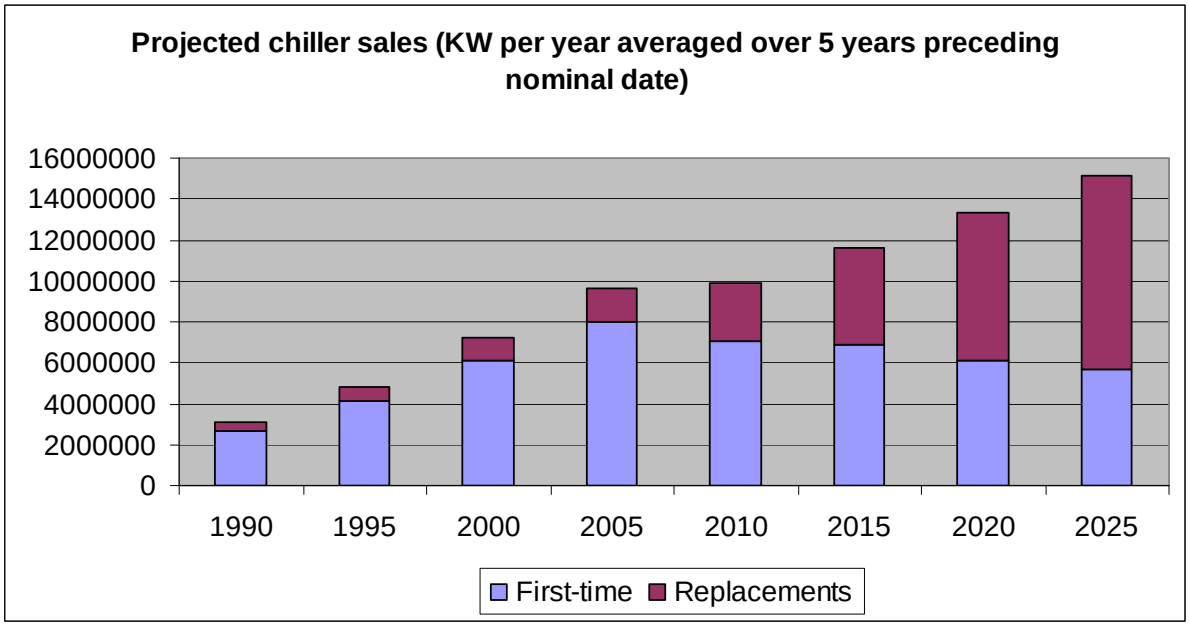


Figure 2 - 36 . Projected chiller sales by number

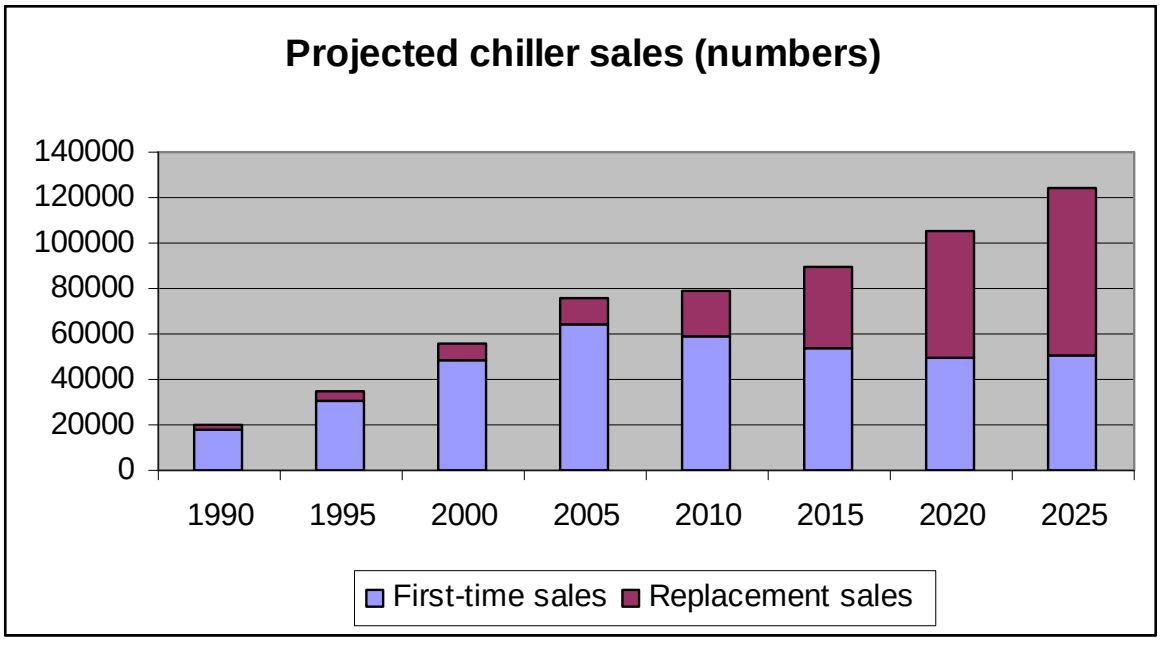


Figure 2 - 37 . Projected chiller stock (cooling capacity)

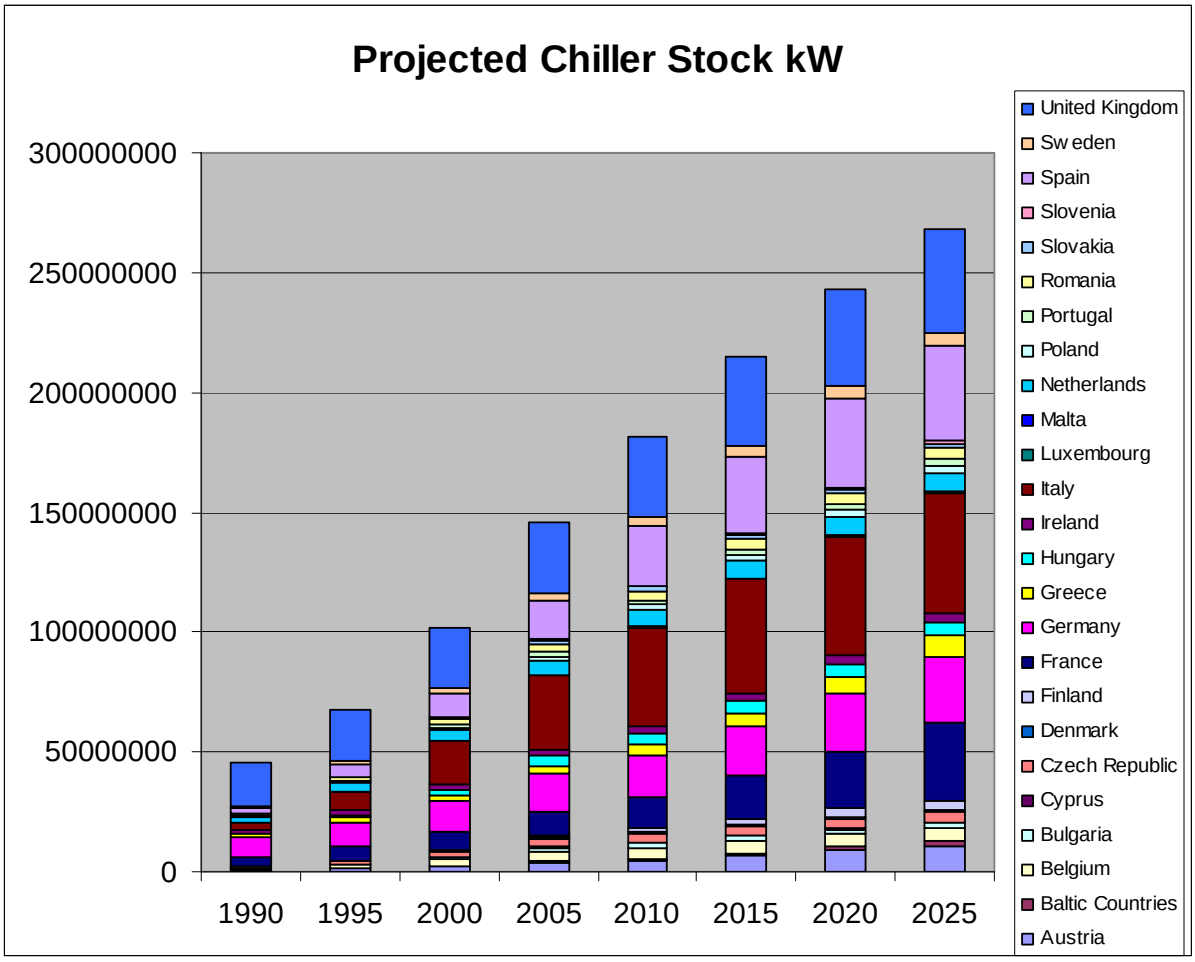
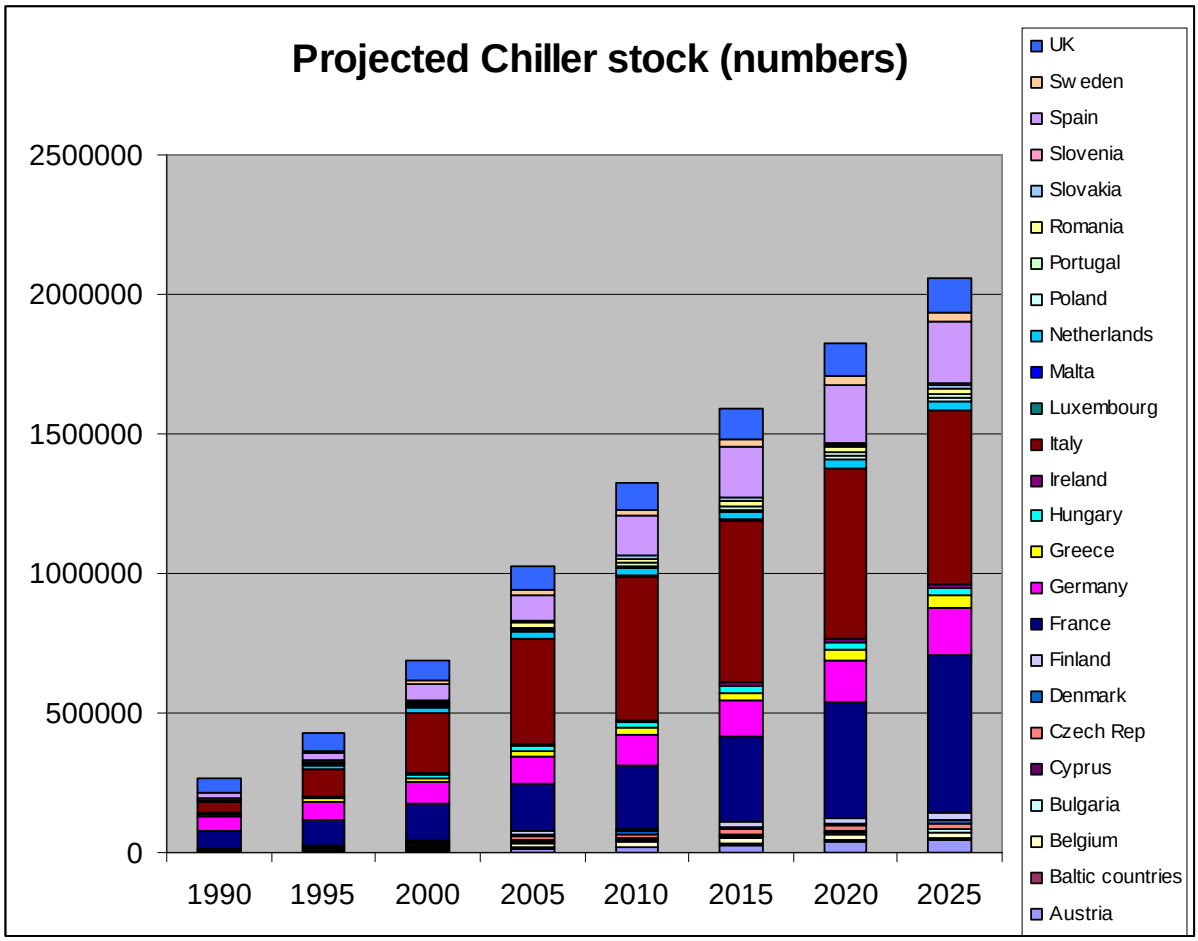


Figure 2 - 38 . Projected chiller stock (number)



The distribution between countries by capacity and number differs because of national differences in average sizes

Table 2 - 9 . Projected sales and stock of chillers

Year		1990	1995	2000	2005	2010	2015	2020	2025
Installed stock	GW	45.3	67.8	101.8	145.9	181.5	214.7	242.7	267.8
	number	268270	428387	688107	1028494	1325144	1589573	1823772	2060326
Annual sales	GW								
First time installation		2.65	4.13	6.14	8.00	7.02	6.86	6.09	5.66
Replacement		0.46	0.71	1.06	1.67	2.84	4.73	7.23	9.49
Annual sales	number								
First time installation		17571	30302	48719	64176	58880	53962	49222	50341
Replacement		2893	4426	6820	11520	20433	35580	56551	74369

Based on the study's stock modeling, and ignoring the impact of the economic downturn, the study estimates that the stock of installed chiller power will rise to 268 GW by 2025.

Because chillers have long lives (around 18 years), in 2025 only 15% of pre-2020 chillers have been replaced, 75% of the stock is pre-2020, and the remaining 10% are first-time installations (after 2020).

2.2.4. Fan coils and other terminal units for central air conditioning systems

Introduction

Market research data are available for fan coil units, which are the most common type of air conditioning terminal units. Summary data are available for other terminals

Fan coil units

Sales by country

Figure 2 - 39 . Fan Coil Sales by Country

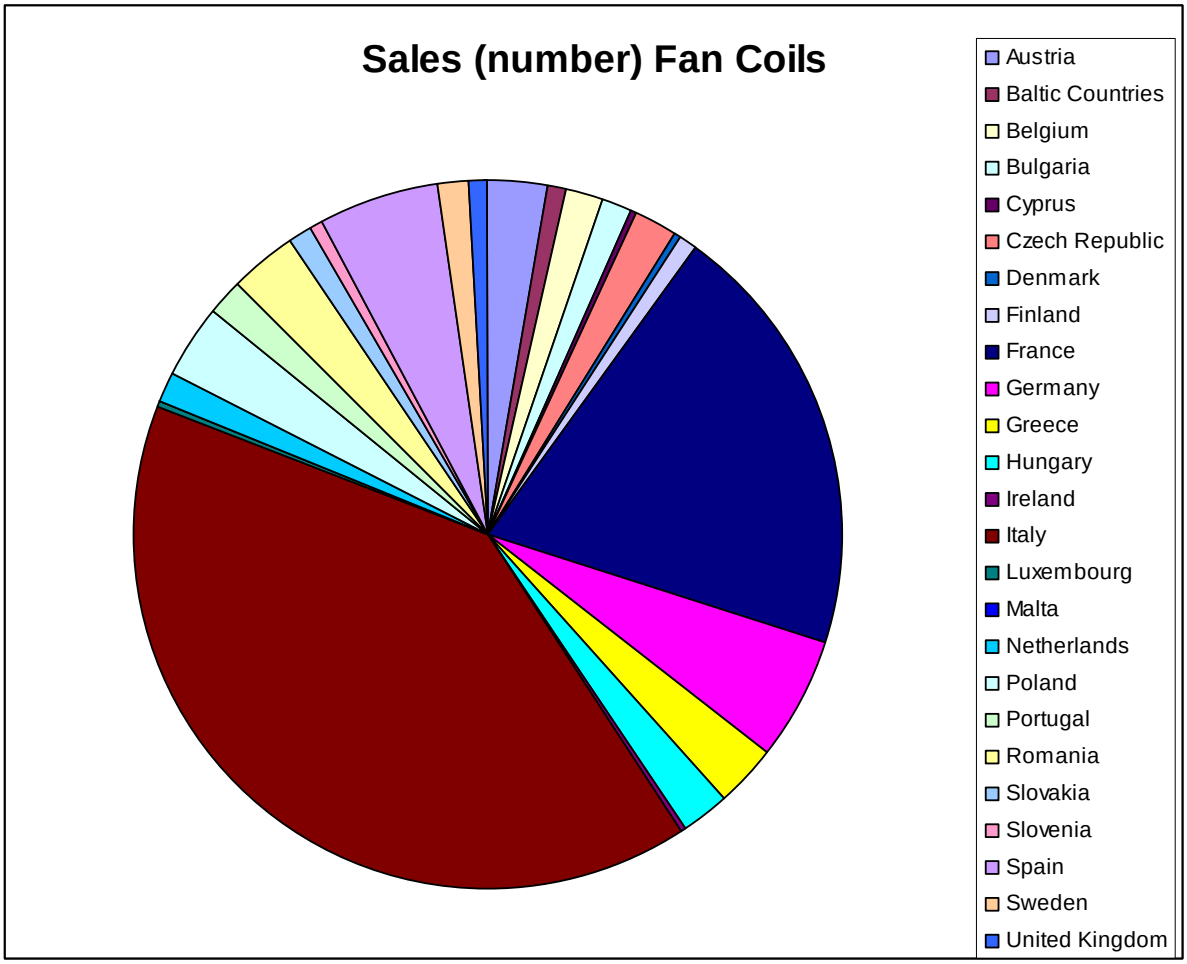


Table 2 - 10 . Fan coil sales

Fan-coil sales 2008	
Country	Number
Austria	27827
Baltic Countries	10566
Belgium	16847
Bulgaria	12744
Cyprus	2808
Czech Republic	22323
Denmark	2484
Finland	6432
France	208284
Germany	56226
Greece	28364
Hungary	24680
Ireland	464
Italy	414685
Luxembourg	1385
Malta	257
Netherlands	15265
Poland	32435
Portugal	19096
Romania	30346
Slovakia	10947
Slovenia	8244
Spain	56640
Sweden	13807
UK	8453
Total	1031609

By far the largest markets for fan coils are in Italy and France, who between them account for 60% of sales. No other country accounts for 10%. The great majority (80%) are 2-pipe units. The distribution of sales of 4-pipe units is a little more even between countries but Italy and France are still the biggest purchasers, accounting for nearly 40% of sales.

