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Energy-Using Product Group Analysis/2

Lot 6: Air-conditioning and ventilation systems

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Draft Report Task 2

Market on Ventilation Systems for non residential and collective residential applications

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Contents

1 Introduction

1.1 Scope

The Task 2 report on Air Conditioning is issued separately. Wherever there is an overlap –i.e. for Air Handling Units—data between the two reports are harmonized.

Definitions of 'ventilation', 'ventilation systems', ventilation products are given in the Task 1 report of the underlying study. In the underlying Task 2 report some of these may be summarized to improve readability, but the definitions in the Task 1 report prevail.

In the Task 3 report further clarification will be given on the functionality of various ventilation systems (systems A, B, C, D, E), especially as regards their functionality in meeting consumer demands.

Typically the ventilation products in the scope are as defined in task 1:

- Air Handling Units (AHU's);
- Central balanced (heat recovery) ventilation units CHRV with >125 W fans;
- Rooftop/boxed exhaust or supply ventilation units >125 W.

where the difference between AHU and CHRV is definitely a 'grey area', determined by the fact whether the units would be fit for mounting a heating/cooling coil or not.

Note that data availability on ventilation systems is extremely poor, therefore Task 2 employs and reports on all relevant information necessary both for a 'top-down' approach (e.g. starting from building stock and demand parameters) and a 'bottom-up' approach (from component level) to generate plausible data-sets on sales and stock. As such natural ventilation systems, local exhaust ventilation units, local balanced ventilation units with or without heat recovery will be discussed. This should not be interpreted as a sign that all these issues will be subject to new Ecodesign measures; they are mere intended to enhance the analysis.

It also means that intermediate data will not always be coherent and consistent. Different sources will have (widely) diverging views on the amount of ventilation units installed or sold, but in a 'data-poor' environment even incomplete and anecdotal information can help. Annex A, for example, gives a more detailed discussion on how data sources were used.

1.2 Task 2 and subtasks

The aim of Task 2 is to place the product group within the total of EU industry and trade policy (subtask 2.1). To provide market and cost inputs for the EU-wide environmental impact of the product group (subtask 2.2). To provide insight in the latest market trends so as to indicate the place of possible Eco-design measures in the context of the market-structures and ongoing trends in product design (subtask 2.3, also relevant for the impact analyses in Task 3). And finally, to provide a practical data set of prices and rates to be used in a Life Cycle Cost (LCC) calculation (Subtask 2.4).

Task 2 should be executed following the MEEuP methodology report[1] and comprises the following subtasks:

Subtask 2.1 Generic economic data

- EU Production;
- Extra-EU Trade;
- Intra-EU Trade;
- Apparent EU-consumption.[2]

Data should relate to the latest full year for which at least half of the Member States have reported. Preferably data should be in physical volume and in money units and split up per Member State.

Information for this subtask should be derived from official EU statistics so as to be coherent with official data used in EU industry and trade policy.

Subtask 2.2 Market and stock data

In physical units, for EU-25, for each of the categories as defined in 1.1 and for reference years

- 1990 or 1995 (Kyoto ref.);
- 2003-2005 (most recent real data);
- 2010-2012 (forecast, end of Kyoto phase 1, relevant also for Stockholm, etc.);
- 2020-2025 (forecast, year in which all new eco-designs of today will be absorbed by the market).

The following parameters are to be identified:

- Installed base ("stock")[3] and penetration rate;
- Annual sales growth rate (% or physical units);
- Average Product Life (in years), differentiated in overall life time and time in service, and a rough indication of the spread (e.g. standard deviation);
- Total sales/ real EU-consumption[4], (also in €, when available);
- Replacement sales (derived);
- New sales (derived).

Subtask 2.3 Market trends

- Latest consumer tests (anecdotal, not necessarily valid for the whole of the EU);
- Description of the market and production structure and identification of the major players;
- General trends in product-design and product-features.[5]

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[1] VHK 2005.
[2] Calculated from production, imports and exports. If available, changes in product stock should be taken into account, but usually this will not be the case.
[3] Forecasts are to take into account population growth rates and/or building growth rates
[4] The objective is to define the actual consumption as reliably as possible for the categories defined in task 1.1, for the latest full year for which consistent data could be retrieved. Significant differences between the actual consumption and the apparent consumption in subtask 2.2 may occur.
[5] From the marketing point of view, not from the perspective of a detailed technical analysis

Subtask 2.4 Consumer expenditure base data

For each of the categories defined in Task 1:

- Average consumer prices, incl. VAT, in Euro.

Determination of applicable rates for running costs and disposal, per EU Member State, specifically[6]:

- Electricity rates (€/ kWh);
- Water (and sewage) rates (€/m³);
- If applicable: fossil fuel rates (€/ GJ);
- Consumer prices of other consumables (detergent, toner, paper, etc.) (€/kg or €/piece);
- Repair and Maintenance costs (€/product life);
- Installation costs (for installed appliances only);
- Disposal tariffs/ taxes (€/product);
- Interest and inflation rates (%).

The following report follows the MEEuP structure, using 1 chapter per subtask.

[6] Note that a part of these data could be harmonised for all product groups.

2 Generic economic data

2.1 Introduction

Official statistics on the production, sales and trade for 'ventilation units' or 'ventilation systems' do not exist. Eurostat (Prodcom, External trade) and the national statistics offices classify ventilation units/systems either as *'fans'*, characterized by their technical typology (axial, centrifugal, etc.) or a size characteristic (>125 W/<125 W; >300 Pa/<300 Pa), or as '*Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units' (Prodcom 28251270)*.

For 'fans' this means a complete mix-up of ventilation units intended for end-users with OEM-fans intended to be built into boilers (combustion fans), chillers (e.g. condenser fans), laundry driers, ovens, fan-coils, etc.. For the Prodcom 28251270 category the ventilation devices (AHU's) are mixed up with large quantities of non-ventilation devices (most fan-coils, terminals, etc.).

2.2 AHU's and CHRV units

2.2.1 Products/systems

As mentioned the production air handling units (AHU's) and probably also central heat recovery ventilation (CHRV) units will be included in Prodcom category (NACE Rev. 2) *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.* These Eurostat production statistics per EU Member State are given in **Table 1** (unit production) **and 2** (value production) for the available period 2003-2009.

For extra-EU trade the CN8 categories 84158300 and 84158390 apply, with description *Air conditioning machines comprising a motor-driven fan, not incorporating a refrigerating unit but incorporating elements for changing the temperature and humidity (excl. of a kind used for persons in motor vehicles, and self-contained or "split-systems")*. The combined results of EU-27 production and extra-EU imports and exports in the period 2003-2009 are given In **Table 3**, also featuring a calculation of the apparent consumption (production + imports - exports).

The conclusion is that the EU-industry holds a relatively strong position in the above mentioned product groups, with Italy (mostly FCU's[7]) and Germany (mostly AHU's) accounting for 62% of the value. EU-27 production in 2009 was 1,3 mln. units at a value of € 1,7 bln. for the above mentioned product groups. Export value amounts to € 0,33 bln. and imports account for € 0,21 bln.

The apparent consumption in 2009 was 0,6 mln. units at a value of € 1,56 bln.. As mentioned, the value of these absolute figures is limited, due to the very heterogeneous nature of the product group. They constitute a maximum value.

But also the reliability of the trends seems limited. The 2009 figures clearly show a 20-30% decrease in unit production with respect of 2008 as a result of the economic crisis. But production value remained fairly stable, mainly due to an unexplainable surge in Italian unit values. Also the sudden

[7] Fan Coil Units

30% decline in unit production (at little effect to the production value) between 2006 and 2007 is difficult to explain and puts into question the reliability of the data.

Table 2 - 1. EU Production volume of non-cooling AC units, AHU's, VAV Boxes, CAV boxes and FCU's, in units x 1000 (Eurostat 2010, PRODCOM)

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

year	EU27	BU	CZ	DK	DE	IRE	ES	FR	IT	LT	HU	NL	AT	PL	PT	FIN	SV	UK
2009	1284	1	124	45	77		36	37	709	4	8		3	50		76	54	25
2008	1716	1	185	53	99		18	22	1038	6	11		3			102	66	29
2007	1837	1	160	79	88	49	27		1119	5	11		3				56	32
2006	2582	0		72	94		29		1208	5	8	4	3	4			18	34
2005	2341	0	260	62	81		71	111	1050	0	7	3	3		1	83	23	22
2004	2200	0	222	15	69		81	132	861	0	8			17	1			23
2003	1919	0		34	70		61		767	0	8	0		16	1	71		32

NOT SHOWN (data not available or 0): BE, EST, EL, CY, LV, LU, MA, RO, SL, SK

Table 2 - 2. EU Production value of non-cooling AC units, AHU's, VAV Boxes, CAV boxes and FCU's, in mln. Euro (Eurostat 2010, PRODCOM)

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

year	EU27	BU	CZ	DK	DE	IRE	ES	FR	IT	LT	HU	AT	PL	PT	FIN	SV	UK
2009	1681	1	29	77	429		36	54	617	3	9	43	38		64	158	61
2008	1716	1	41	93	480		27	55	474	5	9	49	23		87	198	86
2007	1688	1	33	121	416	13	30	79	478	4	9	45	20		93	185	99
2006	1531	1	28	110	397	21	28	84	474	3	2	38	7		72	104	99
2005	1253		30	85	340	19	46	103	267	0	3	36	12	2	66	83	93
2004	1270		22	90	352	19	54	122	240	0	3		11	2	62	72	92
2003	1474		14	68	645	20	51	94	236	0	1		12	2	60	72	107

NOT SHOWN:

BE, EST,CY, LV, LU, MA, RO,SL, NL, SK (data not available or 0); note that estimates for these countries are included in EU-27 total

Table 2 - 3. Production and extra-EU trade 'non-cooling' air conditioning (incl. AHU)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		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									
PRODUCTION	x 1000 units				1919	2200	2341	2582	1837	1716	1284
	x mln. Euro				1474	1270	1253	1531	1688	1716	1681
		84158300 & 8390 Air conditioning machines comprising a motor-driven fan, not incorporating a refrigerating unit but incorporating elements for changing the temperature and humidity (excl. of a kind used for persons in motor vehicles, and self-contained or "split-systems")									
IMPORT	x 1000 units	19	24	27				124	259	***400****	533
	x mln. Euro	224	203	158	165	9	250	254	357	274	207
EXPORT	x 1000 units	93	72					766	1565	1405	***1200****
	x mln. Euro	179	190	228	185		240	270	344	390	328
APPARENT CONSUMPTION	x 1000 units							1939	531	710	617
	x mln. Euro				1454		1262	1516	1701	1600	1559

*=VHK estimates (original Eurostat values contain comma errors for Italy)

2.2.2 Parts

Other relevant Eurostat statistics in this context relate to AHU modules that are manufactured as Prodcom category *28253010: Parts for air conditioning machines (including condensers, absorbers, evaporators and generators)* and that are traded as CN8 categories *84159000 and 84159090: Parts of air conditioning machines, comprising a motor-driven fan and elements for changing the temperature and humidity, n.e.s..* Production statistics per EU Member State are given in **Table 4.** EU-27 trade and apparent consumption data are given in **Table 5**.

The most important conclusion is that the production value (€ 1,7 bln. in 2009) and apparent consumption (€ 1,6 bln. in 2009) are in the same order of magnitude as those of complete airco units without refrigeration PRODCOM 28251270 (€ 1,7 bln. in 2009), discussed in the previous section. And even if we extend this latter with the production value of complete airco units with refrigeration PRODCOM 28251250 (€ 1,74 bln. in 2009, see AC Task 2 report), the parts production is still 50% of the value of complete systems/products. The main reason behind this is probably the fact that air-conditioning systems rarely get replaced as a whole. As mentioned in the AC Task 2 study, their product life 'as a system' may be as long as 30-35 years. But the product life of individual components, such as ventilation modules and heat exchanger modules in an AHU, is typically only 15-20 years.[8] One might classify this as 'repairs', but actually 'replacement sales' would be more appropriate.

The statistics show Germany to be the absolute market leader in this segment (35% of production), but also the Czech Republic, Italy, Sweden, Finland and Slovakia have a significant share in the production. Exports (€ 0,6 bln.) and imports (€ 0,5 bln.) are more or less balanced.

The value of these statistics for the purpose of the underlying study is again very limited, given the mix with non-ventilation products, but at the moment it is the best that Eurostat can offer.

Table 2 - 4. Production Value in mln. EURO, Parts of AC machines (PRODCOM, Eurostat 2010)

	EU27	BE	BU	CZ	DK	DE	IRE	ES	FR	IT	LT	HU	NL	AT	PL	PT	SK	FIN	SV	UK
	28253010 Parts for air conditioning machines (including condensers, absorbers, evaporators and generators)																			
2009	1703		4	254	6	603	4	112	20	167	2	61		19	14	3	61	92	124	54
2008	1985		8	339	9	771	14	127		113	1	70		25	15	3	53	116		80
2007	2073		4	471	9	737	13	174		102	2	66			16	3	24	103		124
2006	1850		4	404	7	694	11	205		76	2	48				5	14	91		117
2005	1563	29	3	303	17	641	12	180	7	57	2	42	15	15		5	12	87	8	113
2004	1444	30	0	119	8	708	17	173	7	65		15		25	6	7	14	105	7	116
2003	1360	24	0	35	10	459	19	473	7	44		9		16	1	7	8	91	8	140

NOT SHOWN: EST, EL, SL (1 mln.); CY, LV, LU, MA, RO (0 mln.)

Note that the above parts cover only a small part of the extra installation materials. The most important materials, also in money terms, are in the air duct-system. Unfortunately, Eurostat PRODCOM does not specify, e.g. within section 24, which tubes and sheets are produced as air ducts and therefore no figures can be presented here. The same can be said about other parts of the duct system: vibration isolators (a.k.a. attenuators, 'isolating' AHU from ducts), take-offs (first divider after AHU), plenums (dividers further downstream), risers/stacks (vertical tin and wide or oval ducts), dampers, terminal units (e.g. VAV boxes), grills and diffusers. The part that deals specifically with ventilation controls is also not shown in PRODCOM.

[8] The FGK supplementary study 2010 on ventilation systems <125 W mentions 17 years as an overall average.