Fan Coil Unit sales and stock estimates

The projected EU27 sales and stock figures for fan coil units are presented in the table hereunder.

Table 2 - 11 . Fan Coil Unit EU27 sales and stock projections to 2025

	Estimated annual sales of fan coil units (Millions)							
Year	1990	1995	2000	2005	2010	2015	2020	2025
	0.55	0.88	1.41	1.34	1.91	1.10	0.55	0.26

	Estimated stock of fan coil units (Millions)							
Year	1990	1995	2000	2005	2010	2015	2020	2025
	10.07	14.34	18.75	22.97	24.31	24.99	25.34	25.51

Historical sales figures show that FCU sales were declining before the economic downturn, with an increasing proportion being replacements. Continuation of these trends implies a market approaching saturation in the next few decades. For this to happen, much of the growth of central air conditioning systems would use other types of terminal. While there appears to be a trend in this direction, it is not clear that this is accelerating to the extent implied by the projected trends. It is therefore possible that the sales and stock estimates for 2025 may be underestimates.

Service provided

In the six countries for which the study has market research data, 2-pipe units account for 75%. 9% of these contain electric heaters, this being particularly common in the UK. 2 – pipe units without electric heaters are most common in southern Europe. By comparing other figures in the reports the study can infer the number of 2 –pipe change-over units sold, which leads to the following breakdown

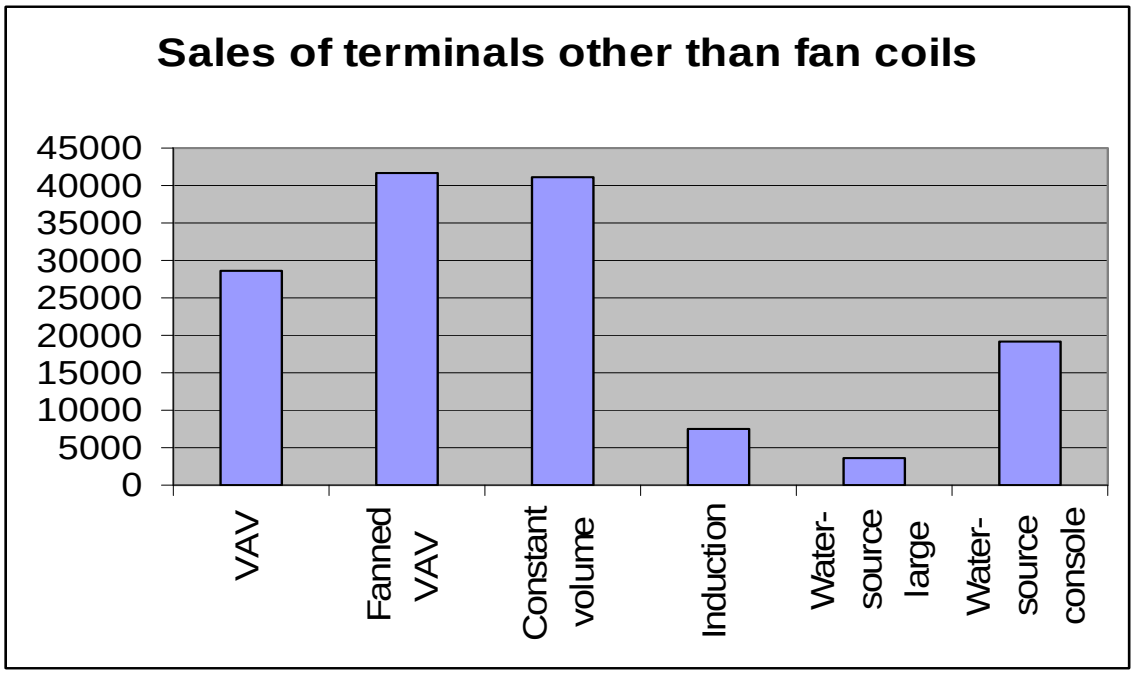
Table 2 - 12 . Fan coils: service provided

Service	
Cooling only	12%
2 –pipe with electric heater	7%
2-pipe change –over	53%
4 – pipe	26%
Heating only	2%

Other terminal units

Sales of other terminal units are much smaller than of fan coils. In the six countries for which the study has data, their combined sales were only 14% of those of fan coils. Most of the terminal products do not use energy directly, although they influence the loads placed on, and therefore the energy consumption of energy-using components including chillers. Most of the terminal units for which data exist are constant volume and variable volume air supply units. Low temperature emitters such as chilled beams and ceilings do not appear to be included in the BSRIA market data.

Figure 2 - 40 . Sales of Terminals



2.2.5. Heat rejection units for central air conditioning systems

Cooling towers

Water-cooled chillers can use cooling towers or dry coolers. Cooling towers result in higher efficiencies heat rejection is at or near the air's wet-bulb temperature rather than the higher, dry-bulb temperature.

However, they consume make-up water and require careful maintenance to avoid risks of legionella.

Air-cooled chillers may use dry or evaporative heat rejection. Evaporatively cooled chillers offer higher efficiencies than air-cooled chillers but lower than water-cooled chillers.

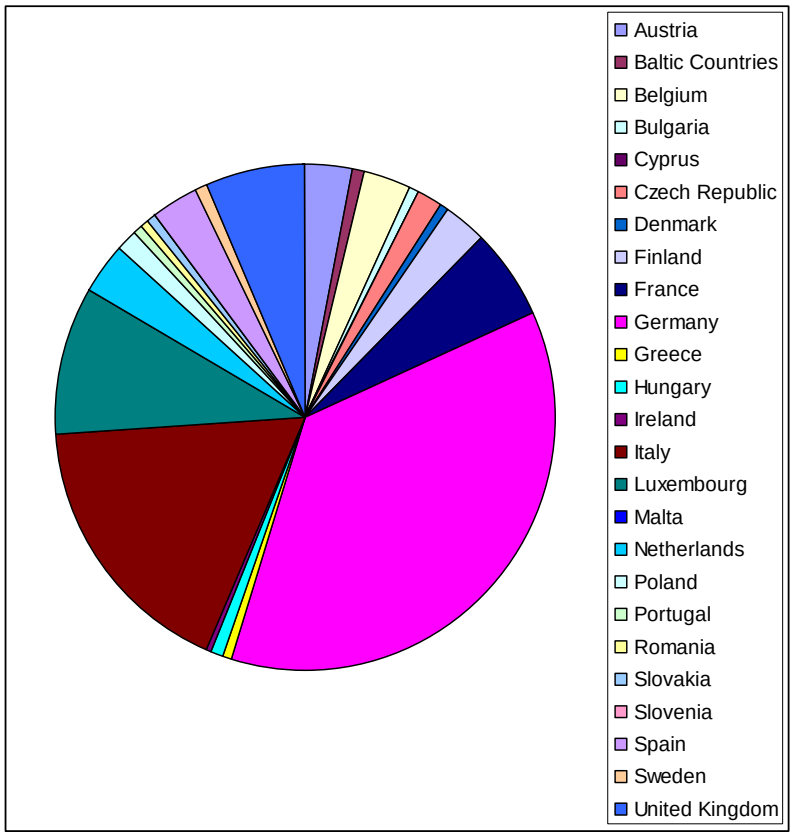
Separate heat rejection units only exist in air conditioning as components of systems that use water-cooled chillers. (In other systems heat rejection is an integral part of the system or chiller). As is shown in the section on chillers, most air conditioning chillers are air-cooled especially in the smaller ratings.

Prodcom shows sales of 59000 units for cooling towers in 2008, but most cooling towers are used in industrial processes rather than for air conditioning.

Water cooled chillers account for 14% of sales by number and 20% by sales, therefore of the order of 13000 units per year. Industry sources suggest that most water-cooled chillers sold today use dry coolers rather than cooling towers – though in the past cooling towers were the norm. The study therefore estimates that sales of chillers using cooling towers for heat rejection is of the order of 1300 pa – less than 3% of the Prodcom figure.

The study has been unable to find data for cooling towers used for air conditioning **Information Request issue.** The available data therefore are dominated by cooling towers that are used for process applications. Three countries account for more than 60% of sales: Germany (35%), Italy (17%) and Luxembourg (10%). Over 60% of these are closed, (rather than open) but of these 2/3 are in Germany and Luxembourg.

Figure 2 - 41 . Sales of Cooling Towers



3. SUBTASK 2.3 - MARKET CHANNELS AND PRODUCTION STRUCTURES

3.1. INTRODUCTION

This section addresses

- trends in product and system design (but detailed analysis of technical potential is in later Tasks)
- a summary of market maturity and structure (more information on the former is contained in the market modeling results already reported)

3.2. TRENDS IN PRODUCT DESIGN AND PERFORMANCE

3.2.1. General

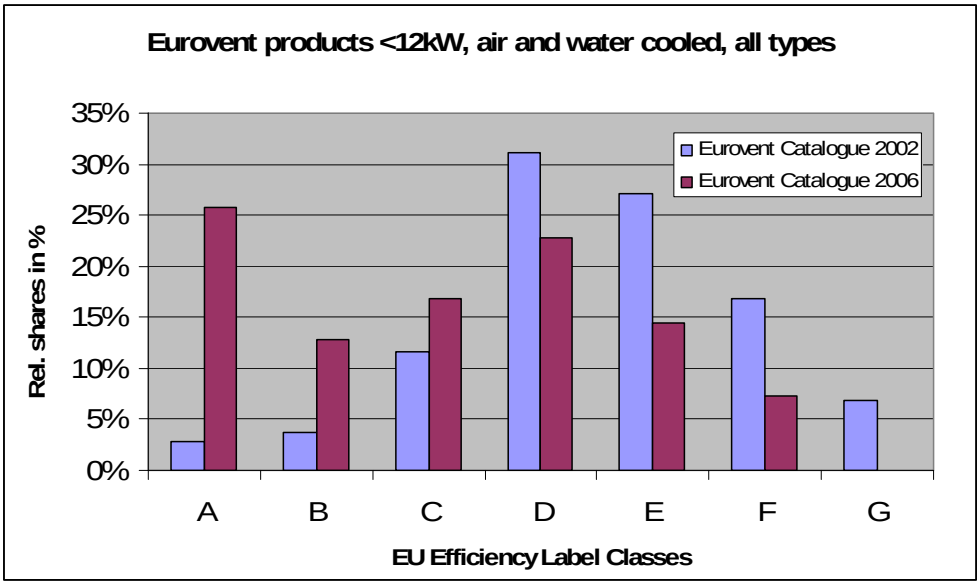
The technology of cooling has developed fairly steadily over a period of many decades and this trend continues today. Current products still fall short of theoretically possible efficiencies because of demanding practical engineering constraints. The extent to which these can be overcome in commercially viable products varies between product types and between markets: some technologies are more practicable at large sizes, others at smaller scales, and some markets will more readily accept a price premium for higher efficiency.

3.2.2. Air conditioners > 12 kW and air conditioning condensing units

Single split air conditioners

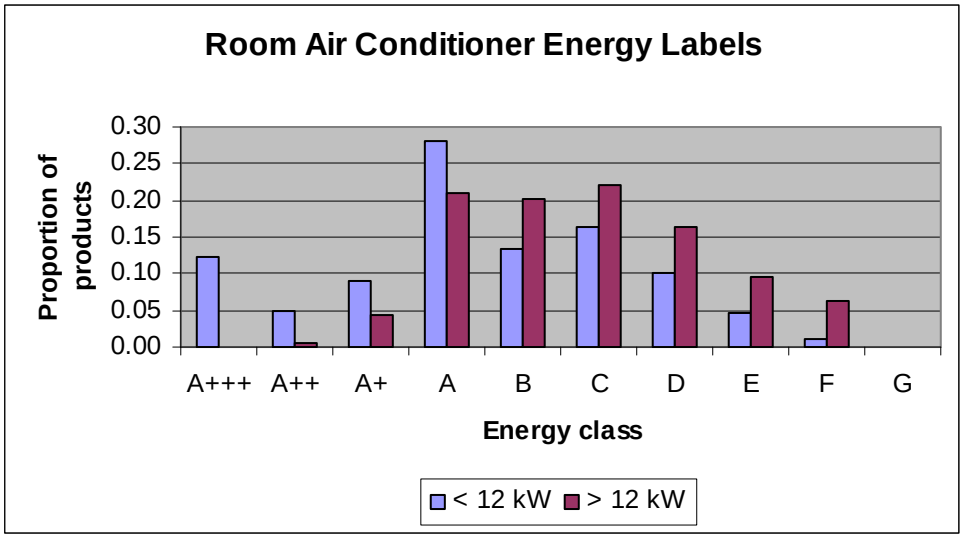
The availability of smaller room air conditioners with high efficiencies (outside the scope of this study) has increased substantially since the Lot 10 study. This reflects a wider use of variable-speed compressors, more effective heat exchangers and improved designs of fans and expansion valves. The figures below are based on performance at standard rating conditions. The technical developments which have been applied have greater impact on seasonal performance than on rated performance.

Figure 2 - 42 . Market distributions of small room air conditioners



Products of over 12kW are not required to have energy labels. Applying the current criteria (extended to A+++) for products below 12kW to larger products in the Eurovent database shows a larger proportion of less efficient products. It also shows that products in this size class of up to (assumed) A++ are on the market, while the median product has a C rating.

Figure 2 - 43 . Energy Rating Comparison between small and larger air conditioners (2010)



Multisplit and VRF systems

These systems – as with room air conditioners – distribute cooling by refrigerant, but serve more than one space. Variable refrigerant systems (VRF) first appeared in the 1980s and have steadily increased their market share. With continuing technical development they can be used in a wider range of buildings than ordinary multisplit units, have high efficiencies and can recover surplus heat from rooms with a cooling demand to be used for heating in rooms with a heating demand or to preheat domestic hot water.

Multisplit units have (equivalent) ratings between F and A+, with a median of B – somewhat better on average than single split units of similar rating. (However, performance will vary according to the combination of indoor units attached to a single outdoor unit, and these figures may not always be realised in practice.)

VRF systems would generally have the equivalent of an A rating. DIN V 18599-7 shows VRF systems to be typically 20% more efficient than traditional multi-split systems which have variable speed compressors.

Rooftops

Eurovent Certification has an energy classification system for rooftop units. There are products currently on the market in all of the label bands A to F, Most fall between A and C, with a median of B.

An American study examined the potential for cost-effective efficiency improvement, concluding that there was little scope for improving efficiency at nominal output beyond the equivalent of an A label. However, the technical advances currently employed in small room air conditioners could be applied to rooftop units to improve seasonal efficiency.

Air conditioning condensing units

By the past, with the domination of chiller based system, most air handling units cooling coils were using chilled water. With the development of DX systems, mainly with the one of VRF systems that can supply heating and cooling to relatively large buildings, the pre-cooling of ventilation air would require a dedicated water based system in addition to the DX system, which may not be cost effective. This seems to pull the sales of more air conditioning condensing units, which are either split, VRF or

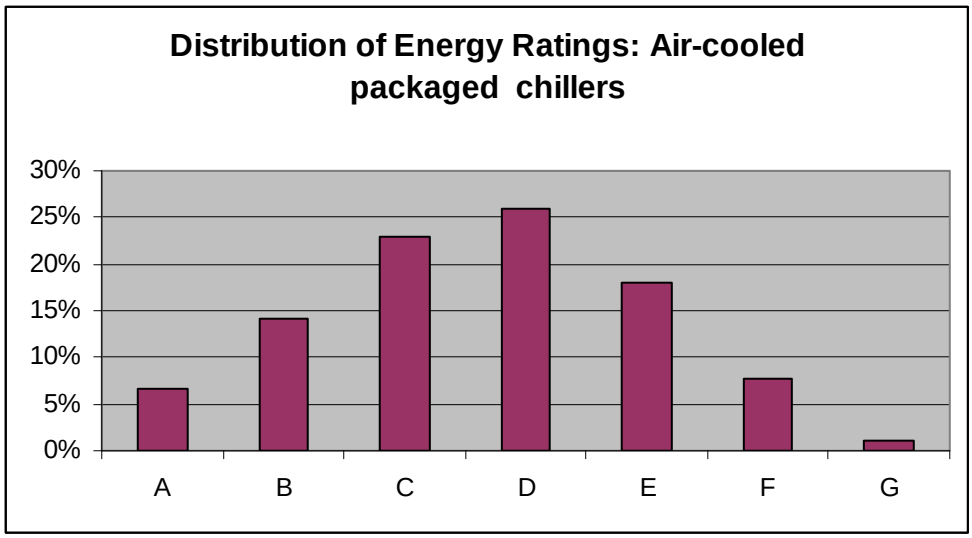
chiller subassembly of the condenser and its fan, the expansion valve and the compression circuitry. The technical developments are thus similar to the ones of DX and chiller based systems.

3.2.3. Chillers

Chiller technology has continually improved with the replacement of reciprocating compressors with different rotary designs (centrifugal, scroll, screw) according to application; the use of electronic expansion valves, more effective heat exchangers, and multi-compressor units.

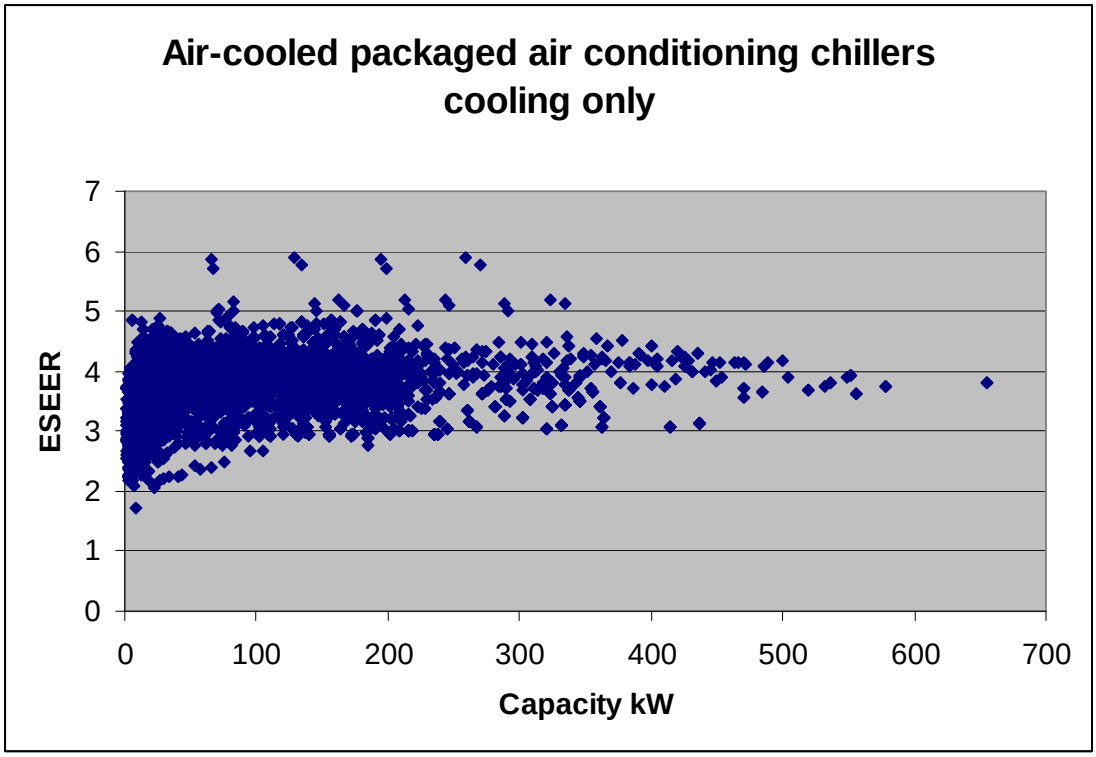
Nevertheless, the products listed on the Eurovent database cover a wide range of energy performance levels (Eurovent voluntary ratings) with a median of D. Comparison with similar data from 1996 shows little difference the distribution of performances (energy rating was not then part of the certification process, though EER figures were certified). There has been a slight reduction in the proportion of lower-efficiency products, but only to a minor extent. This seems to imply that energy efficiency has not been a major market driver.

Figure 2 - 44 . Energy Rating distribution of chillers



There has, however, been an appearance of new high-efficiency products with improved seasonal efficiency, although these represent only a small proportion of models. The most efficient of these have seasonal efficiencies over 5 and combine high-speed compressors using magnetic levitation instead of physical bearings with other advanced features. They also carry a price premium of the order of 30%.

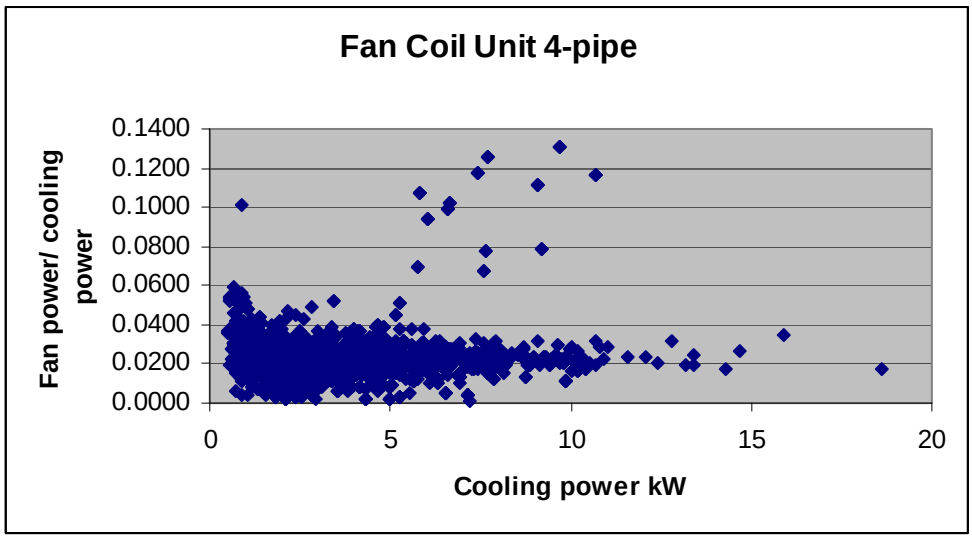
Figure 2 - 45 . Energy Performance of Chillers



3.2.4. Fan coil units

The energy efficiency of fan coil units can be represented by the ratio of fan power to cooling power. Analysis of the Eurovent data shows that this parameter takes a wide range of values – though most products fall into a relatively narrow band. There is more variation in smaller sizes. Some of the variation may well result from products designed for different mounting and applications, so the analysis below should not be considered definitive.

Figure 2 - 46 . Energy Performance of Fan Coil Units



The principle product feature affecting energy efficiency is motor efficiency and control. The use of variable-speed direct current motors can reduce electrical consumption by 50% and allows a greater range of control possibilities. Since the major savings are in control, they do not appear in the chart above.

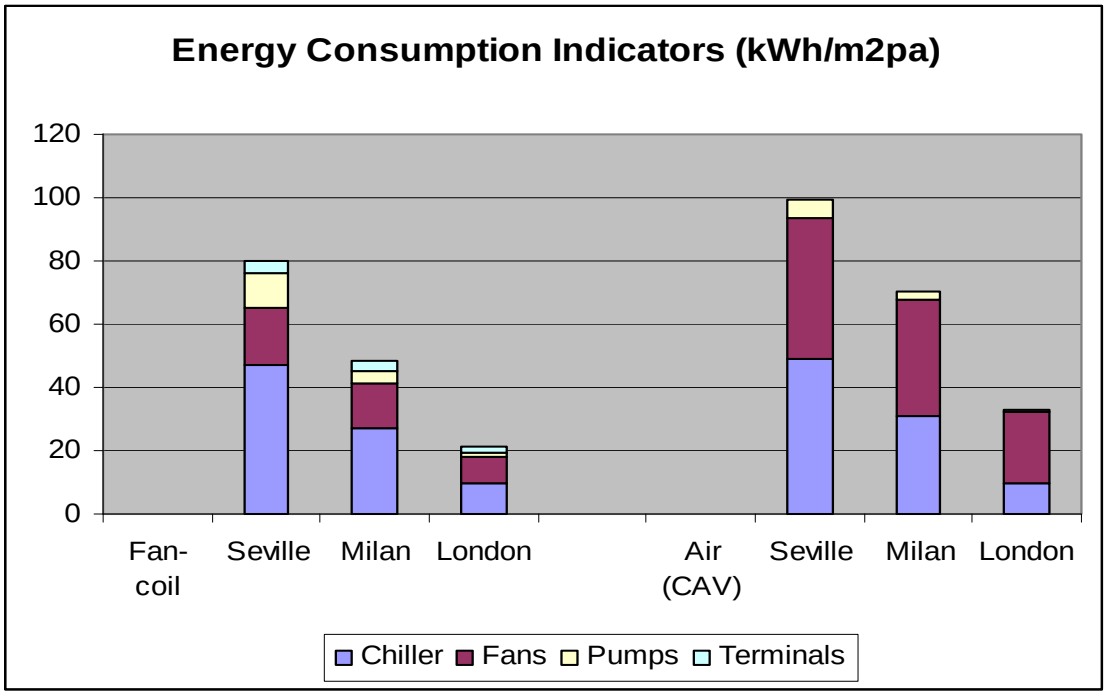
3.2.5. Heat rejection units

As for fan coils, the more important design feature seems to be the development of products with variable-speed direct current motors, which can highly reduce the electrical consumption of both cooling towers and dry coolers.

3.3. TRENDS IN SYSTEM DESIGN

The total energy use of central (and especially chiller-based) systems varies with the configuration of system. In particular, heat transfer using air is much less efficient than that using water or refrigerant. Also the energy required to move air is very sensitive to ductwork size: reducing the diameter of a circular duct by 10% increases the energy needed to transfer the same amount of air (and therefore cooling) through it by 46%. Thus although pipework and ductwork systems do not themselves use energy, they have a significant influence on the prime movers that do.

Figure 2 - 47 . Example Energy Consumptions (based on EECCAC)



The chart above illustrates the relative magnitudes of energy consumed by chillers, fans and other components for water-based and air-based system in three different climatic zones.

The main types of chiller-based systems are described in Task 1. Quantitative estimates of relative frequency seem to be non-existent but, in general terms, it is believed that the trend in central air conditioning in offices in Europe over the last 60 years has been:

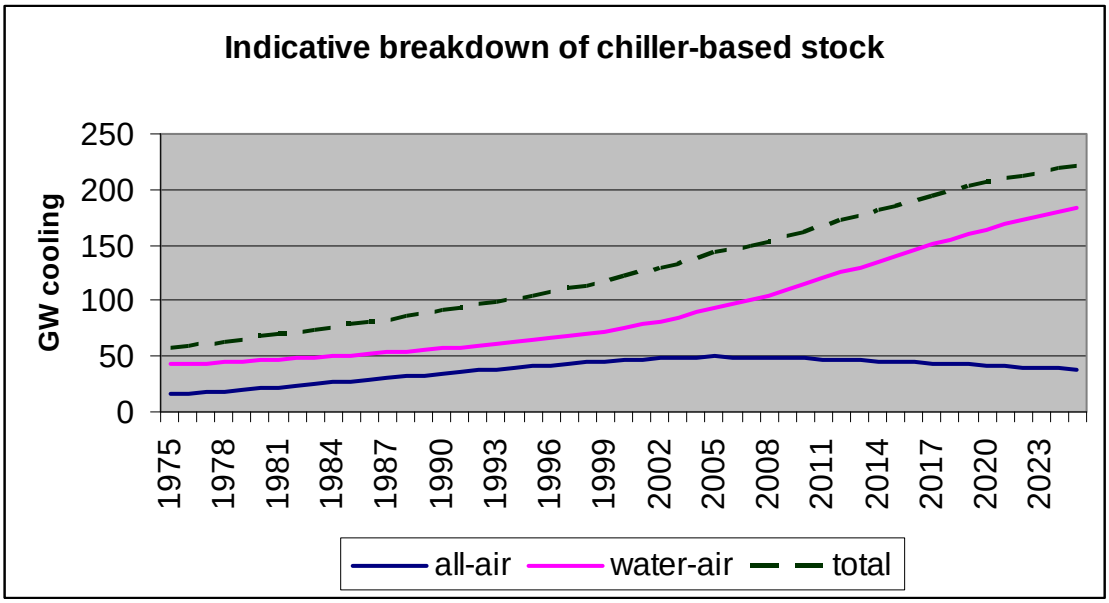
- 1950s: constant volume all-air systems in core areas plus induction or dual duct systems in perimeter areas
- 1960s and 1970s: broadly similar but some new systems introduced in small numbers: variable volume all-air, water loop heat pumps, fan coil–based chiller systems, terminal reheat, chilled ceilings. There was a consequent slight reduction in market share other systems.
- 1980s: growth in use of fan coils and variable volume all-air. First appearance of VRF. Decline of other systems
- 1990s: continued growth of fan coils, increasing use of VRF, chilled ceilings and chilled beams
- 2000s: growth in use of fan coils, VRF, chilled ceilings and beams; declining use of variable volume all-air

Currently, the study estimates that the majority of new central systems use fan coil units, followed by VRF and chilled beams and ceilings.

A feature of this history is that the proportion of systems which use a combination of water and air, rather than the various forms of all-air system, has increased. Figure 2-48 illustrates this trend, but should not be taken as an accurate quantitative assessment since it is largely based on qualitative and sometimes subjective information. This comparison is especially pertinent with respect to the role of air handling units. In air-water systems, their principal function is clearly to provide ventilation (while usually also acting as transport mechanism for part of the cooling service). In all-air systems, the air handling unit is the transport mechanism for cooling and is an essential part of the cooling function.

It is estimated that around 12% of newly-installed chiller-based systems are all-air systems. As central air conditioning systems have long lives, the existing stock is more reflective of the past and the proportion of all-air systems is perhaps three times higher.

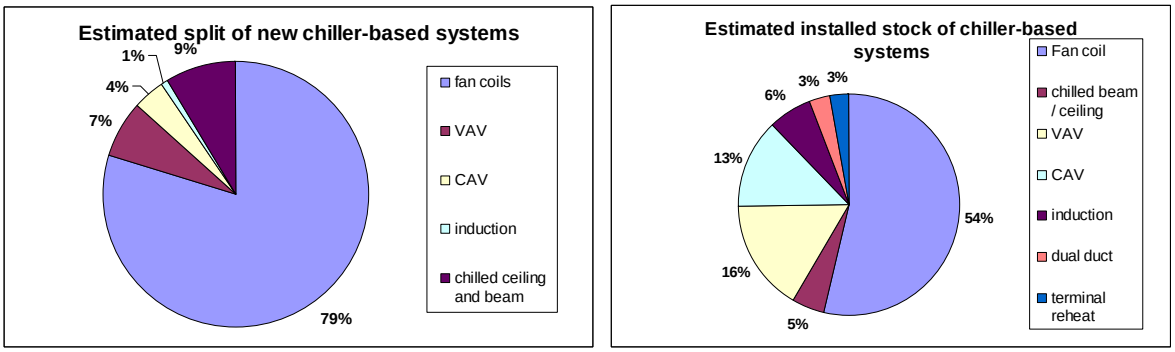
Figure 2 - 48 . Indicative breakdown of chiller-based system stock



The estimation process was:

- assign percentages to each system type for each decade. These are arbitrary values based on qualitative reports of common practice, introduction of new technologies and the like
    - for recent years, the data on terminal sales was also used as an indicator
- estimate numbers of new and replacement systems from the chiller sales modelling already described
- Attribute replacements as either like-for-like systems (component replacement), or change-of-type (change of type is more likely where major refurbishment is being carried out and where an application does not specifically demand use of a particular system.) These are arbitrary judgements.
- Build up an outline stock distribution

Figure 2 - 49 . Estimated split of chiller-based systems: sales and stock by cooling capacity



3.4. DISTRIBUTION CHANNELS

3.4.1 Introduction

Central air conditioning systems and products are predominantly sold business to business. In many cases, the purchaser will not directly specify the system, which will be selected either by an installer or – for larger projects – by specialist consultant engineers. It is not uncommon, especially for new building, for the installer to be a subcontractor to a main contractor.