Table 2 - 5. Production and trade, Parts for air conditioning machines

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		28253010 Parts for air conditioning machines (including condensers, absorbers, evaporators and generators)									
PRODUCTION	x 1000 units				na	na	na	na	na	na	na
	x mln. Euro				1360	1444	1563	1850	2073	1985	1703
		84159000 & 9090 Parts of air conditioning machines, comprising a motor-driven fan and elements for changing the temperature and humidity, n.e.s.									
IMPORT	x 1000 units							425	466	517	227
	x mln. Euro	535	500	428	436	33	427	528	631	679	518
EXPORT	x 1000 units								287	293	364
	x mln. Euro	417	453	444	438	42	487	574	647	651	638
APP. CONSUMP	x mln. Euro				1358	1436	1503	1804	2057	2013	1584

2.3 Central exhaust or supply units

Central exhaust or supply ventilation units > 125 W are included in Prodcom categories (NACE Rev. 2)

- 28252030 Axial fans >125W;
- 28252050 Centrifugal fans >125 W or
- 28252070 Other fans >125 W.

Larger CHRV units are wholly or partly included in the last category.

Eurostat production statistics per EU Member State are given in **Tables 6** (unit production) **and 7** (value production), for the available period 2003-2009.

For extra-EU trade the CN8 code *841459* applies, relating to fans > 125 W. The combined results of EU-27 production and extra-EU imports and exports in the period 2003-2009 are given in **Table 8**, also featuring a calculation of the apparent consumption (production + imports - exports).

Total 2009 production amounts to 30,5 mln. units at a value of € 2,64 bln.. Exports account for € 0,8 bln. and imports for € 0,33 bln., resulting in an apparent EU-27 consumption of € 2,17 bln..

These figures exclude the share Hungary, that is obviously a producer of large numbers of low-cost impellers (€ 2,-/unit) and thus giving a distorted impression of the total EU-27 figures relating to complete fan-units (at average € 40/unit for axial fans and € 150 to € 170/unit for the other two types).

The production trend for all fan-types, except centrifugal, is downward, not only showing the effect of the economic crisis in 2008/2009 but already showing a 20-30% decline since 2007. But reliability may be limited as Eurostat keeps redefining products within this heterogeneous group.

Table 2 - 6. PRODCOM (Eurostat 2010), Fans >125 W, Production volume in units x 1000 (NACE Rev 2)

year	EU27	EU27*	BE	BU	CZ	DK	DE	ES	FR	IT	LT	HU*	NL	AT	PL	PT	FIN	SV	UK
	28252030 Axial fans >125W																		
2009	*18.890*	**13.688**				26	12.347	195	168	497		*5.201*			41	1			277
2008	*24.000*	**15.264**		3				300	167	544		*8.736*			24	2			337
2007	*32.000*	**22.483**		3		36		235		585		*9.517*	351		150	2			275
2006	*32.218*	**21.906**						223		635		*10.312*			109	1			353
2005	*20.047*	**11.600**		47				344	191	609		*8.447*			76	2			241
2004	*30.024*	**21.772**		23				80	188	669		*8.252*	188		68	2			359
2003	*21.000*	**13.065**		0		16		82		555		*7.935*			51	2			524
	28252050 Centrifugal fans >125 W																		
2009	*6.615*	**6.615**		2	50	26	4.562	400	99	952	20			28	46	2	1	30	116
2008	*6.000*	**6.000**		4	56	35		524	541	928	47			29	68	1	1	33	113
2007	*10.000*	**9.999**		3		37		642		1.034	50	*1*			66	1	1	21	93
2006	*5.000*	**4.999**		2		36		599	529	695	38	*1*			106	2		14	142
2005	*4.003*	**4.002**		2		35		591	585	571		*1*			107	1			116
2004	*8.003*	**8.002**		3		31		410	576	724		*1*	132		136	1			143
2003	*4.000*	**3.999**		0		32		367		467		*1*			104	1			132
	28252070 Other fans >125 W																		
2009	*4.960*	**4.959**		3	8	329	2.737	77	23	725		*1*			30		25	479	298
2008	*5.689*	**5.688**		4	11	0		106	119	627		*1*			28		19		139
2007	*5.703*	**5.701**			13	294	2.403	91		696		*1*			8		24		91
2006	*4.620*	**4.619**			14		2.100	117		100		*1*			8	1	19	990	57
2005	*4.161*	**4.160**				161	1.733	73	1.053	94		*1*			7	1	21	722	115
2004	*4.620*	**4.619**		0		94	2.066	499	699	122		*1*		3	7	1	43	698	174
2003	*4.330*	**4.329**		0		160	1.978	678		92		*1*		7	2				174
	TOTAL (only if data complete) UNIT PRODUCTION																		
2009	*30.465*	**25.262**				381	19.646	672	291	2.173	20	*5.202*			117	3	26		691
2008	*35.689*	**26.952**		11				930	827	2.099	47	*8.737*			121	3	20		589
2007	*47.703*	**38.184**				368		968		2.316	50	*9.519*			224	3	25		459
2006	*41.838*	**31.524**						938		1.429	38	*10.313*			222	4		1.005	552
2005	*28.211*	**19.762**						1.008	1.828	1.273		*8.449*			191	4	21		472
2004	*42.647*	**34.394**		26				988	1.463	1.515		*8.254*			211	4	43		677
2003	*29.330*	**21.393**		0		208		1.127		1.114		*7.936*			157	3			831

= Figures for HU (unit value 2 Euro) probably relate to OEM-production of axial propeller only and not to complete fan; EU27 figures thus exclude Hungary

NOT SHOWN:

No production report in EI (Ireland), Cyprus (CY), Malta (MA), Latvia (LV), Luxembourg (LU), Slovakia(SK)

Estonia (EST) reports 4.000 'other fans' in 2007

Slovenia (SL) production of 66.000 'other fans' and 112.000 'centrifugal fans' in 2003, total 178.000 units

Greece (EL) production 1.000 centrifugal fans in 2008

Romania (RO) production 1.000 axial and 2.000 centrifugal fans in 2006

Table 2 - 7. PRODCOM (Eurostat 2010), Fans >125 W, PRODUCTION VALUE in million Euro (NACE Rev 2)

year	EU27	EU27*	BE	BU	CZ	DK	DE	ES	FR	IT	LT	HU*	NL	AT	PL	PT	FIN	SV	UK
28252030 Axial fans >125W																			
2009	*793*	**782**				13	408	57	65	89		*10*	42		19				83
2008	*100*	**100**						51		20						9			
2007	*953*	**932**		1		19	480	67	64	87		*20*	69		15	1	1		112
2006	*892*	**874**		1		18	451	55	59	88		*18*	59		8	1	1		114
2005	*106*	**106**				10		45		21						6			4
2004	*767*	**753**		1		16	401	28	44	121		*14*	34		5	1	1		82
2003	*125*	**125**				10		52		29						5	5		0
28252050 Centrifugal fans >125 W																			
2009	*1.126*	**1.126**			5	43	395	71	83	316	2		52	5	18	2	6	6	81
2008	*508*	**508**					59	124	31	139					1	14	12	0	109
2007	*1.230*	**1.229**	24	1	5	45	390	102	151	330	5	*1*	43		18	2	7	8	80
2006	*1.102*	**1.101**		1	4	42	348	84	137	262	4	*1*	43		18	6	8	5	111
2005	*456*	**456**					31	122	53	103					1	12	2	0	103
2004	*939*	**938**		1		38	238	56	144	265		*1*	50		9	4	0	0	100
2003	*392*	**392**				1	35	56	55	113					0	9	2	0	95
28252070 Other fans >125 W																			
2009	*724*	**724**		1	10	20	373	14	64	85					16		32	50	27
2008	*1.180*	**1.177**		3	17	33	401	148	22	152	1	*3*	21		52	33	4	59	20
2007	*935*	**935**		1	12	20	471	18	96	95			24		12	1	36	0	42
2006	*784*	**784**			10	14	408	26	86	43			23		11	4	29	77	25
2005	*813*	**799**	106	1		49	271	101	24	70	1	*13*	15		16	25	4	26	29
2004	*680*	**679**			7	12	354	33	61	50		*1*	16	10	3	2	21	59	40
2003	*857*	**850**	93			47	298	104	19	124		*7*	4		0	25	19	23	24
TOTAL PRODUCTION VALUE Fans >125W																			
2009	*2.643*	**2.643**			14	76	1.176	142	212	490					53	2	38	56	191
2008	*1.788*	**1.788**						322		312						56	16	59	129
2007	*3.118*	**3.096**		2	17	84	1.341	187	311	512		*21*	135		45	3	43	8	234
2006	*2.778*	**2.759**			14	74	1.207	165	281	394		*19*	125		38	11	38	82	249
2005	*1.375*	**1.375**		1				268		193						43	6	26	136
2004	*2.386*	**2.370**			7	66	992	117	249	436		*16*	100		16	7	22	59	223
2003	*1.374*	**1.374**				59	333	212		266						39	26	23	119

= Figures for HU (unit value 2 Euro) probably relate to OEM-production of axial propeller only and not to complete fan; EU27 figures thus exclude Hungary

NOT SHOWN:

No production in EI (Ireland), Cyprus (CY), Malta (MA), Latvia (LV)

Estonia (EST) reports 1 mln. Euro axial fans in 2008 and 6 mln. other fans, total 7 mln. Euro

Slovenia (SL) production of 4 mln. Euro 'other fans' in 2008

Slovakia (SK) production value 2 mln. Euro 'other fans' in 2008

Greece (EL) production value ca. 1 mln. Euro centrifugal fans amd 1 mln. other fans, total 2 mln. Euro

Romania (RO) production cvalue 1 mln. Euro axial and 2 mln. centrifugal in 2006

Table 2 - 8. Fans>125 W, Value of trade, production and apparent consumption (Eurostat 2010) , in mln. Euro.

Year	EU27	EU27*	BE	BG	CZ	DK	DE	ES	FR	IT	LT	HU*	NL	AT	PL	PT	FIN	SV	UK
	IMPORT (CN code 841459)																		
2009	337	329	7	1	14	3	91	10	24	34	0	8	43	7	15	1	3	15	40
2008	423	414	11	1	21	5	114	13	35	40	1	9	45	10	13	2	5	18	58
2007	422	412	9	1	14	4	109	16	34	46	1	10	51	8	12	1	4	15	69
2006	376	368	7	1	13	4	103	15	35	36	1	8	51	6	8	1	4	13	58
2005	348	340	9	2	8	3	102	15	34	35	1	8	45	5	5	1	4	11	47
2004	356	350	5	0	9	3	103	13	37	42	0	6	52	5	7	1	3	10	44
2003	336	331	5	0	7	2	95	11	32	41	0	5	52	5		1	3	11	42
	EXPORT (CN code 841459)																		
2009	805	803	7	0	5	14	475	27	33	112	5	2	21	8	10	1	13	27	35
2008	989	988	8	1	8	15	535	36	54	139	10	1	29	10	13	1	19	40	52
2007	927	926	6	0	8	17	517	26	41	127	9	1	34	8	12	1	19	43	44
2006	852	851	6	0	5	23	477	20	30	129	6	1	28	8	9	1	13	36	51
2005	707	707	5	0	8	13	376	14	30	114	4	0	34	8	5	0	13	32	44
2004	661	660	5	0	5	8	368	14	28	99	2	1	24	10	6	1	6	40	41
2003	555	555	8	0	5	8	293	11	26	101	1	0	16	7		0	7	25	42
	PRODUCTION (PRODCOM NACE Rev2 codes 28252030+28252050+28252070)																		
2009	2.643	2.643			14	76	1.176	142	212	490					53	2	38	56	191
2008	1.788	1.788						322		312						56		59	129
2007	3.118	3.096		2	17	84	1.341	187	311	512		21	135		45	3	43		234
2006	2.778	2.759			14	74	1.207	165	281	394		19	125		38	11	38	82	249
2005	1.375	1.375		1				268		193						43			136
2004	2.386	2.370			7	66	992	117	249	436		16	100		16	7	22	59	223
2003	1374	1374				59	333	212		266						39	26	23	119
	APPARENT CONSUMPTION (= PRODUCTION+IMPORT-EXPORT)																		
2009	2.174	2.168			23	66	792	125	203	411					59	1	29	44	196
2008	1.221	1.214						299		213					0	56		37	135
2007	2.613	2.583		4	24	71	933	177	304	432		30	153		45	4	29		259
2006	2.301	2.275			22	55	833	160	286	301		26	148		36	11	29	59	257
2005	1.016	1.008		3				269		114						44			138
2004	2.082	2.060			11	61	727	116	258	380		22	128		17	7	19	29	226
2003	1.155	1.150				53	135	212		206						39	22	10	120

Overall the value of these statistics is very limited, covering a large variety of non-ventilation fan-applications on one hand and on the other hand reporting only on fans that are brought on the market as such. Built-in fans, which probably constitute some 80% of all fans with a nominal power > 125 W, are not reported.

VHK estimates that the EU-stock currently is over 2,5 billion fans, of which 0,75 billion fans with a nominal power > 125 W. The vast majority of these ‘fans’ are built in cars and mass-produced appliances, where the manufacturer buys/produces a motor, impeller and housing as separate items. In these cases, the ‘fan’ is never explicitly brought on the (B2B) market and thus not registered in any statistics. But –especially as the production series are smaller (e.g. in professional versions)—there may be still several (unknown) cases where the ‘fan’ does get registered in statistics.

2.4 Installation, repair and maintenance

Eurostat gives production (PRODCOM) statistics on the installation, repair and maintenance of non-domestic cooling and ventilation appliances. These can be found in **Table 9**.

The figures show that repair and installation may be as important for the EU-27 economy as the manufacturing of air conditioning and ventilation products. In 2009 production value the repair and maintenance of 'non-domestic cooling and ventilation products' amounted to € 3,1 bln.; the installation value was as high as € 5,6 bln.. And despite the crisis, the trend is upward.

Extra EU-27 imports and exports obviously do not play a significant role.

Table 2 - 9. Non-domestic cooling and ventilation repair, maintenance and installation. Production value in million Euro x 1000 (EUROSTAT 2010, PRODCOM)

year	EU27	BE	BU	CZ	DK	DE	IRE	EL	ES	FR	IT	LT	HU	NL	AT	PL	PT	SK	FIN	SV	UK
	33121800 Repair and maintenance of non-domestic cooling and ventilation equipment																				
2009	3091	238	3	15		402	3	0	261	648	380		14	214	62		16	12	10	6	501
2008	2912	223	14	24		382	4	0	275	539	417		13	256	62	43	26	19	12	4	613
2007	2500	198	9	15		381	1	2	272	225		1	15	121	46	31	28	12	18	9	612
2006	2168	178	4	19		310	0	5	205	229	368	1	18	106	44	18	27	18	13	17	577
2005	2178	168	4	10		277	0	3	153	232	311	1	17	94	34	27	31	12	8	11	783
2004	2253	155	5	13		249	2	17	203	223	299		16	113	27	16	31	5	7	10	855
2003	2070	142	0	10		271	1		177	200	299		9	111	23	32	27	4	14	9	717
	33202950 Installation of non-domestic cooling and ventilation equipment																				
2009	5600	199	8	51		577		3	365	1054	947	3	24	164	94		38	28	16	36	408
2008	4479	209	18	60		705		5	454	889	766	5	24	182	103		33	40	12	29	538
2007	3600	278	25	79		602		14	503	360		5	16	252	86	86	77	14	27	28	563
2006	3347	251	20	41		507		15	429	308	738	3	20	227	76	86	59		25	21	504
2005	3053	211	16	31		442		18	373	361	649	1	21	164	85	50	58	5	17	29	518
2004	3015	198	8	20		448	1	17	442	351	677		22	178	84	49	60	4	15	30	406
2003	2882	144		47		409	2	11	423	380	590	1	18	197	80	38	70		9	40	414

NOT SHOWN:
EST: 1 mln. repair; 3 mln. install (2009); CY, LV, LU, MA: <0,5 mln. (all); RO,SL: 1 mln. repair (2009)
Also not shown are cells marked as confidential (:C)

In order to get a better impression on how important these items are with respect of the total economic picture for air conditioning, **Table 10** gives an estimate of the 'non-domestic cooling and ventilation products' that are typically subject to the repair and installation costs mentioned above.

The table shows selected production values from PRODCOM 2825…, and in the last column an estimation of the relevant share is made which would make it comparable to non-domestic air-conditioning systems. In this estimation air conditioning units are counted for 100%, ventilation fans for 30%. Also the commercial refrigeration –based on the relative share of the parts production— was set at 30%. The resulting figure of € 9,3 bln., of which € 2,3 bln. in parts and € 7 bln. in products, was then compared to the results from table 9. This is expressed in figure 1, which is by definition incomplete because the manufacturing value only includes manufacturer selling prices (msp) and margins of wholesale and retail are not included. Nonetheless, it already brings together all the figures that could be extracted from the Eurostat Prodcom.

The conclusion is that the repair and installation activities are indeed more significant than the part manufacture.

Table 2 - 10. Estimated EU-27 production value 2009 of 'non-domestic cooling and ventilation products' (selected from PRODCOM 2825…., Eurostat 2010)

PRODCOM	Description	TOTAL mln. EURO	**included * mln. EURO**
28251130	Heat exchange units	4.849	
28251150	Machinery for liquefying air or other gases	2.045	
28251220	Window or wall air conditioning systems, self-contained or split-systems	739	**185**
28251240	Air conditioning machines of a kind used in motor vehicles	1.760	
28251250	Air conditioning machines with refrigeration unit (excluding those used in motor vehicles, self-contained or split-systems machines)	1.742	**1.742**
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	1.618	**1.618**
28252030	Axial fans >125W	793	**397**
28252050	Centrifugal fans >125 W	1.126	**563**
28252070	Other fans >125 W	724	**362**
28251333	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage	478	**143**
28251335	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (excluding for frozen food storage)	1.086	**326**
28251340	Deep-freezing refrigerating furniture (excluding chest freezers of a capacity <= 800 litres, upright freezers of a capacity <= 900 litres)	590	**177**
28251350	Refrigerating furniture (excluding for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)	640	
28251380	Heat pumps other than air conditioning machines of HS 8415	1.621	**1.621**
28251390	Other refrigerating or freezing equipment	2.409	
28253010	Parts for air conditioning machines (including condensers, absorbers, evaporators and generators)	1.703	**1.703**
28253050	Parts for non-domestic refrigerating equipment (including evaporators and condensers)	500	**500**
	TOTAL	**24.422**	**9.336**
	of which Parts manufacture		***2.303***
	of which Products/Systems manufacture		***7.033***

* Equivalent value for air conditioning units. For 28251220 around 30% was taken into account as 'non-domestic'; for 28251333 to - 1340, as well as the 'fan' categories (28252..) installation and repair effort is set at 30% as compared to air conditioning (based on the proportion in parts manufacture)

This table shows all the relevant products in order to allow also a split up of the "Parts".
It clearly shows the ambiguity of the Eurostat data when specifying ventilation products. But the table could be helpful to make the splits with other preparatory studies on e.g. air heating.

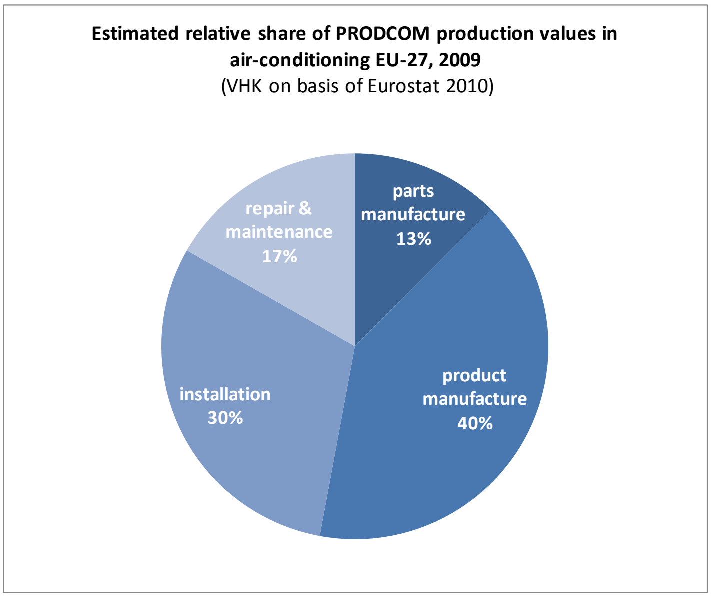

Figure 2 - 1. PRODCOM figures on air conditioning (excluding trade)

The overall conclusion on Chapter 2 is that Eurostat production and trade data may be useful ex-posteriori to confirm data from sector-specific sources. Especially as it indicates not only manufacturer prices, but also installation costs, other installation materials (beside the ventilation unit) and a relatively high share of repair and maintenance.

Having said that, the absolute figures provided by Eurostat are of little use because of the mix of all sorts of different products in one group. At best it can therefore be used as a very rough estimation.

3 Market and stock data

3.1 Introduction

As regards air handling units (AHU's) this chapter is mainly based on a BRE report using predominantly BSHRIA data for the year 2008, supplemented by industry data, information supplied by the University of Trier (DE) and others.

For central exhaust and supply units (rooftop and boxed ventilation units) the information is mainly derived from the preparatory study DG ENER Lot 11 on industrial fans, supplemented by industry data.

3.2 Definitions

Sales, stock and capacity data for AHU's vary widely, depending on the source and the definition used.

The commercial market research company **BSRIA** defines an Air Handling Unit[9] as follows:

- A central station air handling unit is a factory made assembly consisting of a fan or a number of fans and other necessary equipment combining some or all of the function of circulating, cleaning, heating, cooling, humidifying, dehumidifying and mixing of air.
- To qualify as an air handling units rather than an industrial warm air unit, the air handler must have the capacity for the fitting of a cooling coil, though this may not be fitted.
- To qualify as an air handling unit rather than a fan coil unit, the equipment must be able to operate against an external static resistance of over 76 pa (static pressure).

BSHRIA distinguishes between standard ('off the shelf' from a catalogue), semi-custom (varied dimensions/ cross sections, increasingly modular) and custom made (usually > 200 kW, 3rd party condensers and possibly heat exchanger units).

Note that the above definition still allows 'ventilation only' units where the cooling coil '*may not be fitted*' (5% of sales), but the fact that the air handler *must have the capacity for the fitting of a cooling coil* already narrows down the scope to a modular instead of an integrated solution.

EN standards, are even less clear and define an AHU as *"A ventilation system with mechanical air transport and which is used to meet the indoor air quality requirements",* which may include just about anything with a fan and some sort of influence on the indoor air quality.

Eurovent, which has started its market intelligence effort on AHUs a few years ago, defines AHUs (only full AHU to be accounted, not AHU sections) as[10]

"A double wall casing with at least a filter, a fan and a temperature controlling component delivering air to the building with minimum 1000m^3/h;

Temperature controlling components are Heat recovery, Cooling coil, Heating coil, Humidifiers/ Dehumidifiers"

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9 BSHRIA, Air Conditioning Product Definitions, Report 19138/A, April 2005.

10 Eurovent, Yannick Lu-Cotrelle, pers. comm., Oct. 2010.

For central exhaust ventilation units, also known as “rooftop fans” (outdoor) or “boxed fans” (indoor), no definition was found, but at least the DG ENER Lot 11 indicates that they are not just a fan, but something that contains –apart from a motor, drive and impeller—at least a housing and a control unit. And most importantly, it is a fan with a specified purpose, which means that a function-specific load pattern may apply.

All in all, the statistics show a fair amount of “cross-contamination” between AHU and central balanced ventilation units and central exhaust (or supply) units. In the following paragraph VHK will try to make the best estimate after presenting the data available, but it is clear that accuracy will not be high.

3.3 Sales and stock data

Data availability and quality on sales and stock of ventilation units to the non-residential sector is poor. **Annex I** gives a discussion of some of the most important data sources and their respective drawbacks. In short, the main findings are that:

- In BSRIA data the smaller heat recovery ventilation units are under-represent, as they would not normally be within the definition of ‘air handling unit’ (AHU);
- Eurovent data overall cover only 40% of the EU-market. Especially for Germany, the larger AHUs are under-represented;
- National data sources, like from the German RLT, or data from German universities (e.g. Dr. Kaup) are helpful, but also here the focus is on the ‘classic’ AHUs and not on all ventilation systems, including the relatively recent ‘mini’ and ‘compact’ versions below 5000 m^3/h.
- Sources for residential ventilation units (e.g. FGK), are helpful in giving a rough estimate of sales at the smaller units (CHRV) that are just over the limit of 125 W per individual fan, but of course do not cover the larger units.

Keeping in mind the many caveats in the available data, VHK has nonetheless tried to make an estimate of sales at several sizes. The following table gives an overview and Fig. 2. Shows the size distribution (in m^3/h) that was assumed.

The data relate to the year 2008, which was largely before the economic crisis, and therefore optimistic. For 2009, especially in the traditional AHU-market, sales have dropped by around 20% for most countries. Only the Heat Recovery ventilation has fared relatively well (see market trends).

Table 2 - 11. Ventilation equipment collective residential and non-residential estimated sales and stock 2008 [1] [2]

	SALES 2008										STOCK 2008			2008
	TOTAL SALES				REPLACEMENTS			NEW/1st TIME INST.			TOTAL STOCK			cap.
Ventilation collective residential and non-residential EU-27	units	cap	total*		units	total		units	total		units	total		stock
	# x 1000	1000 m³/h	Mm^3/h	%	# x 1000	Mm^3/h	%	# x 1000	Mm^3/h	%	# x1000	Mm^3/h	%	m^3 %
Mechanical ventilation														
AHU-L(>14500 m³/h)	68	35	2.380	*46%*	34	1.190	*65%*	34	1.190	*35%*	799	27.965	*45%*	*20%*
AHU-M (5500-14500 m³/h)	65	10	650	*13%*	25	250	*14%*	40	400	*12%*	715	7.150	*11%*	*5%*
AHU-S (2550-5500 m³/h)	47	4	188	*4%*	15	60	*3%*	32	128	*4%*	237	948	*2%*	*1%*
CHRV (300-2250 m³/h)	140	2,3	315	*6%*	10	23	*1%*	130	293	*9%*	978	2.201	*4%*	*2%*
Central Exhaust	1.100	1,5	1.650	*32%*	200	300	*16%*	900	1.350	*40%*	16.000	24.000	*39%*	*17%*
LHRV (fans <125W)	30	0,1	3	*0%*	0	0	*0%*	30	3	*0%*	300	30	*0%*	*0%*
local fans (<125 W)	6.000	0,1	600	*12%*	3.000	300	*16%*	3000	300	*9%*	60.000	6.000	*10%*	*n.a.*
TOTAL MECH. (excl. loc.fans)	*1.450*		**5.186**		*284*	**1.823**		*1.166*	**3.364**		*19.029*	**62.294**		**45%**
Natural ventilation														
						[built 1998]			**[built 2008]**					
Natural (excl local fans)						**2.200**	*55%*		**2.045**			**75.000**		55%
TOTAL ALL						***4.023***			***5.409***			***137.294***		**100%**

[1] VHK on basis of misc. sources (see Annex). Note that the capacity ('cap') refers to the design air flow rate, not to the actual flow rate (see chapter 5 on control factor and misc. factor). For natural ventilation an estimated 'real' air change rate of 1,7 m^3/m^3 was assumed (relating to a ventilated building stock volume of 40 bln. m³). The size distribution for AHU's and CHRV is based partly on Kaup 2009 and partly on a correction that 'mini' and 'compact' units are underrepresented in Kaup's figures (see graph below)

[2] Dedicated buildings are collective residential 16 bln. m³ ventilated volume (37% mechanical ventilation), tertiary sector 29 bln. m³ (60% mech. vent.), industry & agricultural 22 bln. m³ (17% mech. vent); total 67 bln. m³, of which 40% (27 bln. m³) mechanically ventilated and 60% natural or natural with local fans (40 bln.). To this 4,2 mln. establishments with average 500 m³ have to be added (0,645 bln. m³), amongst which high share of bars and restaurants (high hourly air exchange rate of 2,5-4). Small establishments are 3,5 mln. shops/bars/restaurants + 0,8 mln. professional dwellings (doctors, dentists, etc.). Assumed 50% chilled (90% in South, 30% rest EU)