A consequence of this typically multi-stage supply chain is that the purchase decision is often rarely taken by the organisation that will be responsible for the operating costs. Since many buildings are rented, it is common for there to be at least one additional intermediary.

Where development is “shell and core” followed by “fit-out”, there may be different specifiers: one for the core services (including chillers and main air handling units), and a different one for the distribution systems and terminal units.

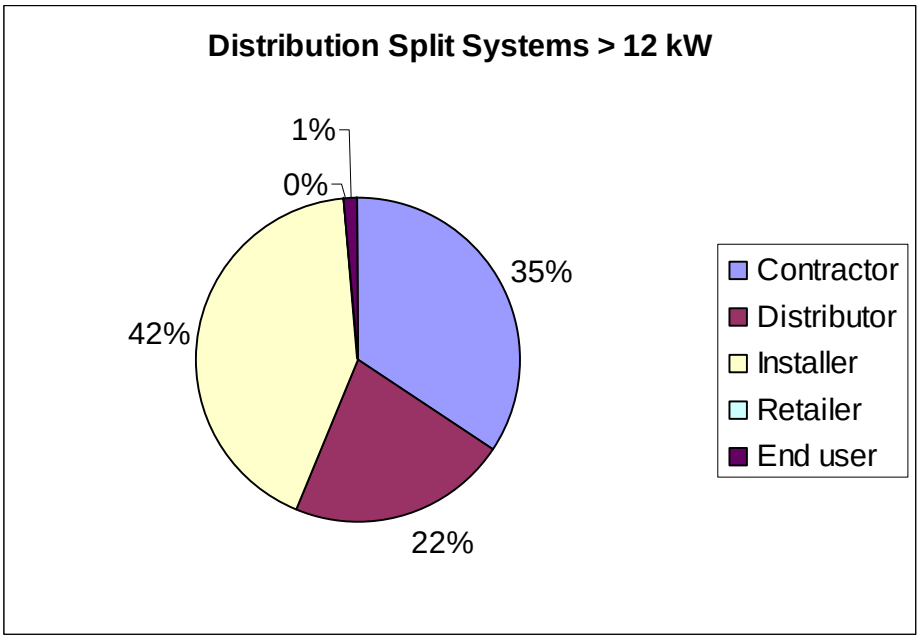
Specification practice seems to differ between countries. In Germany most products are specified by a consultant, though the installer may take this role for smaller systems. In Spain, the contractor and installer have been the main specifiers in the past, though the use of consultant engineers is increasing. In the UK, the trend is towards “design and build” contracts. In France, specification is done by large contractors, consultant engineers and large maintenance companies. In Greece the norm appears to be for the specification to be carried out by a consultant engineer employed by the contractor (rather than by the building owner or his architect).

The following sections show product-specific breakdowns where the study has been able to estimate these.

3.4.2 Distribution routes: air conditioners > 12 kW and air conditioning condensing units

Distribution routes: split systems > 12 kW

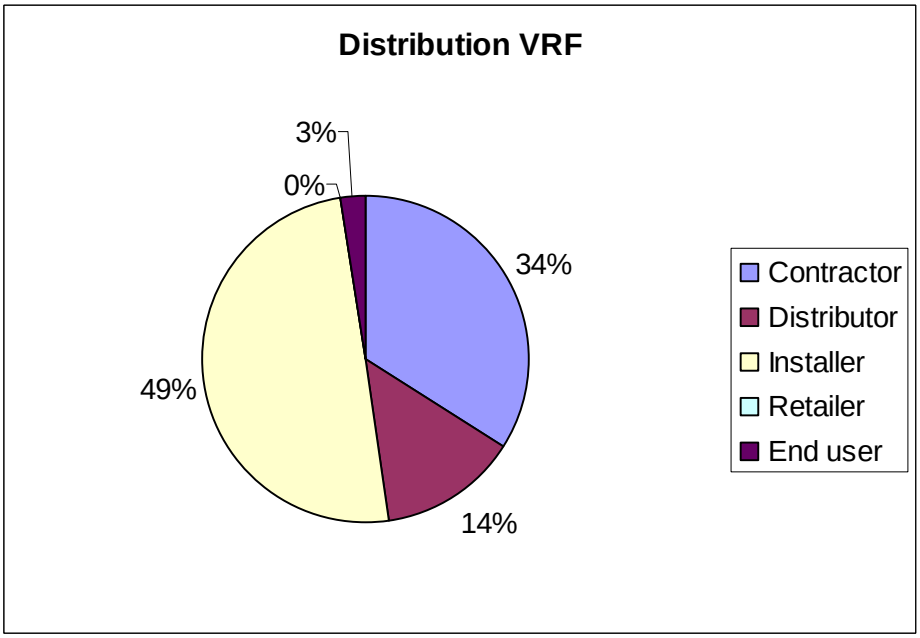
Figure 2 - 50 . Distribution Routes Split systems > 12 kW



Distribution for split systems is divided between installers contractors and distributors.

Distribution routes: vrf systems

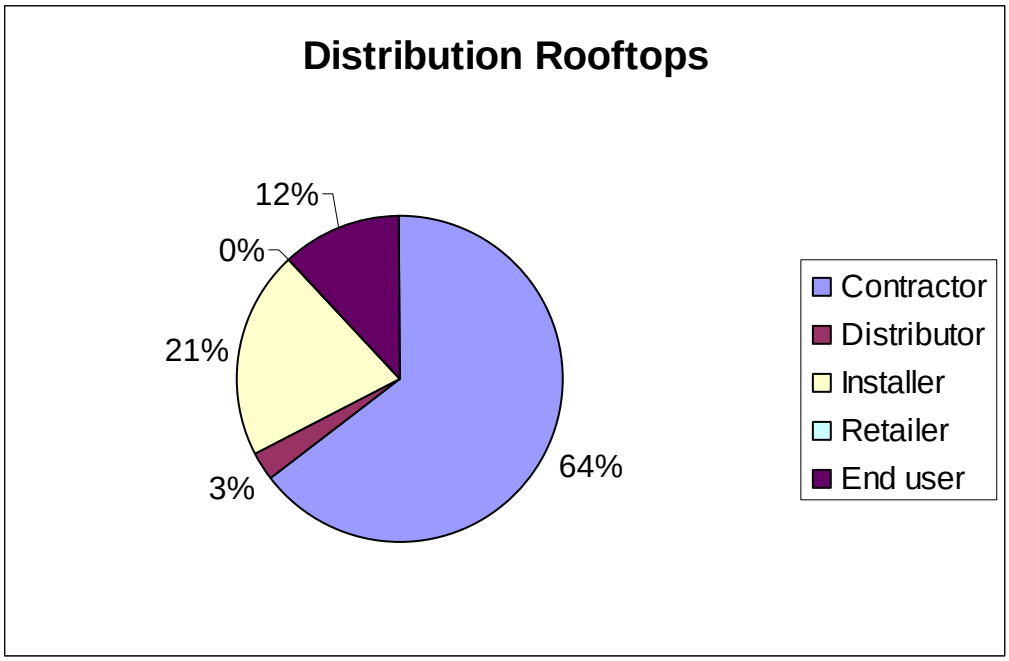
Figure 2 - 51 . Distribution route VRF systems



The principal distribution routes for VRF systems are through installers and contractors.

Distribution routes: rooftop units

Figure 2 - 52 . Distribution Route Rooftop Units



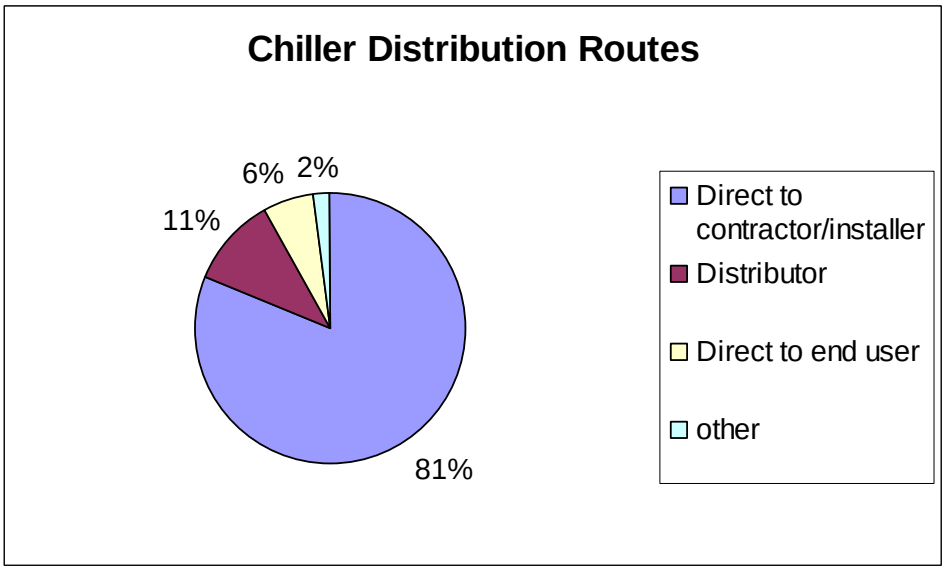
The predominant distribution route is via contractors, with smaller numbers passing through installers and a minority being sold directly to end-users

Distribution routes: air conditioning condensing units

Information Request issue

3.4.3 Distribution routes chillers

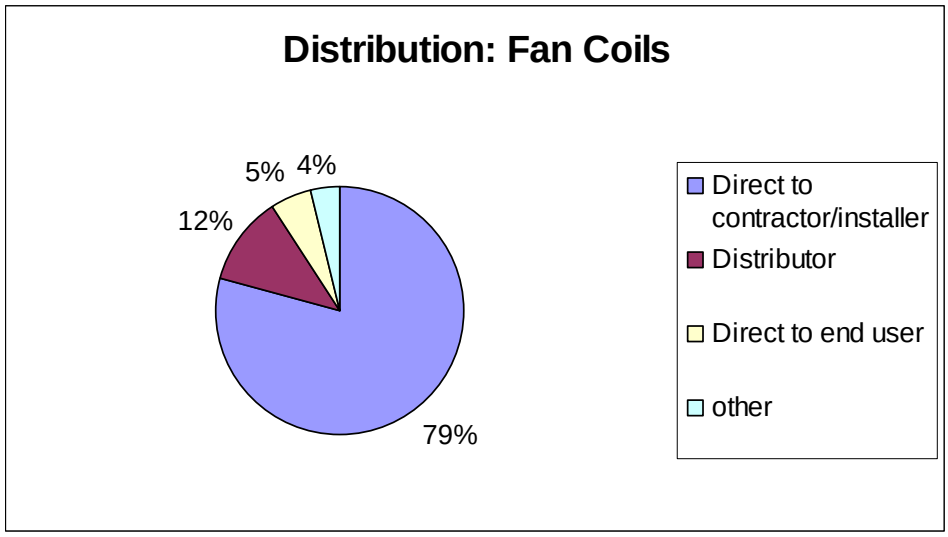
Figure 2 - 53 . Distribution routes – chillers



Over 80% of chillers are delivered directly to the contractor or the installer (the statistics do nor distinguish which). Another 11% go initially to a distributor.

3.4.4 Distribution routes: terminal units including fan coils

Figure 2 - 54 . Distribution routes – fan coils



The frequency of distribution routes for fan coils is almost identical to that for chillers. VAV terminals and « other terminal units » show the same pattern

3.4.5 Distribution routes: heat rejection units

Information Request issue

3.5. PRODUCT APPLICATIONS

3.5.1. Introduction

Products metrics are based on intrinsic performance characteristics, but different product types are more appropriate for use in some circumstances than others. Different applications generate different levels and distributions of cooling demands, resulting in the possibility of product labelling (or other instruments) needing to be application-dependent. This section reports the current distribution of applications of different products as a framework against which analysis can be carried out in subsequent tasks. The information sources are those used for the product sections above, mainly comprising market research data from France, Germany, Greece, Italy, Spain and the UK.. These include the major EU-27 markets, but do not cover the entire market.

This report considers application classes broken down in two ways:
- by end-use
- between replacement of existing products, new buildings and first-time installations in existing buildings.

3.5.2. End-use sectors

Introduction

Different system types are suitable to different degrees to different end-uses. The table below summarises suitability in general terms for a number of building types. The following sections report market research results on actual sales.

Table 2 - 13 . System Types and Applications

		System type							
		Chiller-based systems					Air conditioners		
		All air		Air / water					
Building type	**Sub-type**	Constant volume	VAV	Fan coil & induction & WLHP	Chilled beam/ ceiling	Active chilled beam	Split systems	VRF/ multi split	Rooftop
Offices	Shallow plan		XXX	XXX	XXX	XXX	XX	XXX	X
	Deep plan	X	XXX	XXX	XXX	XXX		XX	
Retail	Small shop						X	XXX	XX
	Large store / Supermarket	XXX		X					XX
Hotel	Public areas	XXX						X	XX
	Bedrooms		X	XX			X	X	
Theatres / cinemas / large spaces		XXX		X					XX
Residential					X		XX	XXX	

Air conditioners > 12 kW and air conditioning condensing units

The market share taken by each type of (non-chiller) system varies between countries, The table below shows the aggregate shares.

Table 2 - 14 . End use indicators: air conditioners > 12kW (by number)

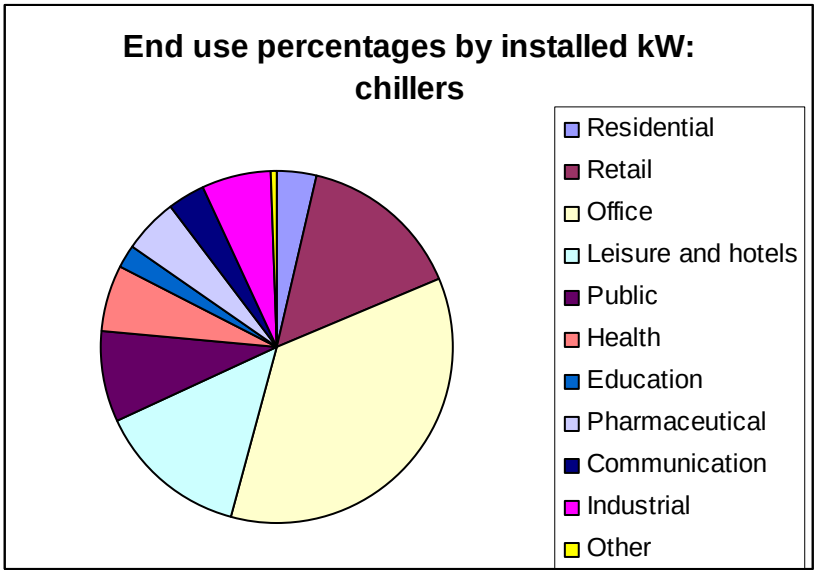
End-use non-chiller systems (6 countries)					
	Rooftops	Ducted splits	Single splits	Multisplits	VRF
Residential	0%	0%	16%	7%	1%
Retail	54%	27%	24%	24%	15%
Office, Leisure and Hotels	20%	50%	40%	43%	72%
Public	7%	10%	11%	13%	8%
Pharmaceutical	1%	4%	1%	1%	1%
Other Industrial	16%	7%	7%	10%	3%
Other	2%	2%	2%	2%	0%

The large offices, leisure and hotels sector (a more detailed breakdown is not available for these products) accounts for the biggest share for all products except rooftop units. Retail is the dominant end-sue for rooftop units.

Regarding air conditioning condensing units, the study team would assume their use would be more or less correlated to the ones of AHUs in buildings heated and cooled by DX systems (others than rooftops). The distribution is thus likely to be a mix of the ones of split, multisplit and vrf systems.

Chillers

Figure 2 - 55 . End-use percentages by installed kW: chillers

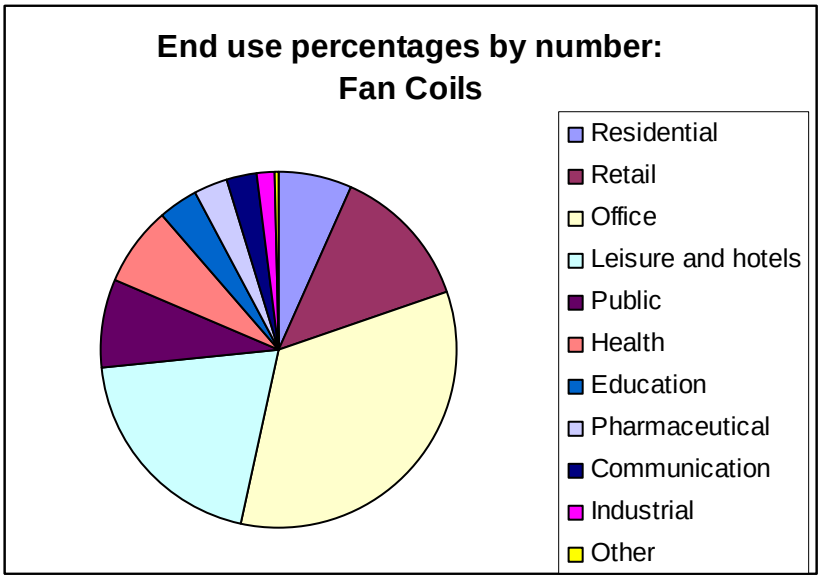


Three end-uses account for 65% of newly-installed cooling capacity: offices (36%), retail (15%) and hotels and leisure (14%). Reported chiller sales exclude dedicated process chillers but may include some chillers that serve a mixture of processing and building air-conditioning. These are most likely to be in the industrial and pharmaceutical sectors which account for 6% and 5% of sales respectively.

Inevitably, there are differences between countries, notably in the proportions of the market taken by retail, public and industrial buildings. This presumably reflects – at least in part - the differing importance of these sectors in national economies.

Terminal units: fan coils

Figure 2 - 56 . End-use percentages by number: fan coils

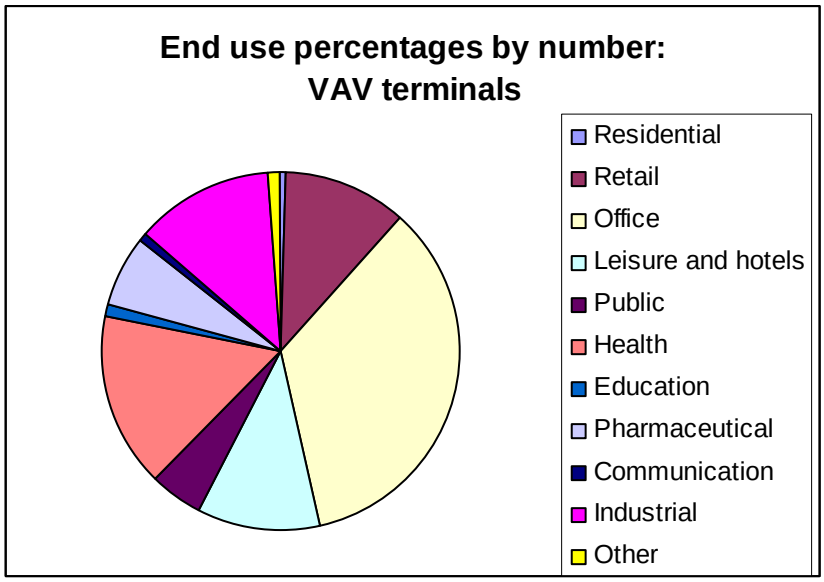


Again, three sectors account for more than half (67%) of the market: offices (34%), leisure and hotels (20%) and retail (13%) - a very similar distribution to that for chillers. However, compared to chillers,

market share is higher in the residential, education and leisure and hotel sectors but significantly lower in industry.

Terminal units: VAV terminals

Figure 2 - 57 . End-use percentages by number: VAV terminals

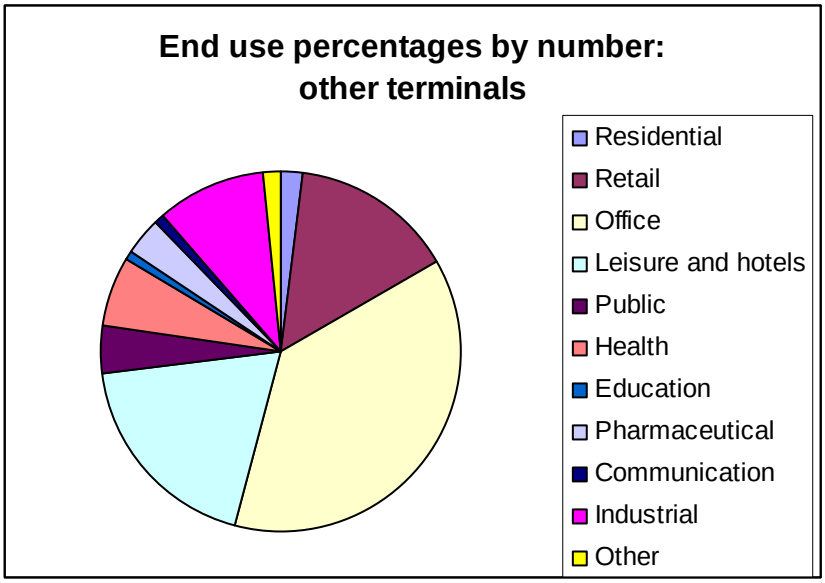


The three largest sectors are offices (35%), health (16%), and industry (13%), followed by retail (11%) and leisure and hotels (11%). Together they account for 86% of sales. Compared to chillers, market share is significantly higher in the health, other and industrial sectors and much lower in the residential sector.

Terminal units: Other terminals

The classification “other terminals” comprises constant-volume terminals, induction units and water-source consoles. Data on chilled beams and ceilings is missing. **Information request issue**

Figure 2 - 58 . End-use percentages by number: other terminals



Three sectors account for 71% of sales: offices (37%), leisure and hotels (19%), retail (15%). The industrial and other sectors have noticeably greater market share than for chillers, while the figure for communications is substantially lower.

Heat rejection units

Information request issue

3.5.3. New-build, refurbishment and replacement market sectors

The three major market segments for central air conditioning systems and components are new buildings, existing building undergoing significant refurbishment and replacement of existing components (the study assumes that replacement of a complete system would be recorded as refurbishment). The study has figures for the relative importance of these for the six countries for which the study has market research reports and, within these countries for several important components. The aggregate figures for chiller-based systems are summarised below...

Table 2 - 15 . New build, refurbishment, replacement: chiller-based systems

	Chillers	FCU	VAV	Other terminal
New build	39%	48%	48%	60%
Refurbishment	32%	49%	52%	40%
Replacement	29%	3%	0%	0%

These aggregate figures conceal substantial difference between countries with, for example replacement chillers accounting for 52% of sales (by capacity) in Italy but only 6% in France. 67% chiller sales in France are reported as being refurbishment but only 12% in Germany. There are similar patterns for air handling units and terminal units. By the process explained in the modelling section of this report, the study has estimated the average service lives of chillers and air handling units. For Italy, Spain, Greece, France and Germany the average life of a chiller is between 18 and 20 years. For the UK the low reported replacement rate implies a life of 30 years – perhaps reflecting lower annual hours of use. Air handling units have longer implied lives, typically of around 30 to 35 years. There appears to be only a very small market for replacement terminals.

Figures for the same countries for air conditioners > 12 kW are shown below. Unsurprisingly, installation in existing buildings is more common than for chiller-based systems, though installation in new buildings is not uncommon (and is the largest sector for VRF and of equal importance to existing buildings for rooftops). Again, there are substantial differences between countries.

Table 2 - 16 . New build, refurbishment, replacement: air-conditioners > 12 kW

	Rooftops	Ducted splits	Single splits	Multisplits	VRF
New	38%	24%	36%	38%	55%
Refurbishment	38%	59%	49%	50%	41%
Replacement	24%	17%	15%	12%	4%

Regarding air conditioning condensing units, the study team would assume their use would be more or less correlated to the ones of AHUs in buildings heated and cooled by DX systems (others than rooftops). The distribution is thus likely to be a mix of the ones of split, multisplit and vrf systems.

3.6. MAIN PLAYERS

Re-branded products have been accounted by original manufacturer where possible. Companies have been identified as “major suppliers” if they have important market shares in the countries with the main markets. In some cases, other suppliers have significant market shares in particular countries or for specific products.

3.6.1. Air conditioners > 12kW and air conditioning condensing units

Room air conditioners > 12kW

There are at least 13 significant suppliers, and at least as many smaller ones.

The major suppliers are Daikin, Toshiba-Carrier, Mitsubishi Electric, Fujitsu and LG. Most products are manufactured outside Europe, although several of the major suppliers also manufacture in Europe.

Multi-split systems

The significant suppliers are essentially the same ones as for room air conditioners. The major suppliers are also the same: Daikin, Mitsubishi Electric, Fujitsu, Toshiba-Carrier, LG.

Again, most products are manufactured outside Europe

VRF systems

There are approximately 12 suppliers, of whom the major ones are Daikin, Mitsubishi Electric and Hitachi. Products are predominantly manufactured outside Europe.

Rooftop units

There are approximately 12 manufacturers, several of whom predominantly supply national markets.

The major Europe-wide suppliers are: Toshiba-Carrier, Trane, Lennox and York. This reflects the greater importance of rooftop units in North America, though production for the European market is divided between European and overseas manufacture.

Air conditioning condensing units

Air conditioning condensing units are supplied by air conditioner manufacturers, chiller manufacturers, large AHU manufacturers who may offer integrated cooling systems as options for AHUs and some compressor manufacturers.

3.6.2. Chillers

There are at least 20 suppliers of packaged chillers, some of whom offer very extensive ranges of product types and sizes, while others are more specialised.

The major suppliers are Toshiba-Carrier, Climaveneta, Trane and JCI (York). Much of the production is within Europe though the major suppliers also import some products.

Chillers and larger air conditioners are complex products requiring significant resources to develop, test and service.

Having said that, there are SMEs producing on demand products and specific designs not made by larger companies. This is the case of Thermal Engineering Systems Ltd in the UK[10]. Additional names may be identifiable via national trade associations. **Information request issue**

For chillers as for air conditioners, the market is competitive in the sense that a number of larger companies manufacture products targeted at the same market, and none of them has a dominant market share. (However, the chillers with the highest seasonal efficiencies appear to use the same proprietary technology under license).

3.6.3. Fan coils

There are at least 40 suppliers of fan coils. Most are also supplying either chillers and/or air handling units.

Although the fan coil unit market contains several large manufacturers, fan coil units are within the capabilities of SMEs to manufacture. It is likely that such manufacture would be aimed at relatively local markets and not be very visible on the European scene. The following manufacturers of fan coil units appear to be SMEs:

- Managair, ZA du Champ, F-01640, Jujurieux, France. www.managair.fr
- Eurapo srl, Via Malignani, 12 – Zona Ind Vllencello, 33170, Pordenone, Italy
- Advanced Air (UK) Ltd, PO Box 153, Burrel Way, Thetford Norfolk, IP24 3WB. UK www.advancedair.co.uk (also trades as Nailor Europe)
- BSB Engineering Services Ltd, Unit E, Tribune Drive, Trinity Trading Estate, Sittingbourne, Kent, ME10 2PG www.bsb-dampers.co.uk
- BPS Clima, Via Einstein, Fontane Di Villorba, Treviso, Italy. www.bpstecnologie.com
- Eca Technilogy S.P.A. 51, Via Dell'Industria 36040, Grisagnano Di Zocco (Vicenza) Italy www.ecatech.it
- Classic Coils Ltd, Anker St, Nuneaton, Warwickshire, UK CV11 4JL

3.6.4. Heat rejection units

Cooling towers main players in Europe for air conditioning are thought to be the same large international players than on other markets, Baltimore Coils, SPX Technologies, Evapco, and so on.

Dry cooler may be used for refrigeration and then cool directly a refrigerant or for cooling water in air conditioning systems. The AC products may then be provided either by refrigeration players as Alfa Laval, Asarums Industri, Searle, LU-VE, Heatcraft, Guntner and also by chillers' manufacturers as Lennox, Carrier, CIAT, and so on.

No SME could be identified.