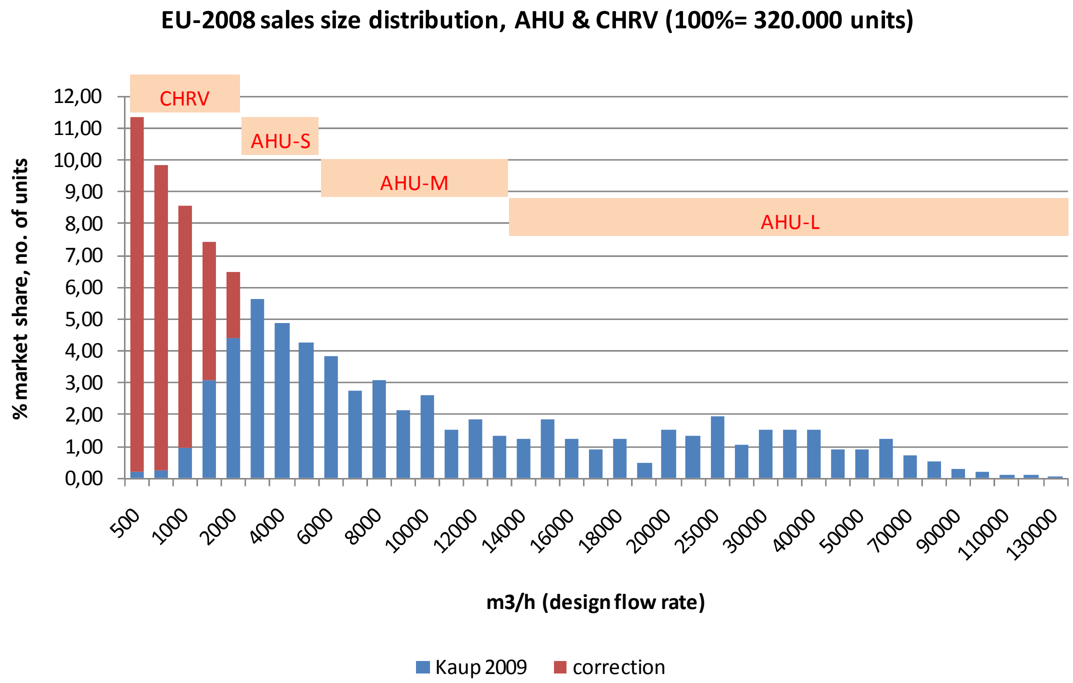

Figure 2 - 2. EU 2008 sales size distribution.

The size distribution is also plausible from the point of view of building size. The graph below gives the example of Sweden, showing that 67% of premises (and 52% of properties) has a surface area of less than 1000 m². Around 0,8% (686.000 premises) have a surface area larger than 20.000 m², according to the Swedish national statistics office).

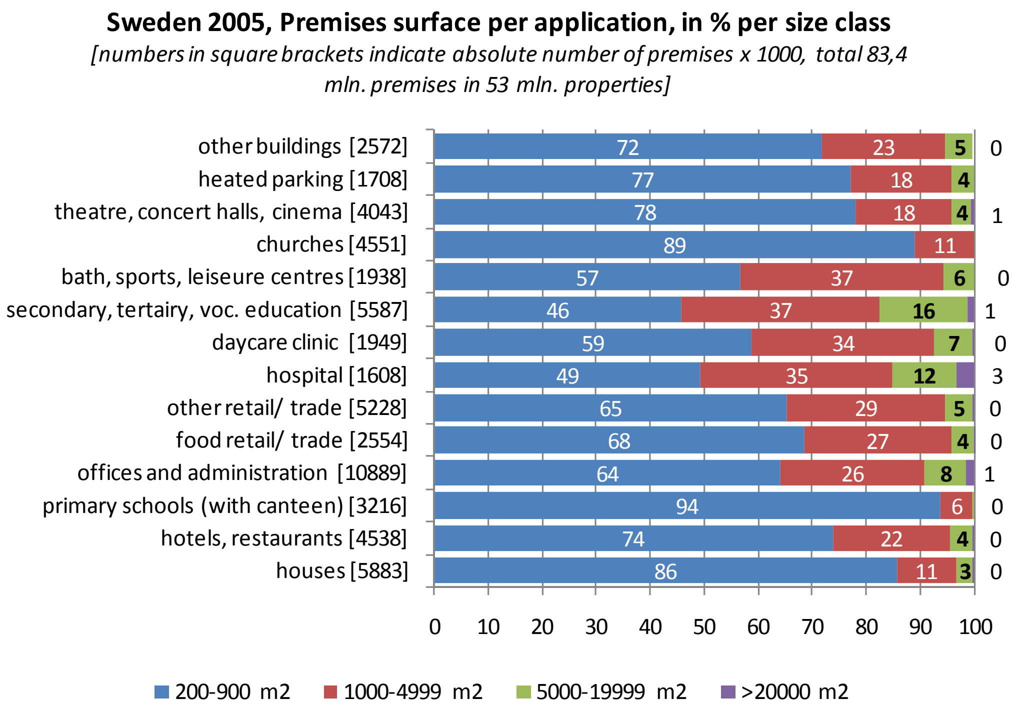

Figure 2 - 3. Sweden building sizes per subsector

4 Market Trends

4.1 General

Most important negative trends are:

- Structural decline in new building construction volume (permits) for the Euro area since 1990. Even before the recent crisis anecdotal data suggest that annual new built volume for non-residential buildings was around 20-25% lower in 2008 compared to 1990.
- Today (July 2010), including the effects of the crisis, the new built volume (in m^3) may be around 40-45% lower than in 1990.
- Until 2008, in terms of revenue, the decline in physical built volume could in part be compensated by increased added value. But since the economic crisis there has also been a >20% decline in added value;
- The decline has been strongest in countries with a relative high penetration of air conditioning (and its air handling units, which imply total mechanical ventilation for the whole building) like Spain and Portugal. Countries with a colder climate (e.g. Poland, Sweden, Finland) still show a positive trend in new construction.
- In Middle and Northern Europe, air conditioning (and its air handling units) is traditionally seen as a 'luxury'. With this, also the penetration of mechanical ventilation in non-residential buildings is moving slowly.
- Despite the recent reforms in Building Regulations on ventilation, there is still a low acceptance with builders, specifiers and their customers that
  - in current building practice mechanical ventilation is necessary to guarantee health and comfort standards,
  - ventilation losses are a major –if not the most important-- factor in the heating and cooling load of non-residential buildings.
  - renovation efforts aimed at energy efficient ventilation may have a larger effect than those directed only at the traditional measures (better insulated windows and building shells);
- The merits of Heat Recovery ventilation, Demand-Side Control and –for cooling—Night Ventilation are still largely unknown to builders, specifiers and customers in large parts of Europe. Especially in Southern-Europe these issues are only linked to buildings with air-conditioning and not to other buildings.
- The negative health image of ducted central ventilation systems persists, especially when mechanical ventilation is linked to air conditioning (e.g. 'sick building syndrome') or –more recently-- in situations where the ambition to create energy saving buildings and the lack of knowledge with the contractors has superseded the necessity to create a healthy environment (e.g. Amersfoort, NL).
- Although the legislator recognizes the merits of energy efficient ventilation, there is a concern that air conditioners may create a summer peak in electricity demand, i.e. that the maximum capacity of power plants in the EU-27 no longer depends on the 'winter peak' but is determined by the air conditioners in the summer. This has repercussions for situations where ventilation is coupled with air conditioning

Most important positive trends are:

- Although new Member States are lagging behind and countries in Southern Europe mainly link the issue to air cooling, most countries in the EU-27 have Building Regulations (following EPBD) that take into account the necessity of mechanical ventilation at high levels of air-tightness of the building and looks at the merits of e.g. Heat Recovery ventilation (see Task 1 report);
- Apart from Building Regulations, the increasingly more stringent regulations on labour conditions and health in general are a driver for both air conditioning and ventilation systems. In countries like the Netherlands the indoor temperature in average offices may be above the critical limit of 26 °C only 4 days a year, and still the production loss is enough to prompt the majority of new offices to have air conditioning (and thus whole building mechanical ventilation). Another driver in this context are anti-smoking regulations;
- Though not complete, the body of European (EN) Standards on ventilation is growing both in number and quality and therefore allow effective regulation (see Task 1 report);
- The European construction market for building renovation is rising structurally. It is estimated that over the period 1990-2008 the value has almost doubled (average annual growth rate almost 4%). The number of permits –an indicator of the physical volume concerned— has also risen, albeit at a more modest scale (ca. 2 % annually);
- Ventilation is more and more decoupled from air conditioning, not only in the perception of the general public but also physically. The market share for traditional central air-based installations, where the same AHU handles both the requirements of air cooling/heating and the ventilation, is in decline as far as new buildings is concerned (replacement market is still very big). Instead, the market share for fan coil units (FCU), chilled beams (High Temperature cooling) and, more recently, variable refrigerant flow units (VRF) is growing. With these newer systems, on the European market since the 1980-'s (FCU) and 1990's (VRF), the 'air handling unit' (rather just a ventilation unit) just takes care of the ventilation, while the fan coils and VRF units –helped by recirculation fans—just handle the air cooling/heating. This configuration avoids (or at least diminishes) the traditional over-sizing of fan capacity, allows independent control (see Chapter 3 of this Task 2 report) and lowers distribution losses (e.g. duct leakage).
- As a result, it opens the market for 'integrated' (or 'compact') small/mid-sized AHU's/ ventilation units that are no longer equipped with/for heating and cooling coil modules. In fact, they do not have the traditional modular built-up of the AHU: Fans, filters and heat recovery heat exchanger are all integrated in one single casing for sizes typically from 500 to 4500 m^3/h (up to 8000 m^3/h maximum). Pre-heating or pre-cooling coils (often DX based) may be optional, but with the heat recovery are often not necessary. The significantly lower acquisition and the installation costs make these units increasingly popular and in fact it is one of the few market segments experiencing real growth.
- Linked with these new systems, especially the VRF and multi-splits, is the ease of retrofitting these air cooling systems in existing, usually smaller commercial buildings (shops, bars, restaurants) that thus far were naturally ventilated. This trend is especially strong in Southern Europe, but can be observed also in the rest of Europe for establishments dealing with food and fashion.
- Another growth sector is the controls-side of air conditioning and ventilation systems, gradually moving from only rudimentary control, to whole building control systems (looking at

zones) to currently room-by-room control through occupancy sensors (yes/no), CO_2 sensors (how many people) and –for wet rooms—humidity sensors. And of course the sensors are only a starting point, because they require the appropriate actuators (dampers, valves, local fans, etc.) and a central processing unit to adjust the central ventilation/air-conditioning system to the needs of the rooms;

- As a next step, there is the most recent development of local heat recovery ventilation systems, with in- and outlets through the façade. Although the market is still relatively small, it is developing in Germany, the Netherlands and the UK. Its main attraction is in true individual control, not just by CO_2 sensors but also with the option for an individual manual override;
- The above trends are detrimental to the sales of simple mechanical exhaust systems ('rooftop fans') in new buildings, but there are some new features that increase the added value, like more efficient DC motors (EC motors, Variable speed drives) and better controls. Especially the combination of mechanical exhausts with local sensors/dampers (compare VAV-boxes) can yield quite important savings. All in all, while numbers are going down, the extra motor and control options may go a long way in keeping revenue stable;
- For the traditional market of simple mechanical exhaust systems, i.e. the industrial and agricultural buildings, there are also some interesting developments for 'roofvent' units –not to be confused with single package rooftop air-conditioners connected to an indoor ducting system—where the unit injects direct (not ducted) fresh air to large production halls, warehouses, malls or amusement centres. These units have ventilation heat recovery and –— can also supply cooling (usually through a DX coil with separate condenser), heating (from the reversible DX or with direct/indirect gas/oil boiler coils) and/or filtration ('clean air' appliances). The air speed (and air speed variations) of these units may not be up to par to the thermal comfort standards for e.g. offices, but the lack of ductwork and the combination with heat recovery certainly makes them an interesting base-load product for large spaces;

4.2 Construction industry trends

Given its impact, this paragraph gives a bit more background on the trends in the constyruction industry.

For the construction industry as a whole, Eurostat reports a production index in July 2009 (2005=100) below the level of the year 2000. The production index is a value-indicator, but corrected for inflation and seasonal effects.

Compared to the previous year, among the Member States for which data are available, construction output fell in ten and rose only in Poland (+10.6%) and Germany (+1.9%). The largest decreases were registered in Spain and Slovenia (both -20.5%) and Romania (-17.5%).

Building construction fell by 12.9% in the euro area and by 13.7% in the EU27, after -10.9% and -12.8% respectively in June. Civil engineering decreased by 3.0% in the euro area but increased by 0.3% in the EU27, after +1.7% and +4.0% respectively in the previous month.

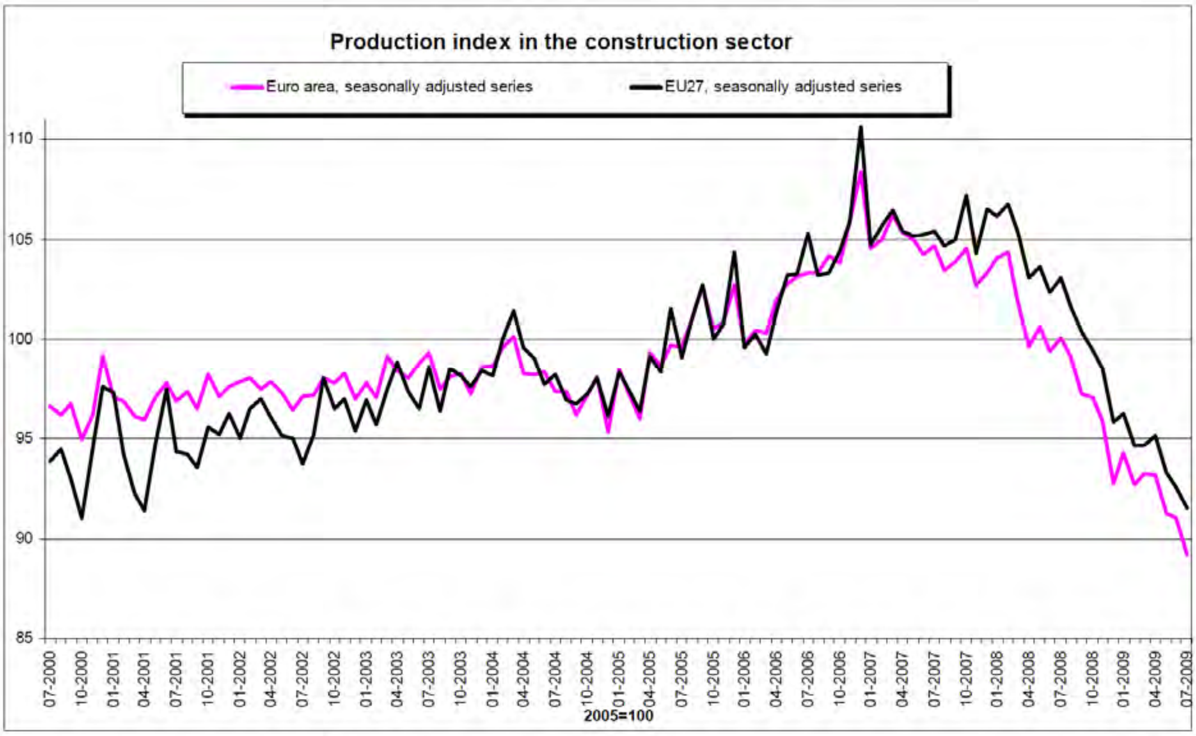

Figure 2 - 4. Construction sector production index July 2000-2009. (Eurostat NewsRelease Euroindicators 134/2009, 17 Sept. 2009)

The table on the next page shows that the trend continued also in the last 12 months, with the EU-27 index at 91,34 in July 2010. This is a 20-point fall with respect of the peak in Jan. 2007. The Euro area index fell to 85,95 with the lowest indices for Spain and and other countries with a warm climate that are important for the air-conditioning industry. Poland is the country with the highest index.

Table 2 - 12. Construction production Index, 2005=100 (SA), source Eurostat 2.10.2010.

Countries	2009				2010						
	Sept.	Oct	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul.
Euro area (16 MS)	89,51	89,67	88,86	89,15	87,66	82,06	87,42	87,53	86,8	88,53	85,95
EU (27 countries)	91,85	91,51	90,91	90,65	89,97	85,45	90,87	91,28	91,2	93,69	91,34
EU (15 countries)	90,45	90,44	89,48	88,72	87,34	84,92	89,82	89,83	89,06	93,35	89,15
Belgium	96,95	98,4	89,46	91,28	98,31	88,21	98,9	97,37	88,43	99,08	101,86
Bulgaria	127,45	124,55	124,49	122,87	93,74	98,24	103,89	105,26	107,73	106,78	105,88
Czech Republic	114,9	110,8	113,3	110,7	87,3	90,6	95,5	100	105,9	107,2	108,8
Germany	109,4	108	108,8	107,1	91,7	91,2	113,3	116	113,9	113	114
Spain	70,53	70,23	68,4	70,77	66,85	65,51	67,04	64,17	63,59	67,28	60,54
France	96,1	95,5	95,8	93,7	93,9	93,4	95,1	93,5	94	94,2	93,3
Italy	:	:	:	:	:	:	:	:	:	:	:
Luxembourg	105,23	104,74	104,15	100,73	102,32	98,83	112,12	106,83	104,17	107,68	108,75
Hungary	77	76	71,6	74,5	68,5	70,8	73,3	68,7	69,6	68,2	70,6
Netherlands	102,78	101,22	100,27	98,78	96,98	94,78	96,2	96	96,19	94,66	95,3
Austria	107,4	106,8	109,2	107,8	106,7	101,3	102,4	103,2	103,3	105,4	102,1
Poland	156,2	154,2	157	155,3	135,7	132,6	140,8	143,1	151,9	159,3	157,7
Portugal	84,1	80,2	81,3	77,1	76,1	78,3	80,4	77,3	76,4	74,4	78,1
Romania	157,8	146,9	162,9	175,6	164,4	140	141,4	141,4	139,6	174,4	125,1
Slovenia	118,5	119,5	113,4	111,6	116,8	109,2	113,6	108,4	107	105	101,6
Slovakia	115,52	108,14	116,33	108,74	106,06	107,53	111,44	121,9	117,41	118,75	121,12
Finland	108,8	108,1	108,6	108,7	109,8	110,8	116,3	115	116,1	137,3	:
Sweden	117,32	117,47	117,45	117,19	120,23	119,34	119,56	121,35	120,1	122,15	122,36
United Kingdom	92,6	90,8	90,3	89,8	89,2	88,6	88	93,6	96,2	98,8	103,1

:=Not available

The value of the production has remained fairly constant over the last decade, due to a rise in construction costs, at least until 2008 (see graph, source Eurostat). This includes not only labour costs, but also material costs rising from around 85 to 110 (ca. +30% =3,5% annually over 2000-2008).

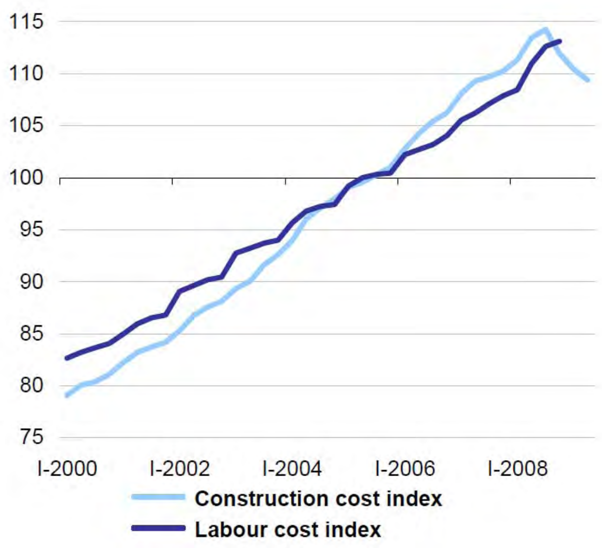

Figure 2 - 5.
Construction and labour cost trends

It is difficult to retrieve data on physical new building volume (in m³) in the non-residential sector, but anecdotal data from individual Member States show there has been effectively a strong decline.

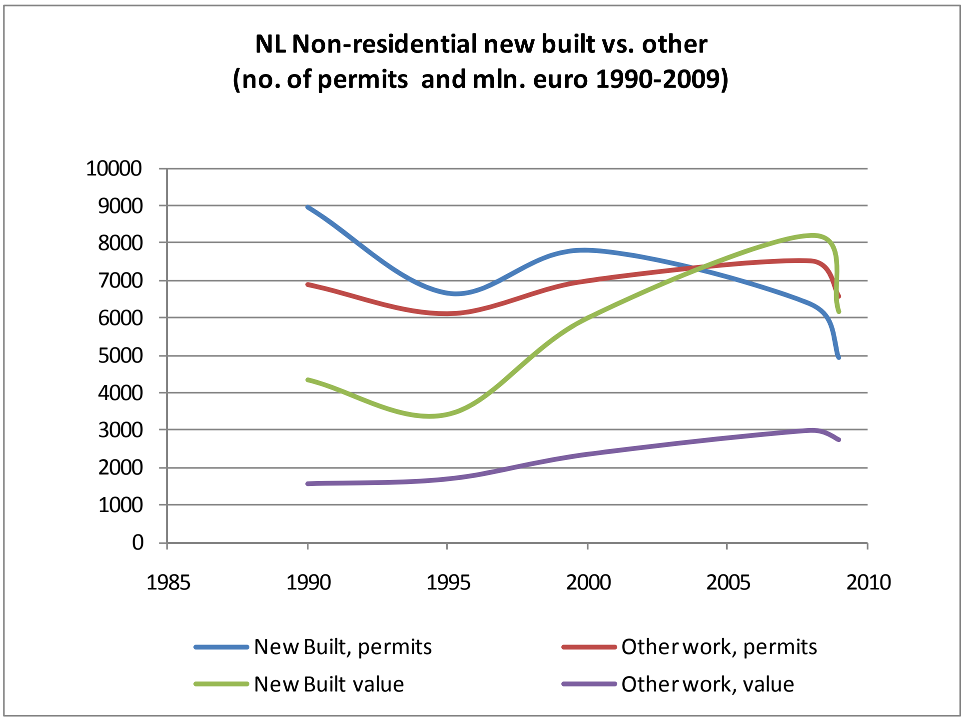

Figure 2 - 6. Netherlands non-residential market building permits

4.3 Market Players

4.3.1 Manufacturers AHU's

Manufacturers in the scope of this part of the study identify themselves as producers of air handling units, ventilation systems or both.

Manufacturers of AHU's represent one sector of the European Committee of Air Handling and Refrigeration Equipment Manufacturers EUROVENT. Related sectors deal with air filters, heat exchangers and ducts.

The purpose of EUROVENT is :

- To represent the European air conditioning, heating, ventilating and refrigeration manufacturers with national trade associations on International and European issues;
- To keep members informed of relevant legislation emanating from the European Union or other bodies;
- To develop a reliable global statistic reporting system;
- Through the Eurovent Certification Company, develop product certification programmes for our industry;
- To assure participation in international standardization;
- To improve communication on general issues such as refrigerants, energy or indoor air quality;
- To publish guides and technical application manuals;

- To develop co-operative pre-competitive research;
- To prepare the Association as an organisation that can self regulate our industry.

Main focus of Eurovent is the Refrigeration and Air handling equipment.

Not all Eurovent members are AHU-producers. The list below shows the producers that currently have Eurovent certification.

Table 2 - 13. EUROVENT: AHU Manufacturers certified

	KLISOM Klima Sogutma Isitma Montaj San. Ve Tic A.S. (KLISOM)
ACS KLIMA IMALAT SAN.TIC. LTD SIRKETI (ACS)	LENNOX EUROPE (LENNOX)
AIRCHAL SAS (AIRCHAL)	MAICO GULF LLC (DYNAIR)
AIRWELL GROUP (WESPER, AIRWELL, ELECTRA)	MEKAR s.r.l. (MEKAR)
AL SALEM YORK Manufacturing Co, Ltd (YORK)	Munters Belgium S.A DH Division (TOUSSAINT NYSSENNE)
AL-KO THERM GMBH (ALKO)	NOVENCO (Novenco)
ALARKO CARRIER SAN. TIC. A.S. (CARRIER)	PAMSAN A.S (PAMSAN)
ALDAG Isitma Sog. Klima San.ve Tic AS (ALDAG)	PETRA ENGINEERING INDUSTRIES CO. (PETRA)
CARRIER HOLLAND HEATING B.V. (CARRIER)	RHOSS S.p.A (RHOSS)
CIAT (CIAT)	ROBATHERM GMBH+Co.KG (ROBATHERM)
COVENT AS (COVENT)	ROSENBERG VENTILATOREN GmbH (ROSENBERG)
EFATAR Group (COLD MAGIC)	ROX KLIMATECHNIK GmbH (ROX LUFTTECHNIK)
EQUIPAMENTOS DE VENTILACAO E AR CONDICIONADO, S.A. (EVAC)	Saiver srl (SAIVER)
ETA Engineering Pvt. Ltd (ETA)	SANDOMETAL Metalomecanica e Ar Condicionado, SA (SANDOMETAL)
EUROCLIMA APPARATEBAU GmbH (EUROCLIMA)	SAUDI AIR-CONDITIONING MANUF. CO. (CARRIER)
EUROCLIMA S.p.A. AG (EUROCLIMA)	Shanghai Yileng Carrier Air Conditioning Equipment Co, Ltd (CARRIER)
FLAKT WOODS AB (FLAKT WOODS)	SKM Air Conditioning LLC (SKM)
GEA Air Treatment Services GmbH (GEA Air Treatment)	SONMEZ METAL ENDUSTRI VE TICARET AS (SONMEZ)
GEMCOOL Corporation FZC (GEMCOOL)	Swegon AB (SWEGON)
GIORDANO RIELLO INTERNATIONAL GROUP SPA (AERMEC , FAST)	SYSTEMAIR A/S (SYSTEMAIR)
HESA Havalandirma Endustri Sanayli ve Ticaret ltd. sti. (HSK)	TCF TERMOVENTILATORI CONDIZIONATORI FELSINEA SRL (TCF)
HIDRIA IMP KLIMA d.o.o. (HIDRIA)	TRANE (TRANE)
HYDRONIC (HYDRONIC)	TURAN Klima SAN. ve TAHHUT C.S. (Turan)
IMEKSAN Izmir Menfez Klima Sanayi Ltd. Sti. (Imeksan)	UAB AMALVA (KOMFOVENT)
INTERKLIMA S.A. (INTERKLIMA)	UNIC S.A.L. (COOLER)
IV PRODUKT AB (IV PRODUKT)	UNTES (UNTES)
J & E Hall Refrigeration Sdn.Bhd (J & E Hall, McQuay, DAIKIN, ACSON)	VIEIRA LOPES (OCRAM-CLIMA)
JOHNSON CONTROLS (YORK)	VTS sp. z o.o. (VENTUS)
KLAS ISITMA SOGUTMA KLIMA SANAYI TICARET LTD STI (KLAS)	WOLF GmbH (WOLF)
KLIMAKAR Klima Sanyi ve Ticaret AS (FOUR SEASON, ATC)	ZAMIL AIR CONDITIONERS (ZAMIL & COOLINE)

4.3.2 Ventilation unit manufacturers

The are several hundred small and medium sized companies in Europe, producing and/or selling either components for, or the complete mechanical ventilations systems that are discussed is this Preparatory Study. The list below represents a list of companies that are active in the field of Heat Recovery and of which some companies also produce products for the non HR-ventilation systems. In principle they all produce both residential and non-residential units. Apart from this list there are numerous companies producing (or importing) and selling all kinds of mechanical extract and supply units (fans and boxed fans), passive air inlet devices, air transfer devices, orifices, ducts, controls, cowls, etc.