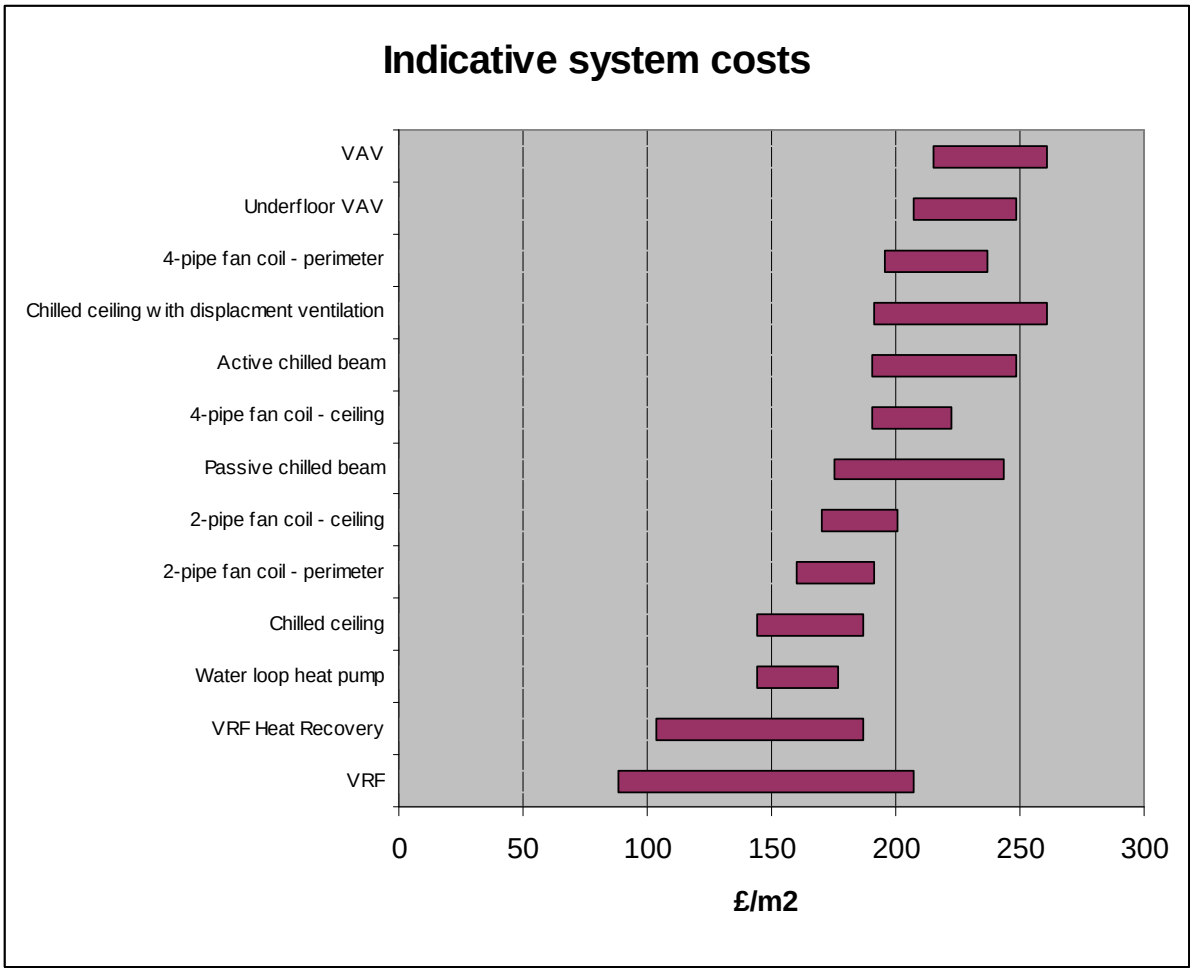
[10] www.thermal-eng.co.uk

4. SUBTASK 2.4 – USER EXPENDITURE BASE DATA

4.1. SYSTEM COSTS

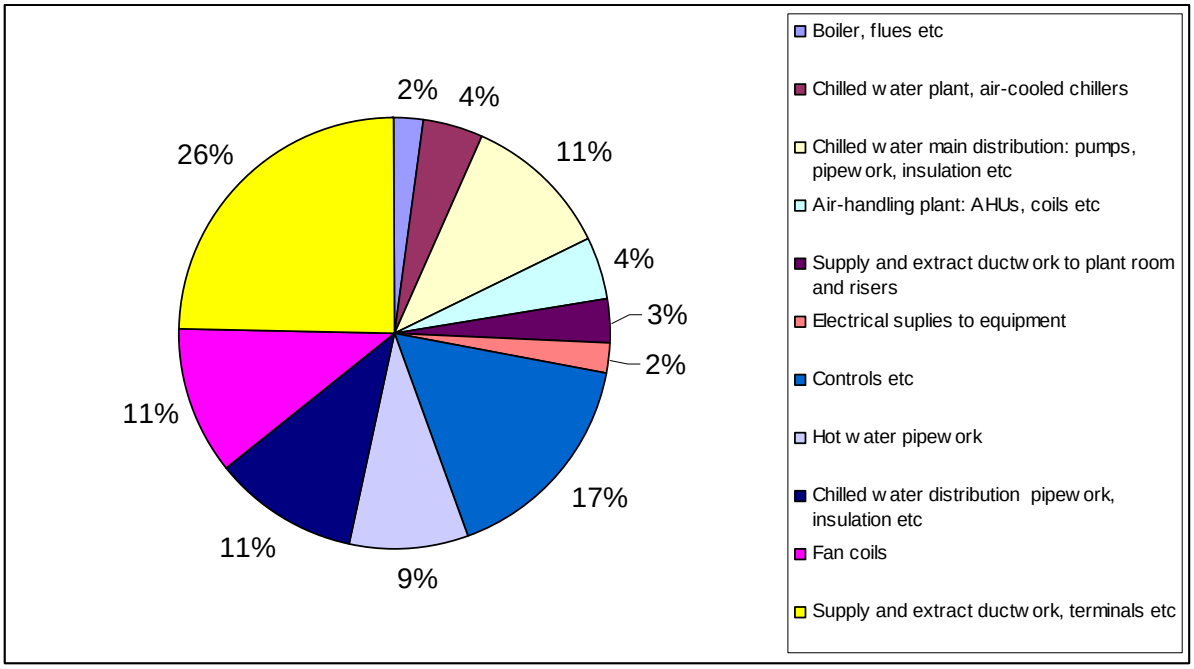
Air conditioning components can be used in many configurations of systems which differ in cost and energy efficiency and other characteristics. The chart below shows typical cost ranges for offices in the UK. The study has been unable to find similar data for other countries. **Information Request issue**
As can be seen, absolute costs for a given system type are often quite variable. At the time the exchange f rate was approximately 1.4 Euro = 1 £.

Figure 2 - 59 . Indicative system costs (2006, UK)



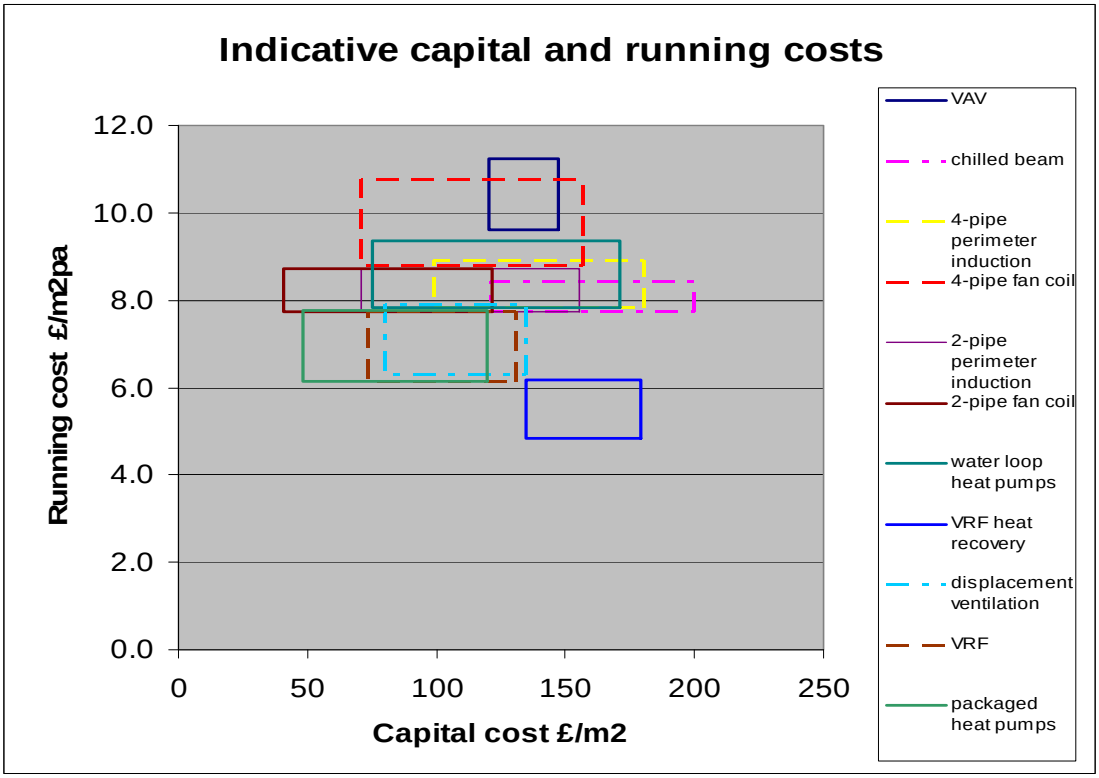
Much of the cost is associated with components that do not use energy directly. The chart below shows a cost plan for a 4-pipe fan coil system for an office in the UK. It can be seen that those components that directly use energy, account for only a small proportion of the system cost: 4% for the chillers, 4% for the air handling units and 11% for the fan coil units. Distribution systems (ductwork, chilled water pipework, heating pipework plant room equipment) accounts for nearly 2/3 of the system cost.

Figure 2 - 60 . Indicative cost breakdown: 4-pipe fan coil system



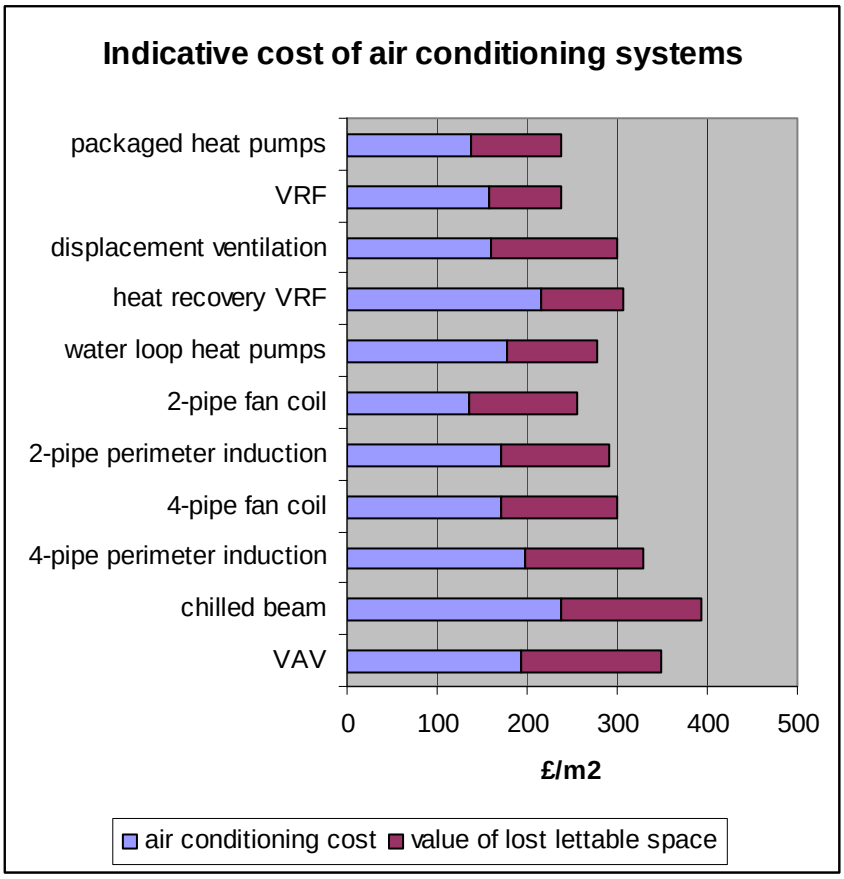
A further indication of the variation of capital and operating costs faced by potential investors for different system types is shown in the figure below, which is based on data provided by a large cost consultancy

Figure 2 - 61 . Indicative capital and running costs (UK 2008)



There are also indirect costs the figure below is based on published cost consultancy advice on the value of lost lettable space for different systems.

Figure 2 - 62 . Indicative direct and indirect capital costs (UK 2008)



4.2. PRODUCT PRICES

4.2.1. Statistical data at EU scale

From the market research reports, the study has average product prices for six countries (FR, DE, GR, IT, ES, UK). Prices are those faced by the initial purchaser from the manufacturer.

The study does not have up to date prices for rooftop units, VRF systems, multisplit systems or large split systems: the reported values are estimates obtained by uplifting older data.

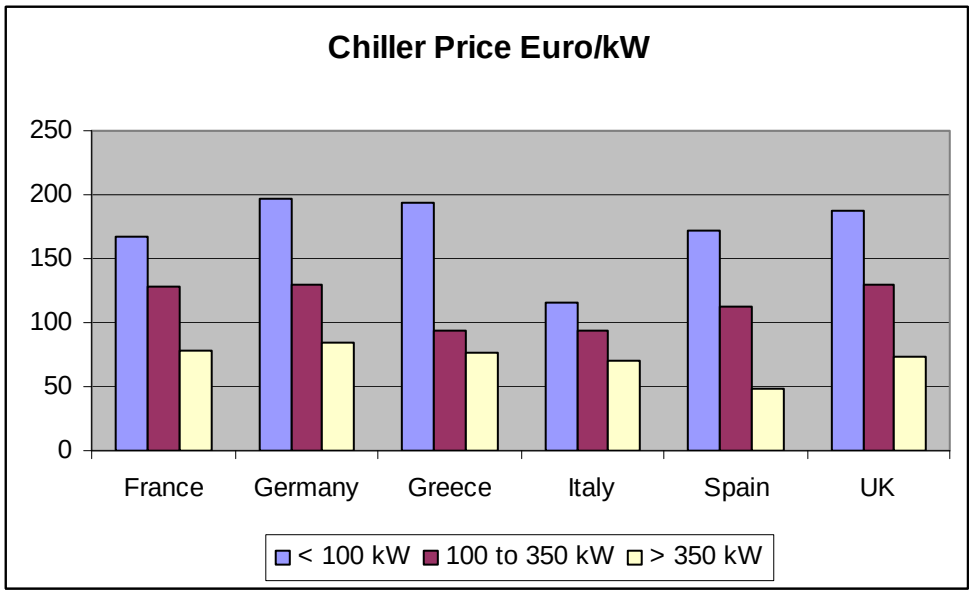
Comparisons are complicated by several factors that vary between countries:

- different product mixes, including chiller technologies, air handling unit sizes and configurations, fan coil specifications
- different discounting practices (discounting from list prices is very common, and the level of competitiveness in particular sectors varies between countries)

Chillers

There are significant differences of average sales price between countries. As can be seen, the cost per kW decreases systematically with chiller capacity, but varies appreciably between countries. France and Italy have sizeable markets for small chillers and the lowest prices for this category of product.

Figure 2 - 63 . Chiller Prices



According to German figures, air-cooled chillers are typically 30% to 40% more expensive than water cooled chillers. Screw chillers are 15% to 20% less expensive than scroll chillers except for water-cooled chillers of more than 500 kW capacity.

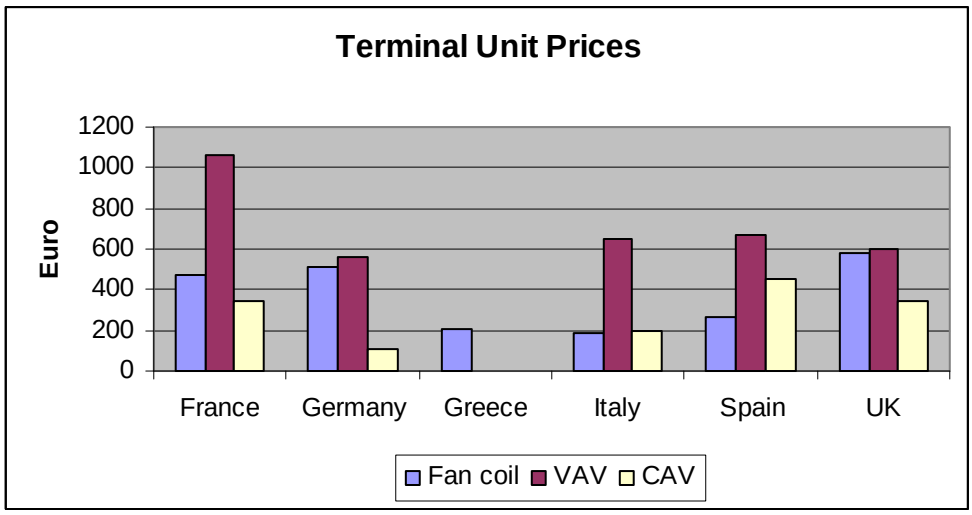
Prices for air conditioners > 12 kW and air conditioning condensing units

Market research data provide only limited data on prices of air-conditioning systems and do not specify the capacities of systems to which the prices refer. So for air conditioners and air conditioning condensing units, typical prices are to be extracted directly from manufacturer list prices.

Terminal units

There are clearly differences in prices between countries, but as the study has very little information on differences of product characteristic between countries, it is very difficult to explain them.

Figure 2 - 64 . Terminal Unit Prices



Heat rejection units

The study team currently has no statistical data at EU scale on prices of heat rejection units. So for rejection units, typical prices are to be extracted directly from manufacturer list prices.

4.2.2. Examples of manufacturer selling prices

The study team has some recent manufacturer's price lists at disposal (USA, UK or EU, 2010-2011), with prices expressed in $, £ or €. To convert all values into €, the chosen conventions are 1€/$1.3 and £1/1.2€. The derived figures are provided only as a matter of example. This data, completed with catalogues and statistical information, will be used in task 4 in order to estimate the manufacturer selling prices of specific base case products.

Most orders of magnitude of figures below are believed to be realistic (apart from some chiller ranges), as well as trends in price changes with nominal cooling capacities.

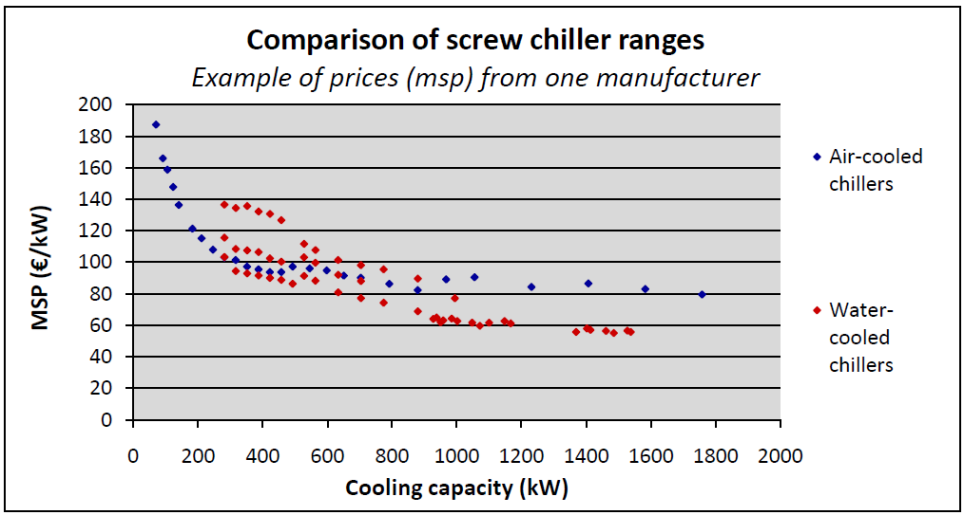
There is often a clear "power-law function" decreasing trend in prices per kW with an increase in cooling capacity (rooftops, cooling towers, fan-coils, indoor units of DX-systems, see below).

It is also worth noting that there is no systematic evidence that more efficient products with higher EER/SEER are more expensive than standard products, taking several manufacturers all together. However, there can be significant price differences between different product ranges of the same manufacturer, whose average products have different efficiencies. Hence, it is possible to read estimate price premium for a given efficiency level or technical option.