Table 2 - 14. Incomplete list of companies producing and/or selling mechanical (HR-) ventilation units

Company	Web	HR	SUP.	EXH.
AUSTRIA				
Drexel und Weiss	http://www.drexel-weiss.at/	x		
Frivent	www.frivent.at	x		
CZECH REPUBLIC				
Atrea	www.atrea.cz	x		
GERMANY				
Aerex	www.aerex.de	x		
Airflow Lufttechnik GmbH	www.airflow.de	x		
Alpha-InnoTec GmbH	www.alpha-innotec.de	x		
Benzing Lüftungssysteme GmbH	www.benzing-ls.de	x		x
Bosch Thermotechnik GmbH	www.junkers.com	x		
Dimplex Airsystems	www.dimplex-airsystems.eu	x		
EnEV-AIR GmbH	www.enev-air.de	x		
GLT Grohmann	www.glt.de	x		
Heinemann GmbH	www.heinemann-gmbh.de	x		
Helios Ventilatoren GmbH + Co.	www.heliosventilatoren.de/start.html	x		x
Kampmann GmbH	www.kampmann.de	x	x	x
LÜFTA Wohnlüftsysteme GmbH	www.luefta.de	x		
LUNOS Lüftungstechnik GmbH	www.lunos.de			x
Maico GmbH	www.maico.de	x		x
Meltem Lüftungsgeräte GmbH & Co. KG	www.meltem.com	x		x
Öko-Haustechnik inVENTer GmbH	www.inventer.de	x		
Paul Wärmerückgewinnung GmbH	www.paul-lueftung.net	x		
Pluggit GmbH	www.pluggit.com	x		
Rosenberg Ventilatoren GmbH	www.rosenberg-gmbh.com	x		
SCHAKO KG	www.schako.de	x		
Schrag GmbH	www.schrag.de	x		
Siegenia-Aubi	www.siegenia-aubi.com	x	x	x
Stiebel Eltron GmbH & Co.KG	www.stiebel-eltron.de	x		
Trox	www.trox.de			
Vaillant Deutschland GmbH & Co. KG	www.vaillant.de	x		
Viessmann Werke GmbH & Co.	www.viessmann.de	x		
Westaflexwerk GmbH	www.westaflex.com	x		
Wolf Lüftungstechnik	www.wolf-heiztechnik.de	x		
Zehnder GmbH	www.zehnder-online.de	x		
Systemair GmbH	www.systemair.com	x		x
DENMARK				
Airmaster	www.sirmaster.dk	x		
Danfoss	www.lueftung.danfoss.com	x		
Exhausto	www.exhausto.dk	x		

Genvex	www.genvex.dk	x		
Nibe	www.nibe.dk	x	x	
NILAN A/S	www.nilan.dk	x		
FINLAND				
Enervent	http://www.enervent.fi	x		
Vallox	www.vallox.fi	x		
FRANCE				
aereco GmbH	www.aereco.de			x
Aldes	www.aldes.de	x		x
Anjos Ventilation	www.anjos-ventilation.com			
Atlantic	http://www.atlantic-ventilation.com/	x		x
Autogyre	www.autogyre.fr			
Caladair International	www.caladair.com			
CIAT	www.ciat.fr			
France Air	www.france-air.fr			
Unelvent	www.unelvent.com			x
Ventil´distribution				
ITALY				
VORTICE ELETTROSOCIALI S.p.A.	www.vortice-export.com	x	x	x
LIECHTENSTEIN (markets AT, CH, DE, etc., Total 15 countries)				
Hovalwerk AG	www.hoval.li	x		
LATVIA				
Salda	www.salda.lt	x		
NETHERLANDS				
Bergschenhoek	www.ihb.nl	x		x
Brighten up your life	www.brightenupyourlife.nl	x		x
Brinkclimatesystems	www.brinkclimatesystems.nl	x		x
ClimaRad BV	www.climarad.nl	x		
Ferroli	www.agpoferroli.nl	x		
ITHO	www.itho.nl	x		x
J.E. Storkair	www.jestorkair.nl	x		x
Orcon	www.orcon.nl			
SMEETS Luftbehandlungs-	www.jos-smeets.nl	x		x
POLAND				
ASK	www.asp-polska.com	x		
SWEDEN				
Enventus	www.enventus.com	x		
Fläkt Woods	www.flaktwoods.com/ventilation	x		
Flexit Sverige	www.flexit.com			
Fresh	http://www.fresh.se	x		
IV Produkt	www.ivprodukt.se	x		
Luftmiljö	www.luftmiljo.se	x		x
Östberg	www.ostberg.com	x		
REC INDOVENT	www.rec-indovent.se	x		
Swegon	www.swegon.com	x		
Ventilation & Energie	www.ventoenergi.com			x
Switserland				
Kapag	www.kapag.ch	x		
SPAIN				
Soler & Palau GmbH	http://www.soler-palau.com	x	x	x
UNITED KINGDOM				
All Four Seasons Ltd.	http://www.allfourseasons.co.uk/		x	x
Enviro Vent	www.envirovent.com/specifier/specifier.php	x	x	x
Glen Dimplex	www.dimplex.co.uk/index.htm	x		
Greenwood Air Managment LTD	www.greenwood.co.uk/products.asp	x	x	x
Nuaire	www.nuaire.co.uk	x	x	x
Passivent	www.passivent.com	x		
Robinson Willey Ltd	www.robinson-willey.com			
Titon	www.titon.co.uk	x	x	x
Vent Axia	www.vent-axia.com	x	x	x

Xpelair Applied Energy Products LTD	www.applied-energy.com	x	x	x

The majority of these manufacturers of *mechanical residential ventilation equipment* purchase their fans (pre-assembled motorized impellers) from dedicated fan manufacturers and subsequently develop and assemble around this OEM-component their own mechanical ventilation unit for either exhaust, supply or HR-function. For the exhaust and supply units, this additional development is relatively simple and involves mainly topics like air flow optimisation, minimisation of noise and vibration and ease of installation, and controls. For Heat Recovery Units a lot more technical aspects are involved in the development process at both product- and system level, amongst which:

- heat recovery efficiency
- pressure drop / airflow optimisation
- flow balance
- air tightness heat exchanger
- air tightness air channels (internal and external)
- comfort (speed and temperature of supply air, noise)
- air filtering
- removal of condensate
- frost protection
- controls
- noise and vibrations
- maintenance (cleaning and replacement of components)
- durability of specs over time
- mixing of air (for room based HR-units)
- ventilation effectiveness
- total unit efficiency
- ease of installation (preferably foolproof)

In this context, optimisation of the fan (impeller and motor efficiency) is left to the fan manufacturers.

The other OEM-components that are involved here are filters and heat exchangers and sensors/controls. The manufacturers that are specialized in the design and manufacture of these components develop dedicated solutions for their clients in the residential ventilation sector.

The development of a new mechanical HR-unit from scratch to products sold, typically takes 2 to 3 years.

Apart from these mechanical ventilation units a large number of other components are necessary to build a fully functioning ventilation system, especially for the centralized systems that need tubing of all kinds, adapters, fasteners, noise dampers, inspection hatches, orifices, wall ducts, grids, trickle vents, insulation, etc. Some companies provide and sell all these components, while others focus on the key components (mechanical ventilation units) and use standard installation materials/components from other suppliers.

Industry Associations for Ventilation exist on a Member State level, with often separate departments for companies dealing with natural ventilation, exhaust ventilation and heat recovery ventilation.

In most Member States the national association departments dealing with HR-ventilation are the most active ones, mainly because this type of ventilation involves a lot more technical guidance and education and training of system designers and installers, and because extra investments costs need to be accounted for to the DMU (Decision-Making-Unit) in the market chain.

On a European level there is no dedicated trans boundary association for manufacturers of Residential Ventilation systems. As a result, preparations on EU-legislation related to EUP for Residential Ventilation could so far not sufficiently be supported by specialist of the residential ventilation industry.

With the new **"European Ventilation Industry Association" (EVIA)** currently being established, this deficit shall be solved, and representatives of the EVIA can support future EU-projects on both residential and non residential ventilation.

VHK estimates the employment in manufacturing of AHU's and other non-residential ventilation units to be around 10.000 people.

4.3.3 HVAC Professionals

Other relevant EU-associations and organisations are:

REHVA: Federation of European heating, ventilation and air-conditioning associations
REHVA, established in 1963, connects European professionals in the area of building engineering services (heating, ventilating and air-conditioning for energy efficient healthy buildings) and, representing more than 100 000 engineers from 28 European countries. REHVA´s main activity is to develop and disseminate economical, energy efficient and healthy technology for mechanical services of buildings.

REHVA is the "*leading professional organization in Europe, dedicated to the improvement of health, comfort and energy efficiency in all buildings and communities. It encourages the development and application of both energy conservation and renewable energy sources. In these areas, REHVA has a significant impact on National and International strategic planning and research initiatives, as well as on the associated educational and training programmes.*"

REHVA has developed contacts with important Directorates in European Commission. DG Energy and Transport in for energy issues, and DG Health and Consumer Affairs for indoor environmental issues. REHVA regularly keeps the contact with most important officers and informs them regarding the needs of HVAC industry, and also REHVA´s members regarding the upcoming directives and regulations on European level.

EVHA: European Ventilation Hygiene Association

The European Ventilation Hygiene Association (EVHA) was founded in 1999 by a small group of people representing a number of countries across Europe. The purpose for founding this Association was "*based on the idea that one day Ventilation Hygiene would play a huge role within the Union and therefore, it was imperative that a degree of professionalism was brought to an industry that was and still is, in its infancy.*"

The EVHA has a current membership across a broad spectrum of companies that are actively involved in the ventilation hygiene marketplace, including contractors manufacturers and university professionals.

The aim is *"to unify our marketplace throughout Europe and become a voice, a single voice, for all those that care passionately about our industry and our environment."*

The EVHA Guides that were introduced in November 2006 are currently being updated as part of our continual upgrade program. It concerns the "Guide to Cleaning and Hygienic Management of Ventilation Systems" and the "Guide to Cleaning and Risk Management of Grease Extract Systems."

The first European training and certification programme took place in Copenhagen on the 10th and 11th January 2008.

AIVC: Air Infiltration and Ventilation Centre

In recognition of the significant impact of ventilation on energy use, combined with concerns over indoor air quality, the International Energy Agency (IEA) inaugurated the Air Infiltration and Ventilation Centre in 1979 (To be more precise, the AIVC is one of the annexes running under the ECBCS, Energy Conservation in Buildings and Community Systems, which is one of the Implementing Agreements of the IEA). The AIVC offers industry and research organizations technical support aimed at optimising ventilation technology.

AIVC offers a range of services and facilities, including comprehensive database on literature standards, and ventilation data. They also produce a series of guides and technical notes.The Centre holds annual conferences and workshops. We also publish a quarterly newsletter, Air Information Review. Through this newsletter, the readers are informed of a wide range of ventilation related issues. The operating agent of the AIVC is INIVE eeig (www.inive.org)

INIVE: International Network for Information on Ventilation and Energy performance

NIVE is a registered European Economic Interest Grouping (EEIG) founded in 2001. From a legal viewpoint its full members act together as a single organisation and bring together *“the best available knowledge from its member organisations.”*

The present full members are organisations in the building sector, with expertise in building technology, human sciences and dissemination/publishing of information. They also actively conduct research in this field.

INIVE has multiple aims, including the collection and efficient storage of relevant information, providing guidance and identifying major trends, developing intelligent systems to provide the world of construction with useful knowledge in the area of energy efficiency, indoor climate and ventilation. Building energy-performance regulations are another major area of interest for the INIVE members, especially the implementation of the European Energy Performance of Buildings Directive.

4.3.4 Distributors

Non-residential ventilation systems may be delivered directly to the installer, via a distributor or directly to the end-user. Over 90% of air handling units, i.e. units over the size of ca. 4500 m^3/h, is delivered directly to the contractor/installer.

Products may be specified by a consultant engineer (for larger installations) or an installer (for smaller installations). Smaller ventilation products (below 4500 m^3/h) are often sold through a wholesaler.

Total output for service & installation of air conditioning and ventilation systems in 2009 is set by Eurostat at € 8,7 bln. (see chapter 1). At an average turnover of 100-150.000 per employee this means an employment of 60-80.000 staff, of which an estimated 30% (20-27.000) can be partitioned to non-residential ventilation.

4.3.5

4.3.6 Cost structure

For a number of reasons, it is very difficult to give a generic breakdown of the prices/costs of non-domestic ventilation units:

- Unit prices vary from less than € 200 for standard central exhaust units up to a few € 100.000 for a custom-built air handling unit. With the prices also the margins and cost structure vary. Small standard products follow the route from producer-wholesale-retailer-installer-builder-customer, with sometimes –depending on the project- an additional partitioning of installation engineer costs. With each party taking some 20-30% margin (<10% for engineer) the total price excl. VAT that the consumer pays may be 2,5 – 3,5 times the manufacturer selling price. Whereas the large units may be sold directly from manufacturer to builder (with the intervention of a specifier/ engineer) and the final customer pays only twice the msp.
- Given the unpredictable nature of the sales chain, manufacturer list prices are always very much on the safe side and it is not unusual for installers to give more than 30% discount to their best customers (15% is more or less standard).
- VAT is mostly a price element not taken into account, e.g. in most non-residential applications, but sometimes, e.g. in the (collective) residential sector, it is a real part of the costs;
- Unit prices are only a fraction of the total acquisition costs. Additional installation materials like ducts, grilles, controls, etc. often cost as least as much and the labour costs may be as high as the total unit + material costs.
- Labour costs and margins vary largely between EU Member States. ENER Lot 1 mentions that boilers prices in Scandinavian countries, Germany and Austria are around 60-70% above EU average, while Eastern European countries may be 50% below the average and Southern EU countries are around 20-30% below average. "Average" countries in terms of pricing, within a margin of 10%, are e.g. France, the Netherlands and the United Kingdom.

Data availability is poor. Sector-specific averages of the non-residential product pricing could not be found. For the domestic ventilation sector FGK[11] recently published some indicative figures, which may be transferable to the smaller non-residential applications (< 3.000 m³/h), but data for larger installations were not given. Professionals like installation engineers usually work with commercial databases that give default values for material and labour costs. But the level of detail is limited and the assumptions behind the figures may vary, depending on the country and the specific application. Nevertheless, it is one of the better data sources and therefore the Annex X gives the cost breakdown of ventilation systems in several non-residential building projects. List prices, also included in the same Annex, show a highly inflated picture of the prices that are actually paid. Especially "de luxe" items that are relatively new for the sector, like DC motors, CO_2 sensors, wireless communication, etc. – are usually subject to a heavy commercial bonus. Still, in some instances the relative proportion shown in price lists may be helpful.

The estimate of the cost structure is presented in the table on the next page.

For smaller central heat recovery units and the central exhaust ventilation data from the FGK study were used as a basis and corrected for the non-residential sector.

For the split-up of the air handling units, the data were taken from the analysis by elemental consulting, but without the cost mark-up for the air-conditioning. See Annex II for further details.

[11] FGK, Supplement to preparatory study, 2010. (DG ENER Lot 10)

Table 2 - 15. Cost split up of non-residential ventilation units

	CEXH		CHRV	
	margin	msp x	margin	msp x
labour costs for finishing, assembly, testing and packaging	15%	0,15	20%	0,20
subassemblies, materials and components	50%	0,50	40%	0,40
manufacturer overhead (admin., sales, R&D, capital, margin)	35%	0,35	40%	0,40
manufacturer selling price (msp)		*1,00*		*1,00*
wholesale	30%	1,30	30%	1,30
installer	25%	1,63	25%	1,63
main contractor/builder incl. design costs	30%	2,11	30%	2,11
selling price excl. VAT		*2,11*		*2,11*
installation materials (grilles, ducts, etc.)	210%	6,55	35%	2,85
Installation costs (labour)				
Renovation (first installation in existing building)	93%	12,64	75%	4,99
New built (no barriers to built ductwork, etc.)	38%	9,04	45%	4,14
At 50/50 split between new built and renovation	65%	10,81	60%	4,56

	AHU-S		AHU-M		AHU-L	
	margin	msp x	margin	msp x	margin	msp x
labour costs for finishing, assembly, test, etc.	17%	0,17	15%	0,15	10%	0,10
subassemblies, materials and components	38%	0,38	35%	0,35	30%	0,30
manufacturer overhead	45%	0,45	50%	0,50	60%	0,60
manufacturer selling price (msp)		*1,00*		*1,00*		*1,00*
wholesale	20%	1,20	10%	1,10	5%	1,05
installer	20%	1,44	10%	1,21	8%	1,13
main contractor/builder incl. design costs	30%	1,87	30%	1,57	30%	1,47
selling price excl. VAT						
installation materials (grilles, ducts, etc.)	360%	8,61	680%	12,27	1200%	19,16
Installation costs (labour)						
Renovation (first installation in existing building)	80%	15,50	80%	22,08	80%	34,50
New built (no barriers to built ductwork, etc.)	50%	12,92	50%	18,40	50%	28,75
At 50/50 split between new built and renovation	70%	14,64	65%	20,24	65%	31,62

5 Expenditure base data

5.1 Overview

Relevant expenditure data for this product group are

Acquisition costs:

- Product prices,
- Installation costs

Running costs:

- Electricity rates (small commercial up to industrial rates)
- Aggregated space heating/cooling rates (to calculate the merits of heating/cooling recovery)
- Consumables (filters)
- Repair and maintenance costs
- Interest and inflation rates

Disposal costs are assumed negligible.

5.2 Acquisition costs

Product prices and installation costs

Based on the cost structure in the previous sector and market prices as presented in the Annex X, the costs for the 5 principal ventilation products in the scope is given below. The Products are a central exhaust unit (CEXH), a central heat recovery ventilation unit (CHRV) and 3 air handling units in 3 different capacities Small-Medium-Large (AHU-S, AHU-M, AHU-L).

Table 2 - 16. Prices base-case non-residential ventilation units (Sales 2010)

Product -->	CEXH	CHRV	AHU-S	AHU-M	AHU-L
Features					
flow rate (m^3/h) [5]	**1.500**	**2.250**	**4.000**	**10.000**	**35.000**
Ext. ΔP (in Pa) [6]	154	181	244	460	670
HRS market share[7]	0%	100%	70%	70%	70%
HRS thermal efficiency [8]	0%	80%	62%	62%	62%
PRICES in Euro 2010					
	CEXH	CHRV	AHU-S	AHU-M	AHU-L
labour	45	500	680	1.200	2.000
materials	150	1.000	1.520	2.800	6.000
overhead	105	1.000	1.800	4.000	12.000
msp	***300***	**2.500**	***4.000***	**8.000**	**20.000**
wholesale price	390	3.250	4.800	8.800	21.000
installer price [1]	488	4.063	5.760	9.680	22.680
builder price [2]	634	5.281	7.488	12.584	29.484
ducts, grills, ctrls [3]	1.965	7.130	34.445	98.155	383.292
inst. labour avg. [4]	2.172	8.072	37.692	106.229	412.175

[1]= end-customer unit price replacement (excl. VAT)

[2]= end-customer unit price new built/retrofit (excl. VAT)

[3]= not for replacements

[4]= "avg."= For CHRV the split up is 45/45/10 between new built/retrofit/replacement(in 2010); for CEXH and AHU the split up is 35/30/35 between new built/retrofit/replacement(in 2010).

END PRICES					
Inst. labour new built	*2.711*	*10.338*	*51.667*	*147.233*	*574.938*
Inst. labour retrofit	*3.792*	*12.477*	*62.001*	*176.679*	*689.926*
inst. replacement(50% on ex installer price)	*244*	*2.031*	*2.880*	*4.840*	*11.340*

[5] Design flow rate F (in m³/h)= 65% of flow rate at 0 Pa [EN 13799]

*[6]Design external pressure drop h (in Pa), according to EN 13799 is measured at 65% of maximum (flow rate=0). Practical values above are estimated as follows: if design flow rate F<10.000 m³/h then href= 0,036*F+100 ; if 10.000≤ F <25.000 m³/h then href=0,0146*F+304; if F≥25.000 m³/h then href=75*ln(F)-190,5 (equation Kaup, supply side, but subtract 100 for heat/cool coil)*

[7] HRS=Heat Recovery System. First estimates

Based on the above, the following graphs give a partitioning of the total costs per application: new built, retrofit (1st time installation) and replacements.

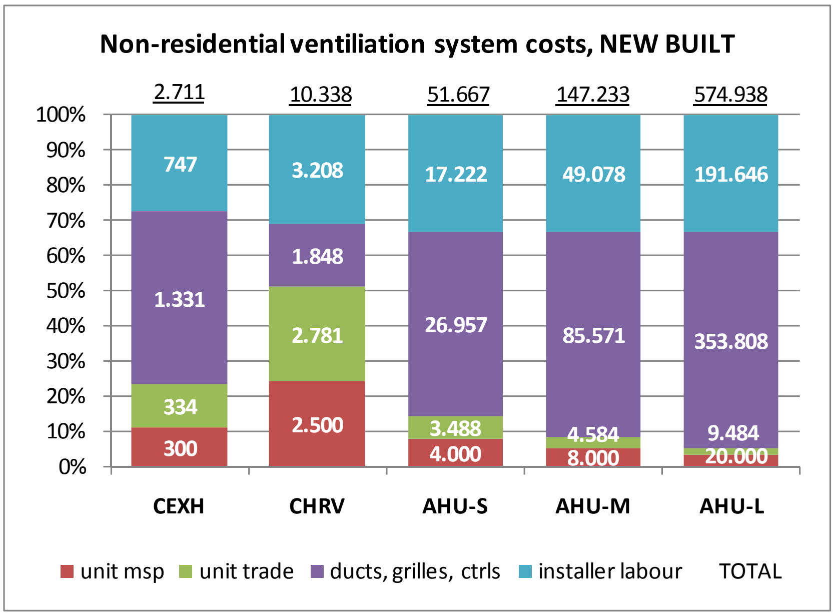

Figure 2 - 7. System costs, ventilation in new buildings

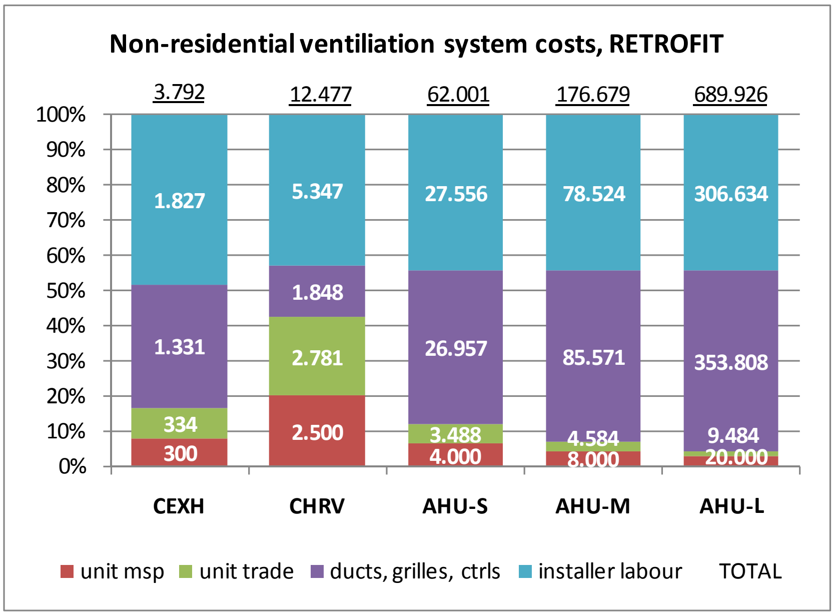

Figure 2 - 8. System costs, ventilation retrofit in existing buildings

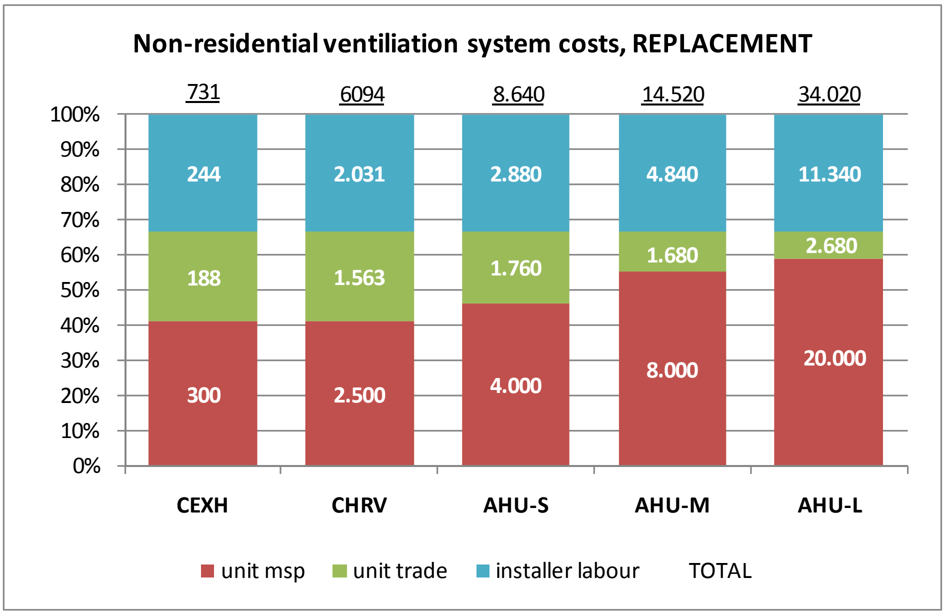

Figure 2 - 9. System costs, unit replacement

5.3 Cost Rates

5.3.1 Electricity and fuel rates

Ventilation units consume electricity but save on space heating fuel, thus both rates are relevant. Furthermore, rates differ between small commercial/residential clients and industrial/large commercial clients. Finally, the price increase of both electricity and fuel, in absolute value and at constant prices are relevant for calculations in the remaining tasks. The table below gives a summary of the rates used (source Eurostat):

Table 2 - 17. Energy rates EU27 for reference years, long term increments (users 3500 kWh/a)

Abbreviation	Value	Description
Rel2005	0,152	Electricity rate 1.1.2006 [€/ kWh electric] Eurostat
Rel2009	0,164	Electricity rate 1.7.2009[€/ kWh electric] Eurostat
Relinc	2%	Electricity annual price increase
RelInfInc	0%	Electricity annual price inflation corrected (2%)--> constant prices 2005
Rgas2005	0,047	Gas rate 2005 [€/ kWh primary GCV]
Roil2005	0,061	Oil rate 2005 [€/ kWh primary GCV]
Rfuel2005	0,053	2005 average space heating mix rate [€/ kWh primary GCV] : rates as above, weighting at 76% gas, 21% oil, 3% electric
Rfuel2009	0,058	[€/ kWh primary GCV];
Rfuelinc	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.
RfuelInfInc	5,30%	Fuel annual price increase inflation corrected (2%) --> constant price 2005
Rfuel2018	28,5	[€/ GJ primary GCV]= € 0,102/kWh; Used in LCC-calculations. Fuel price halfway product life, starting 2010/2011

Table 2 - 18. Energy rates EU27 for reference years, long term increments (industrial/larger commercial users)

Abbreviation	Value	Description
RLel2009	0,107	Electricity rate 1.7.2009[€/ kWh electric] Eurostat
RLelinc	2%	Electricity annual price increase
RLelInfInc	0%	Electricity annual price inflation corrected (2%)--> constant prices 2005
RLgas2005	0,0216	Gas rate 2005 [€/ kWh primary GCV]
RLgas2009	0,0388	Gas rate 2009 [€/ kWh primary GCV]
Roil2009	0,044	Oil rate 2009 [€/ kWh primary GCV]
Rfuel2009	0,036	2005 average space heating mix rate [€/ kWh primary GCV] : rates as above, weighting at 76% gas, 21% oil, 3% electric
Rfuelinc	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%
RfuelInfInc	7,30%	Fuel annual price increase inflation corrected (2%) --> constant price 2005
Rfuel2018	19,9	[€/ GJ primary GCV]= € 0,102/kWh; Used in LCC-calculations. Fuel price halfway product life, starting 2010/2011

A split-up of energy rates per country can be found in the DG ENTR Lot 6, Task 2 report on air conditioning systems.

For scenario modeling, in constant prices, one fixed rate (e.g. Rel2009, Rfuel2009) and the inflation-corrected increments (RelInfInc, RfuelInfInc) are used. Scenario/impact modelling is the subject of Task 7/8, and later Impact Assessment, and it uses stock assessments per year.

For Life Cycle Cost (LCC) calculations, the average inflation-corrected electricity rate for 2018 (Rel2018=Rel2009= € 0,164/kWh) and the 2018 fuel rate (Rfuel2018= € 28,5 /GJ) can be relevant parameters for checking the life cycle costs. Alternatively, the average price increases of the fuel and electricity can also be integrated in the Present Worth Factor PWF, together with product life, interest and inflation rate (see hereafter).

5.3.2 Interest, inflation, discount rates and product life

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:

- Product life *N* 17 years;
- 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.