Chillers

Several ranges of one chiller manufacturer are compared. Water-cooled chillers seem to be slightly cheaper at high cooling capacities (above 500-600 kW) than air-cooled chillers, which somewhat matches statistical German figures reported before.

Figure 2 - 65 . Comparison of screw chiller ranges



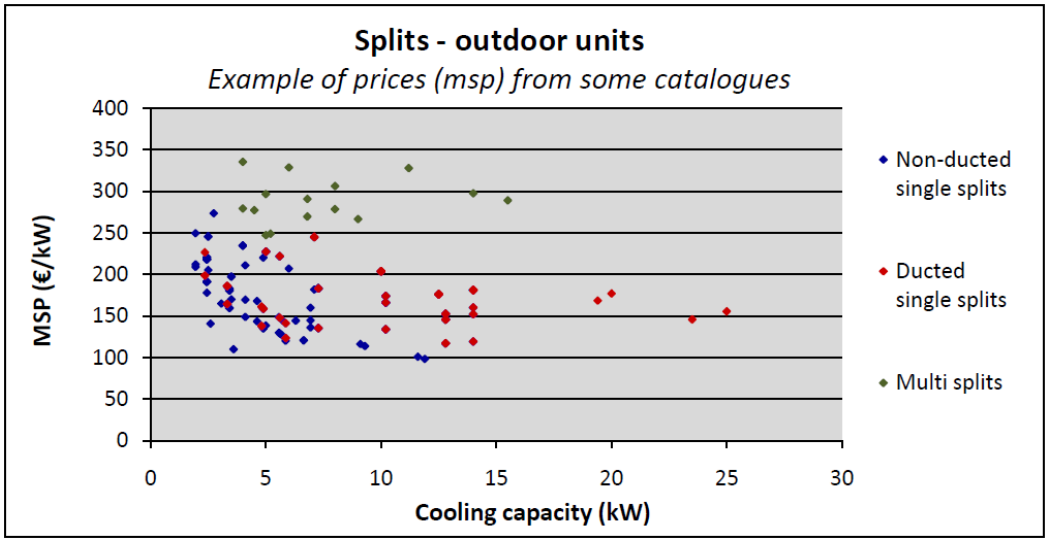
Air-to-air air conditioners

Split systems

Products from 3 main manufacturers, currently sold in the UK, are compared.

Note that outdoor units specific to multi split systems look more expensive than outdoor units used in single split systems. There does not seem to be a significant price difference between the outdoor units used in non-ducted single split and ducted single split systems.

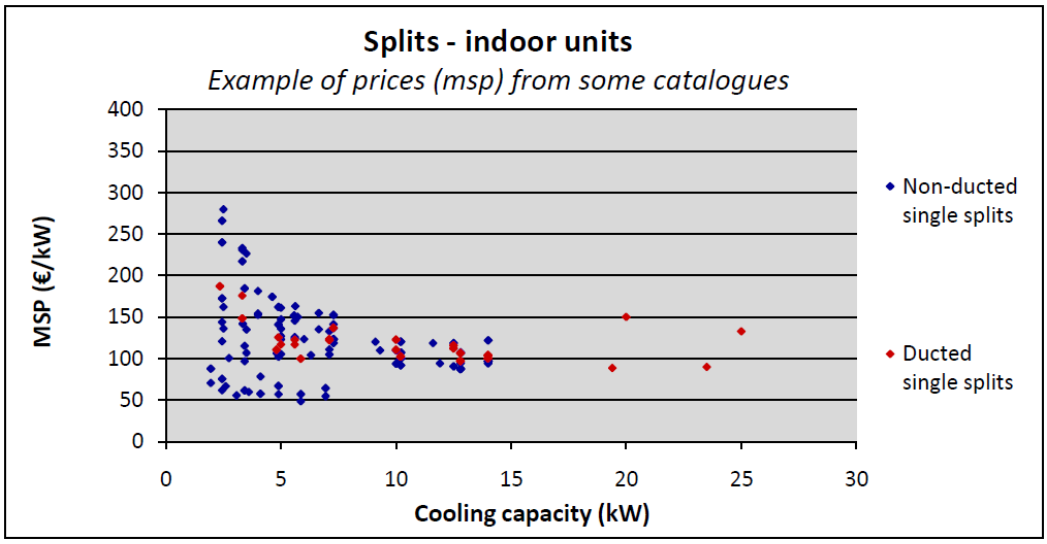
Figure 2 - 66 . Ranges of split systems sold in the UK – Outdoor units



Looking at indoor units, there are dramatic price differences depending on the mounting type: *floor-mounted/standing (concealed/unconcealed), high wall, ceiling suspended, cassette, ducted …* The same remark applies to fan-coil units, which have similar shape to indoor units of DX-systems, though to a lower extent. The most expensive mounting type is the cassette, the less expensive mounting type being generally the floor-mounted unit.

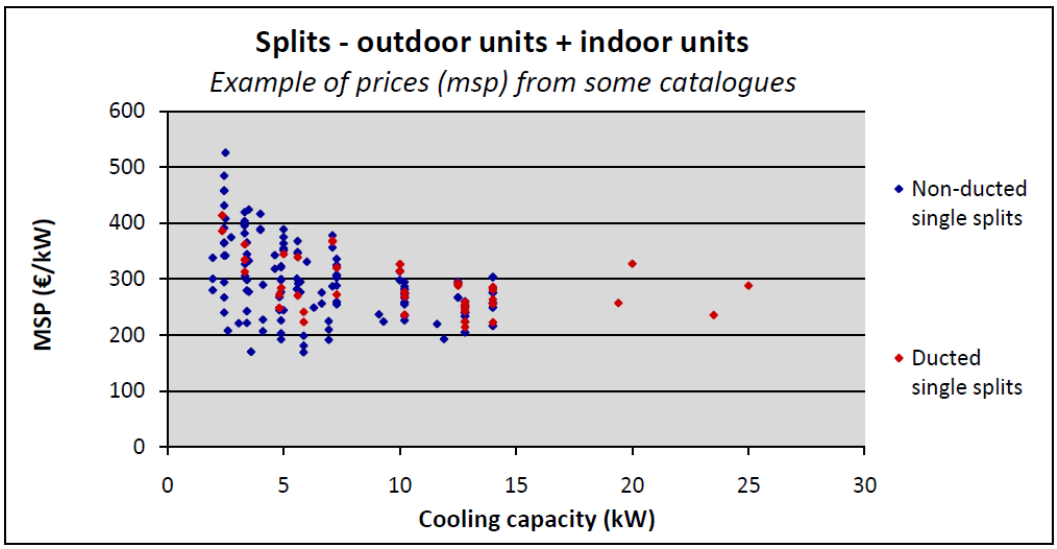
There is no significant price difference between ducted indoor units and simple ceiling suspended units.

Figure 2 - 67 . Ranges of split systems sold in the UK – Indoor units



Eventually, adding outdoor unit and indoor unit figures leads to the following plot, still with no significant difference between ducted systems and non-ducted systems.

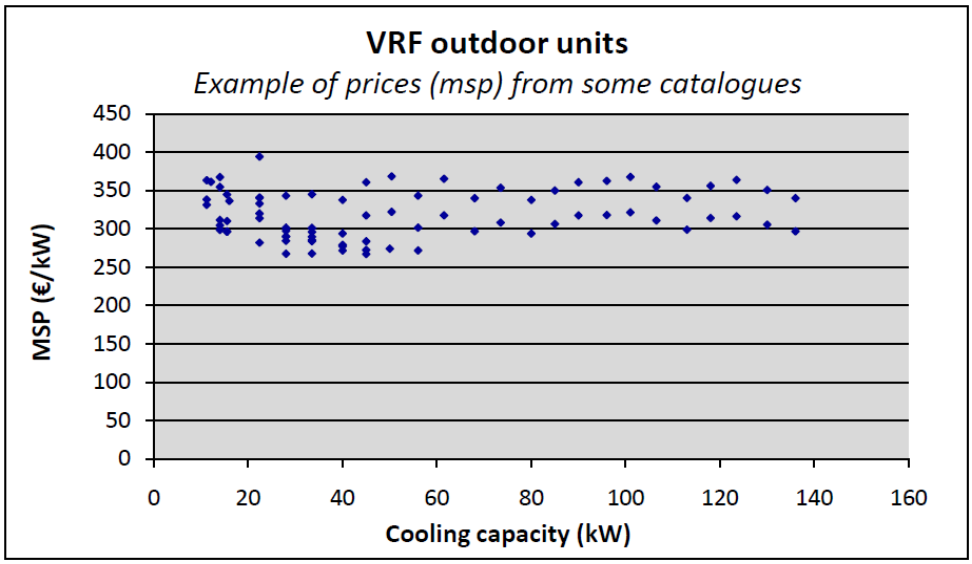
Figure 2 - 68 . Ranges of split systems sold in the UK – Outdoor units + Indoor units



VRFs

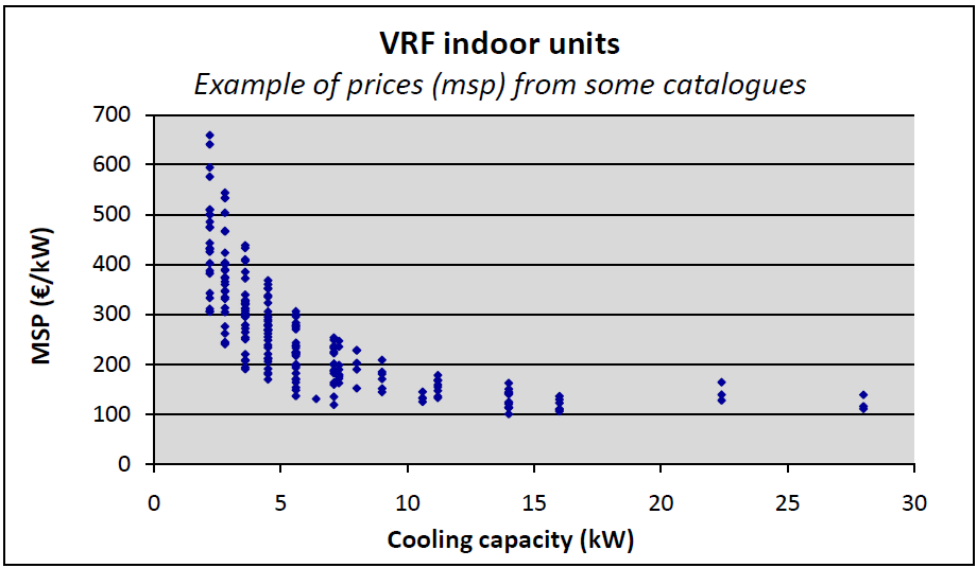
Contrary to split systems, there is not obvious decrease in price per kW with an increase in cooling capacity for VRF outdoor units. To reach for instance a 60 kW cooling capacity, some manufacturers tend in fact to join three identical units of 20 kW cooling capacity each. Similar practices might explain the reported figures.

Figure 2 - 69 . Ranges of VRF systems sold in the UK – Outdoor units



Same remarks than for split indoor units apply to VRF indoor units (there are no significant technological differences between them).

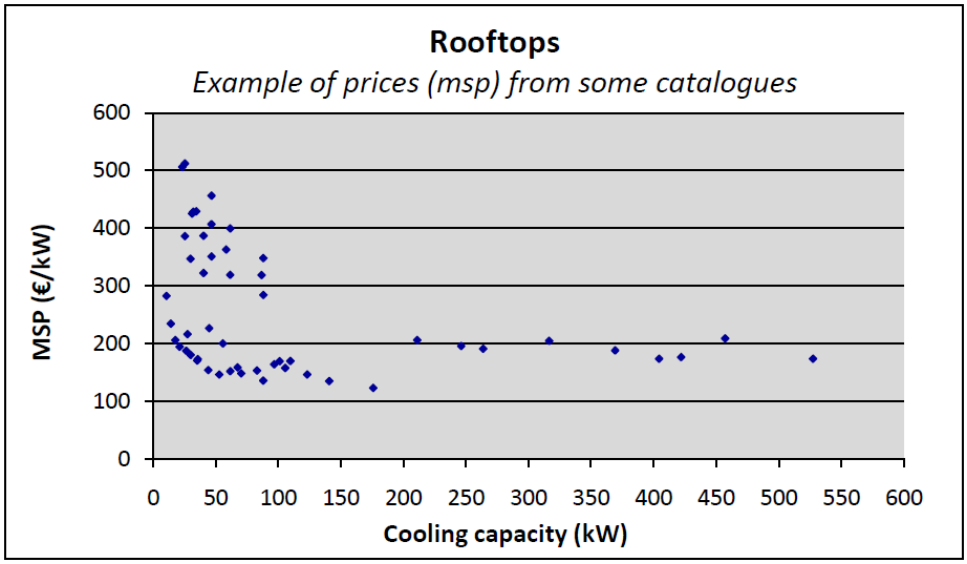
Figure 2 - 70 . Ranges of VRF systems sold in the UK – Indoor units



Rooftops

Three manufacturers are represented, from 2 EU price lists and 1 US price list. The US values are a bit lower, with present currency values.

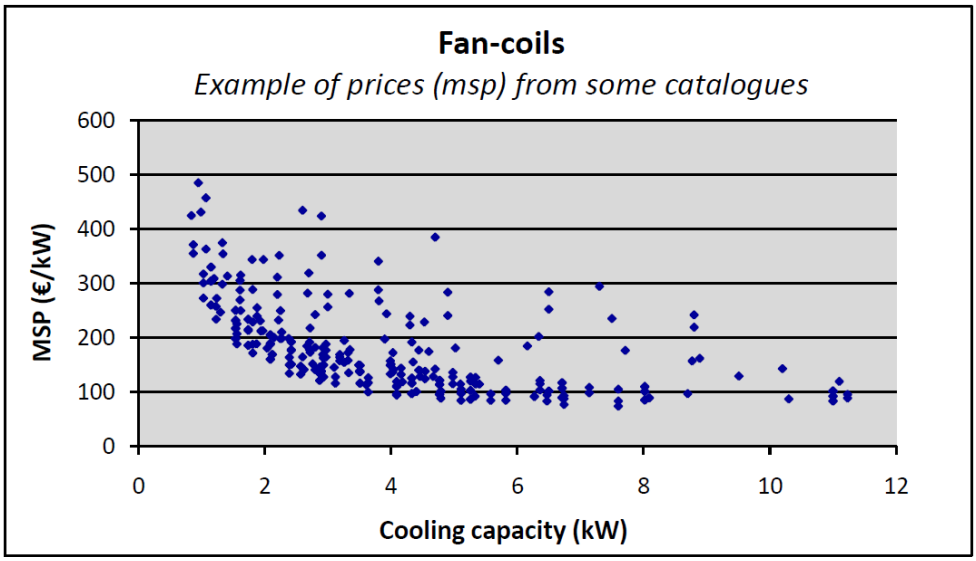
Figure 2 - 71 . Ranges of rooftops sold in the US and EU



Fan-coils

The study team thinks the reported fan-coil prices are more accurate, since the corresponding price lists are expressed in € and other known studies report similar values. The reasons behind price differences are the same than for DX-systems indoor units, with cassettes being more expensive than other mounting types. Ducted fan-coils have similar prices than non-ducted fan-coils.

Figure 2 - 72 . Ranges of fan-coils sold in the EU

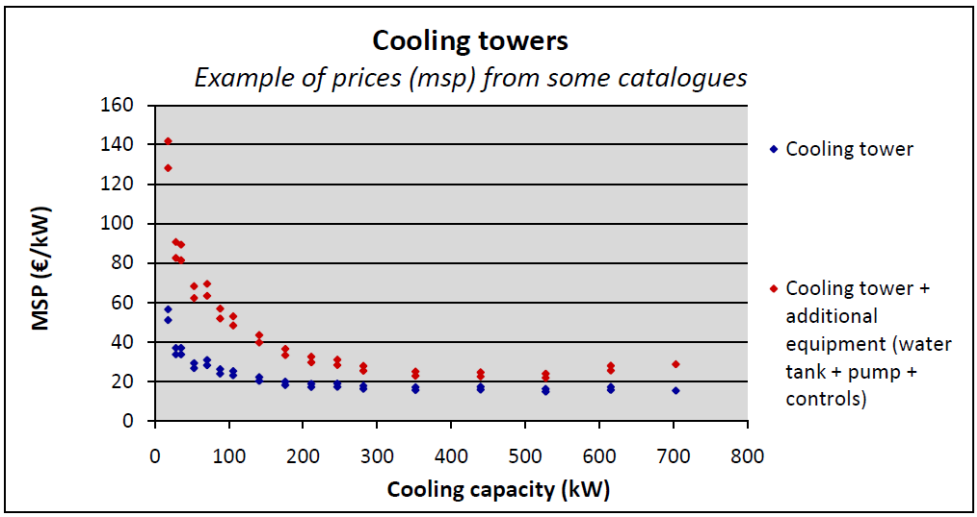


Heat rejection units

Cooling towers

The cooling tower market has been decreasing in the EU to the benefit of dry coolers. The few data at the team's disposal comes therefore from US price lists (2 manufacturers), with the guess that equivalent products sold in the EU might be more expensive (to what extent is unknown).

Figure 2 - 73 . Ranges of cooling towers sold in the US

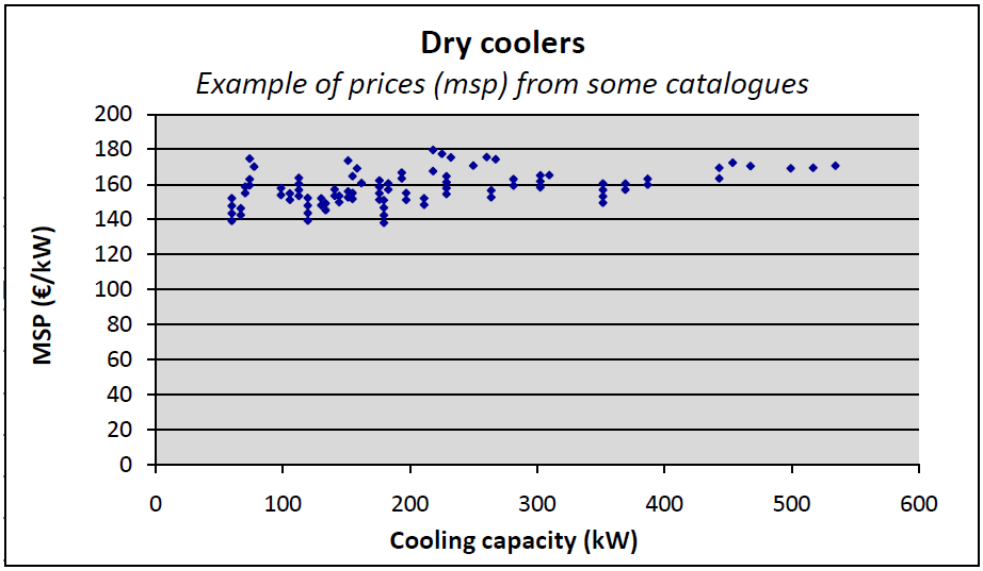


Dry coolers

There are only a few major dry cooler manufacturers in the EU (as registered in Eurovent's database), each one having probably large market shares. The study team does not have price lists from these manufacturers and derives figures from the USA. Interestingly, msp per kW do not vary with the cooling capacity. Dry coolers are indeed modular products, made of more or less long fin-and-tube heat exchangers in combination with axial fans. Increasing the cooling capacity of a dry cooler is simply done by adding more modules (one module being one "piece" of heat exchanger with one fan).

There are huge price differences between cooling towers and dry coolers, with more data being needed to refine current results.

Figure 2 - 74 . Ranges of dry coolers sold in the US



4.3. REPAIR AND MAINTENANCE COSTS

Other running costs relate to repair and maintenance and including the cost of replacing refrigerant that has leaked from the system. According to en 15459:2009 annual preventative maintenance

including operation, repair and servicing costs for air conditioners are typically 4 % of the initial investment (including installation costs).

4.4. DISPOSAL COST

The study has no product-specific information on disposal costs, but typical UK prices for disposal of this type of product are around €33 (£40) for up to 100 kg.

The study would like to receive relevant information from other countries **Information Request Item**

4.5. ENERGY AND WATER TARIFFS

The tables below summaries energy prices from Eurostat Country-specific prices are also available in Eurostat. Almost all air conditioning units use electricity but prices for other fuels may be relevant.

Table 2 - 17 . Summary of Energy Prices

Energy Prices and Trends from Eurostat				
	Small users (3500 kWh/a)		Industrial/larger commercial users	
	Price	***Explanation***	***Price***	***Explanation***
Electricity	0,152	Electricity rate 1.1.2006 [€/ kWh electric] Eurostat	0,107	Electricity rate 1.7.2009[€/ kWh electric] Eurostat
	0,164	Electricity rate 1.7.2009[€/ kWh electric] Eurostat	2%	Electricity annual price increase
	2%	Electricity annual price increase	0%	Electricity annual price inflation corrected (2%)--> constant prices 2005
	0%	Electricity annual price inflation corrected (2%)--> constant prices 2005		
Gas	0,047	Gas rate 2005 [€/ kWh primary GCV]	0,0216	Gas rate 2005 [€/ kWh primary GCV]
			0,0388	Gas rate 2009 [€/ kWh primary GCV]
Oil	0,061	Oil rate 2005 [€/ kWh primary GCV]	0,044	Oil rate 2009 [€/ kWh primary GCV]
Average heating	0,053	2005 average space heating mix rate [€/ kWh primary GCV] : rates as above, weighting at 76% gas, 21% oil, 3% electric	0,036	2005 average space heating mix rate [€/ kWh primary GCV] : rates as above, weighting at 76% gas, 21% oil, 3% electric
	0,058	[€/ kWh primary GCV];		
Rate of increase	7,30%	Eurostat official annual fuel price increase July 2007-July 2009. Note that avg. annual fuel price increase over period Jan 2006-July 2009 from 14,7 to 16,21 €/GJ was higher, at 9%. But Eurostat was used.	9,30%	Eurostat official industrial gas price increase 2005-2009 is from 6,01 to 9,40 EUR/GJ. This is an average annual increase of 9,3%
	5,30%	Fuel annual price increase inflation corrected (2%) --> constant price 2005	7,30%	Fuel annual price increase inflation corrected (2%) --> constant price 2005
2018 reference	28,5	[€/ GJ primary GCV]= € 0,102/kWh; Used in LCC-calculations. Fuel price halfway product life, starting 2010/2011	19,9	[€/ GJ primary GCV]= € 0,102/kWh; Used in LCC-calculations. Fuel price halfway product life, starting 2010/2011

Currently the average EU water price incl. sewage tax is estimated at € 3,70 / m3, with an annual nominal growth rate of 2,5% (equal to inflation) (VHK, 2011). Information is scarce and figures are not available for all countries.

4.6. DISCOUNT RATES

The same hypothesis as mentioned in the ventilation task 2 report of May 2010 are used. An extract is made below.

In an LCC calculation running costs have to be discounted to current prices, using the Present Worth Factor PWF. For the calculation of PWF the following long-term rates are relevant:
- Inflation rate 2%;
- Interest rate 6%;
- Discount rate= interest minus inflation = 4% (parameter r).

The equation for PWF is PWF= {1 – 1/(1+r)N}/r . And it is used in the life cycle cost calculation with the general format LCC= PP + PWF*OE, where PP is the purchase price and OE is the annual operating expense.

CONCLUSIONS

The study understands that the most important task 2 information table for ecodesign policy makers are the projected stock and sales figures by number of units. These are summarised below.

Sales figures are for units sold, based on market research for historical data and modelling projections for future years. They include both new installations (in both new and existing buildings) and replacements.

Figure 2 - 75 . Estimated sales of air conditioning units

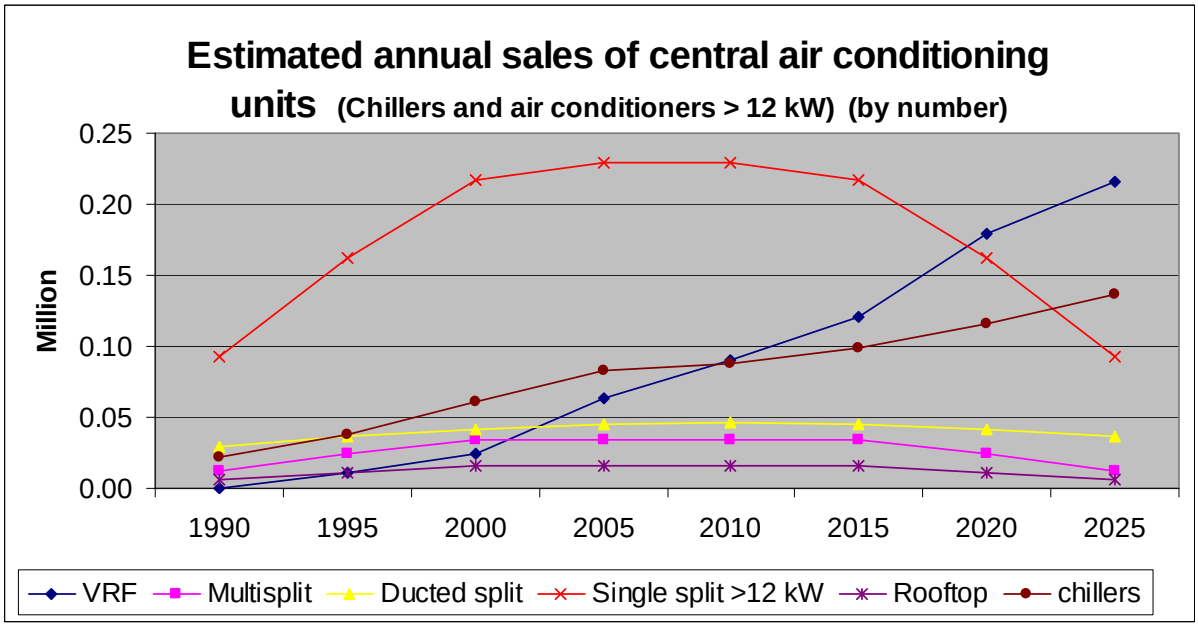


Table 2 - 18 . Estimated Sales of Air Conditioning units

Estimated Annual Sales of Air Conditioning Units (Millions)								
Year	1990	1995	2000	2005	2010	2015	2020	2025
Ducted splits > 12 kW	0.030	0.036	0.042	0.045	0.046	0.045	0.042	0.036
Single splits > 12 kW	0.093	0.162	0.217	0.230	0.230	0.217	0.162	0.093
Multisplits > 12 kW	0.012	0.024	0.034	0.034	0.034	0.034	0.024	0.012
VRF > 12 kW	0.000	0.011	0.024	0.063	0.090	0.121	0.179	0.216
Rooftops > 12 kW	0.006	0.011	0.015	0.016	0.016	0.015	0.011	0.006
Chillers	0.023	0.038	0.061	0.083	0.087	0.098	0.116	0.137

Regarding terminal units, sales of fan coil units in 2008 amounted to 1.1 million with an aggregate cooling capacity of 2.7 GW . This is 27% of the aggregate cooling capacity of chillers sold in the same period. Unlike chillers, sales of fan coil units have been gradually falling from a 2002 peak value of 1.32 million. Other terminal units represent sales of about 150000 units in 2008.

The historical and projected sales figures for fan coils are reported below:

Table 2 - 19 . Estimated Sales of fan coil units

	Estimated annual sales of fan coil units (Millions)							
Year	1990	1995	2000	2005	2010	2015	2020	2025
	0.55	0.88	1.41	1.34	1.91	1.10	0.55	0.26

The sales figures for new installations result in estimated stock figures as shown below.

Figure 2 - 76 . Estimated stock of air conditioning units

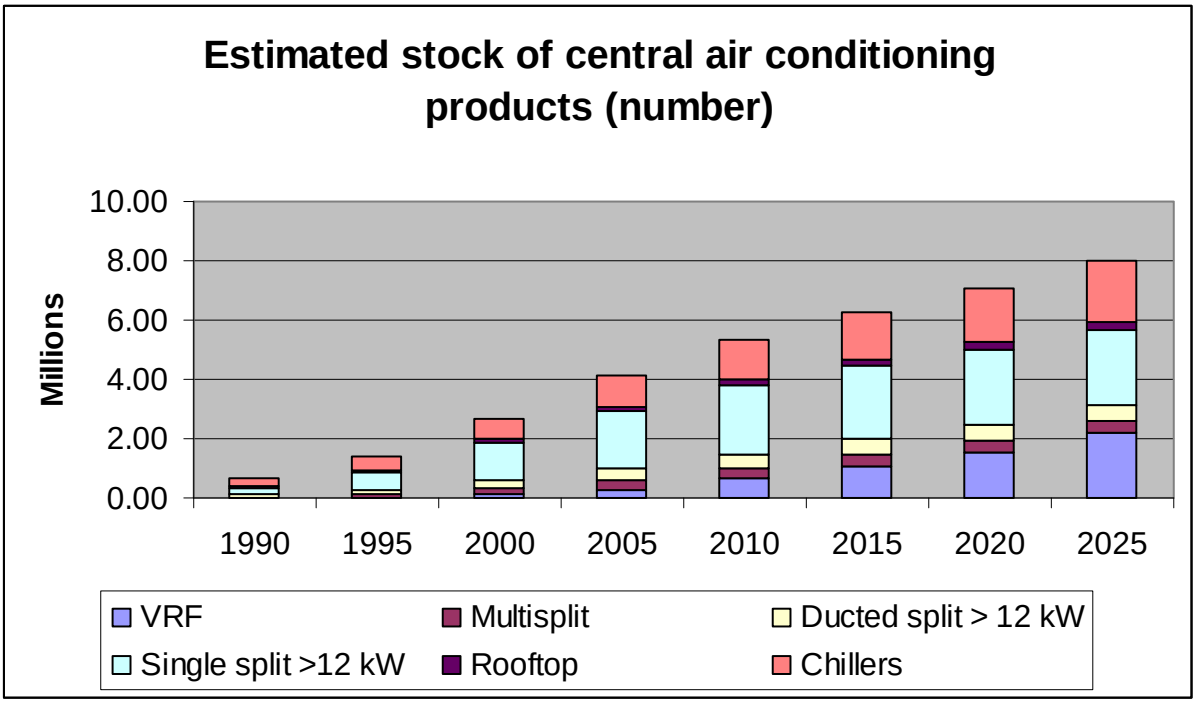


Table 2 - 20 . Estimated Stock of Air Conditioning units

Estimated Stock of Central Air Conditioning Units (Millions)								
Year	1990	1995	2000	2005	2010	2015	2020	2025
VRF	0.000	0.022	0.107	0.256	0.634	1.046	1.535	2.173
Multisplit > 12kW	0.026	0.086	0.209	0.332	0.392	0.411	0.417	0.418
Ducted split > 12 kW	0.094	0.173	0.278	0.384	0.463	0.511	0.535	0.547
Single split > 12kW	0.233	0.615	1.278	1.942	2.324	2.478	2.531	2.548
Rooftops > 12 kW	0.027	0.061	0.114	0.166	0.200	0.217	0.223	0.226
Chillers	0.268	0.428	0.688	1.028	1.325	1.590	1.824	2.060

In terms of energy consumption, installed capacity is important. Because chillers have substantially larger cooling powers per unit than the other system types, on this measure they are substantially more significant. (Figures are presented earlier in this report).

The general picture is of continuing growth in stock, though (in capacity terms) at decreasing rates. However, there are substantial differences in the markets in different Member States. An increasing proportion of product sales will be for replacement.

Many of the products are reversible. The table below shows the current proportions by number. Anecdotally the proportions have been increasing. Although 47% of chillers are reversible, these are predominantly low capacity units and the proportion by capacity is only 16%.

Table 2 - 21 . Reversibility of Products

Product	Percentage reversible (by number)
Chillers	47% (16% by capacity)
Ducted split systems > 12 kW	82%
Unducted split systems > 12 kW	66%
Multisplit systems	64%
VRF systems	88% (includes those with heat recovery)
Rooftops	62% (an additional 11% have gas heating function)

Most air conditioning chillers are packaged units with integral air-cooled condensers. Sales of water-cooled and condenserless chillers amounted to 10.6 thousand units with an aggregate cooling capacity of 2.3 GW. Each of these will have associated heat rejection equipment in the form of cooling towers or separate dry condensers.

For terminal units – fan coil units -, the historical and projected stock figures are reported below.

Table 2 - 22 . Estimated Stock of fan coil units

	Estimated stock of fan coil units (Millions)							
Year	1990	1995	2000	2005	2010	2015	2020	2025
	10.07	14.34	18.75	22.97	24.31	24.99	25.34	25.51

TASK 2 REFERENCES

Bass model, http://bassbasement.org/BassModel/Default.aspx

BSRIA historical product sales data Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Portugal, Spain, Sweden, United Kingdom. Covers 1992 to 2009.

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