5.3.3 Maintenance and repairs

Maintenance costs consist of duct cleaning (assumed once every 10 years) and –most importantly— air filter costs. Especially in air filters there is a wide range of options in typology with significant differences in filtration effectiveness, filter life, internal pressure loss and thus price.

Central exhaust units (‘CEXH’) do not have filters and there the maintenance can be limited to a duct cleaning. But there is also a small segment (in the UK or in special applications) of central supply units. Elsewhere in this report it is assumed to show the same characteristics as the central exhaust units, but on this particular point there is a large difference, i.e. in filter costs: CEXH has none, whereas CSUP (abbreviation for central supply ventilation unit) does have the burden of F7 filter costs.

As a baseline 15% of electricity costs are taken as a basis for the maintenance and repair costs in the baseline calculations.

ANNEXES

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ANNEX I : Sales and stock data sources

DATA RETRIEVAL & ANALYSIS FOR SALES AND STOCK VENTILATION SYSTEMS

Statistics show a fair amount of “cross-contamination” between AHU and central balanced ventilation units and central exhaust (or supply) units. In the following paragraphs VHK will try to make the best estimate after presenting the data available, but it is clear that accuracy will not be high.

Data sources: ‘Bottom-up’ approach

BSRIA is –amongst others-- a market research company that gets its data from interviews and literature. The table below gives BSRIA sales and capacities for the six countries where data are available .

Table I.1 . AHU unit sales and estimated capacity 2008, according to BSRIA definition (source BSRIA 2009)

m^3/s classes	average m³/h per class	COUNTRY												TOTAL	
		France		Germany		Greece		Italy		Spain		UK			
		units	Mm^3*	units	Mm^3	units	Mm^3	units	Mm^3	units	Mm^3	units	Mm^3	units	Mm^3
< 1,53	**3600**	5.734	20,6	9.380	33,8	600	2,2	1.895	6,8	1.410	5,1	1.298	4,7	20.317	73,1
1,54 - 2,36	**7020**	1.856	13,0	12.078	84,8	680	4,8	3.468	24,3	2.629	18,5	2.596	18,2	23.307	163,6
2,37 - 4,25	**11916**	1.498	17,9	11.366	135,4	920	11,0	10.295	122,7	4.940	58,9	2.726	32,5	31.745	378,3
4,26 - 6,61	**19566**	1.664	32,6	7.992	156,4	260	5,1	19.708	385,6	2.095	41,0	2.596	50,8	34.315	671,4
6,62 - 9,44	**28908**	1.050	30,4	7.070	204,4	100	2,9	2.009	58,1	775	22,4	1.623	46,9	12.627	365,0
9,45 - 18,9	**51030**	653	33,3	3.188	162,7	40	2,0	1.607	82,0	508	25,9	1.947	99,4	7.943	405,3
>18,9	**72000**	346	24,9	926	66,7	30	2,2	1.194	86,0	343	24,7	495	35,6	3.334	240,0
total		12.801	172,7	52.000	844,1	2.630	30,1	40.176	765,5	12.700	196,4	13.281	288,1	133.588	2296,8
average m³/h (calc.)		**13.489**		**16.233**		**11.436**		**19.054**		**15.465**		**21.692**		**17.193**	

**= million m³/h*

**= note that only individual sales and capacity numbers stem from BSHRIA. Conversion of m³/s class to m³/h average by VHK

As the aforementioned 6 countries make up around two-thirds of the market, BRE concludes that the AHU sales are around 185.000 units in 2007. In 2009 the sales will be 10-20% lower, due to the economic crisis. The German market is the largest and therefore additional sources were compared with BSRIA data.

The ***Herstellerverband Raumlufttechnisher Geräte RLT*** is the German association of ventilation unit manufacturers, pre-dominantly aiming at the non-residential market. Members are AL-KO THERM, Berliner Luft, FlaktWoods, GEA Klimatechnik, Howatherm, Huber & Ranner, Klimatec, NOVA, Robatherm, Rosenberg, ROX, Troges, Weger, Wolf (Centrotec group), Wolf-Anlagentechnik.

The table below shows the result of a market survey amongst RLT –Members:

Table I.2 . Herstellerverband RLT, Germany. Production of air handling units(source C. Kaup, 2009)

Year	Turn-over Mio.€	Export Mio.€	Export %	Units	with HR	HR %
2006	323,8	88,1	27,2	43.759	11.108	25,4
2007	365,5	106,2	29,1	43.656	11.941	27,4
2008	431,4	111,3	25,8	42.236	15.569	36,9
3 yr. average	373,6	101,9	27,4	43.217	12.873	29,9

RLT reports a size distribution which is quite different from BSRIA, i.e. with approx. 40% of units smaller than 1,53 m³/s (ca. 17.000 units, compare BSRIA 18%, 9380 units). In 2008 heating coils (avg. 96,3 kW) are in 11.083 units and cooling coils (88,9 kW) are in 5.630 units of the total 42.236 units sold. This leaves 25.523 units with ventilation only (60% of total). Some 80% of sales are balanced units (supply + exhaust fans).

The RLT members cover only part of the German market. Several larger HVAC manufacturers like Trane, Carrier, Airwell, etc. are missing as are large boiler/radiator manufacturers (Vaillant, Viessmann, Zehnder) that have ventilation systems in their catalogue that (also) serve the small non-residential market. Also an industrial ventilation specialists like Hoval is not a member.

All in all, VHK estimates that RLT overlaps with BSRIA in the larger sizes, but clearly extends on sizes smaller than 5500 m³/h. Overall, also counting non-RLT members it is estimated that for these smaller classes some extra –ventilation only-- 20.000 ventilation only units have to be added to the BSRIA-total.

The commercial **Eurovent Market Intelligence** database has started the category ' Air Handling Units' only a few years ago and reckons that it is now covering around 40% of the AHU market. Especially a country like Germany is underrepresented (explaining probably the low flow rate). In this light the table below gives a first rough estimate of the average capacities. Coverage and therefore the data quality is expected to improve in the coming years.

Table I.3. Average capacity AHU per country

Country	m^3/h	Country	m^3/h
Austria	3.469	Luxembourg	805
Baltic states	6.599	Netherlands	4.290
Belgium	11.659	Poland	12.236
Bulgaria	7.657	Portugal	1.831
Cyprus and Malta	9.078	Romania	2.033
Czech Rep.	10.180	Slovakia	2.375
Denmark	5.973	Slovenia	1.908
Finland	10.975	Spain	12.700
France	9.078	Sweden	11.601
Germany	4.019	UK	13.281
Greece	18.543		
Hungary	8.145	AVERAGE	9.162
Ireland	14.184		
Italy	14.117		

The only public domain data source, **Eurostat,** was discussed in chapter 2. AHU's are incorporated in PRODCOM *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.* In itself, from its generic description, this category could also incorporate central ventilation ('ventilation only') units, but the corresponding CN8 trade categories categories 84158300 and 84158390 are clearer in this respect with the description that the products should incorporate *'elements for changing the temperature and humidity.* So therefore 'ventilation only' units are excluded. But of course fan coil units (FCU's) make up a large part of the number and Eurostat data have to be split coherently between AHU and FCU, using also FCU sales data. VAV and CAV boxes are believed to make up only a moderate part of the total, also because it is not clear whether all VAV and CAV boxes are included or only those preheating the air with electric resistance heating elements.

In that light it is relevant that Eurostat gives group sales for PRODCOM 28251270 BSRIA estimates FCU unit sales to be 1,7 million units in 2008 and 1,3 million in 2009 at a value (msp) for both years of around € 1,7 billion. BSRIA estimates FCU sales to be around 1,2 mln. units in 2008 and 0,95 mln.

units in 2009 for 14 countries that are believed to make up >90% of the EU-27 total. CAV&VAV unit sales are around 0,16 million units[12] and BSRIA reports AHU sales as being 0,2 mln. units. The BSRIA totals for FCU+AHU+CAV&VAV of 1,56 (2008) and 1,31 mln. units (2009) are close to Eurostat data. Based on anecdotal price data, the value of the production fairly matches an average estimated msp of € 5.500 per AHU and € 400 per FCU or average VAV/CAV box. Using these latter numbers we arrive at values of € 1,64 bln. (2008) or € 1,54 bln. (2009).

Overall, it is concluded that the Eurostat data confirm the accuracy of the BSRIA data at least for the larger sizes (hereafter 'AHU's). For the smaller sizes, which will be predominantly 'ventilation only' and will be defined as 'CHRV' Central Heat Recovery Ventilation an estimate will be made based on the RLT data. The limit between AHU's and CHRV's is –arbitrarily-- set at around 3,5 kW input power and 4500-5000 m³/h.

For the central exhaust unit the data from DG ENER Lot 11 will be used (see Annex).

Data sources: 'Top-down' approach

A top-down approach tries to verify whether unit sales and stock data are consistent with the building stock data. As will be clear from Task 3, reliable and detailed construction and stock data for the non-residential sector are hard to come by.

National and EU statistics offices give out data based on the number and volume (in m³) of building permits, where the problem is that a building permit may relate to a new building, a part of a new building, an extension of an existing building or –although this is usually specified separately—a renovation of an existing building. Hence, there is a considerable margin of error when estimating building stock and non-residential construction from building permits. The split-up between types of buildings ('retail', 'schools', 'factory', etc.) introduces a further error.

Another possible data source is the turnover of the construction industry (e.g. from Euroconstruct). These data are usually based on the value of the new construction and may be used to indicate trends, but they are not very helpful determining the absolute number and volume of buildings.

The most helpful are publications where national statistics offices, per country or working as a group, have made a specific effort and additional research in trying to establish the number and volume of non-residential buildings. Especially in the Nordic countries (Norway, Sweden, Finland) there are very detailed statistics on the non-residential building stock. In an EU-context the most detailed statistics come from joint annual publication on the building stock (e.g. Boverket 2005), which unfortunately stopped in 2006, for the EU building ministers.

In the DG ENER Lot 1 preparatory study, based on the above sources, a first estimate was made of the number and 'heated volume' of the EU non-residential sector.

For the collective residential (multi-family dwellings) sector the DG ENER Lot 1 preparatory study estimated a total heated volume of 17 bln. m³ (16 bln. m³ without the small commercial establishments) in 12,8 multi-family buildings. Of this, 1,5 mln. buildings (30 mln. dwellings are high-rise (>4 storeys) with a heated volume of around 6 bln. m³.

For the tertiary sector it was estimated that there is an EU 2005 stock of 4,74 mln. dedicated commercial and public buildings plus 4,3 mln. small commercial establishments (shops, restaurants, professional studio) that are part of a residential apartment building. For the dedicated buildings an average size of 2500 m² and 9000 m³ (at 3,6 m floor height) was estimated and a total heated

[12] For six countries making up two-thirds of EU-27 total, BSRIA reports total 2008 sales of 110.000 units, split up between 70 mln. VAV (of which 43 mln. fanned) and 40 mln. CAV boxes.

volume (@ 18 °C equivalent) of 42,7 bln. m³; the smaller units are probably on average 70-80 m² and 300 m³, with a heated volume of around 1 bln. m³.

For the agricultural and industrial sector (incl. warehouses), which is not within the scope of the underlying study but useful for analysis, an estimate of around 24 mln. m³ 'heated volume' was concluded, divided over 2,67 buildings.

All in all, the total 'heated volume' (at 18 °C equivalent) was estimated at 83,7 bln. m³/h.

Given the uncertainty of especially the nature of building permits, the estimate for the non-residential sector is probably on the high side.

VHK tried to incorporate an extra dimension by checking building data against statistics on 'economic activity', using at least the EU-totals of their own proprietary database. This is included in Task 3 report of DG ENTR Lot 6 study. It focuses on the '*ventilation volume demand*'.

One consequence of focusing on ventilated volume instead of heated volume, is in the average ceiling height without the 'plenum' ('false ceiling'). So, the floor height is more in the area of 3,2 m instead of 3,6 assumed for heating. Furthermore, the figures relate to the effective indoor area, which is excluding the interior and exterior walls. Finally, the ventilation rate was set for most sectors at 1-1,2 m³/h per m³ of building volume, which is conservative in particular for the tertiary sector. E.g. restaurants, sports facilities, auditoria/theatres, hospitals etc. have much higher (factor 2 to 8) nominal ventilation rates and it was assumed that this would be compensated by a) the fact that –even with a basic control—these would be peak-situations and the 'normal' ventilation rate would be much lower, and b) the fact that the standard ventilation rates for e.g. single offices, hotel rooms etc. have standard ventilation rates.

Task 3 concludes to a collective residential plus non-residential ventilated volume of around 68 bln. m³/h, of which 16 bln. in collective residential (incl. small commercial establishments), 23 bln. in industry and agriculture and 29 bln. in the tertiary sector: 15 bln. in (semi-)public and 14 bln. in commercial buildings.

Again, this figure relates to a standard comfort ventilation rate:

- It does <u>not include extra process ventilation</u>, like in operating theatres, laboratories, mines, etc..
- It does <u>not include the extra (fresh air) ventilation flow for air-heating or air-cooling</u> (air-based 'air-conditioning') if the ventilation unit is also used for that purpose. In this context, it can be seen that a ventilation unit for a combined functionality (an AHU) has a nominal supply air flow capacity that is 50% higher than that of a dedicated ventilation unit.[13] [14] If we assume that one-third of tertiary sector buildings has some sort of air-conditioning (cooling/heatin) and 50% of that portion are air-based systems, it means an extra 4,6 bln. m³/h of ventilation.
- It does <u>not include the ventilation rate sizing beyond the standards that is dependent on systems-considerations and comfort aspects</u>. For instance, there are minimum requirements for a balanced air-flow and there is one part of a building-zone that has higher air flow requirements (e.g. a restaurant) then also the adjacent 'open' parts of that zone (lobby, reception, offices) are influenced and will show (much) higher ventilation rates than is required. Another problem is the maximum air velocity (to avoid discomfort, partly also

[13] Or, formulated the other way around: The strict ventilation air flow is set at the design capacity (65% of nominal) of the air handling unit.

[14] And, although in the past recirculation was important, currently this extra air is very often 90% fresh (outside) air and thus has a significant impact on the heating/cooling load.

relevant for noise) which sometimes a more dominant design-factor than the ventilation air flow requirement.

- It constitutes a standard air-flow demand. It does not relate to the peak demand (extreme conditions) of the ventilation units in the building and therefore not to the maximum capacity of the ventilation units. According to the standards and certification test procedures, the actual ventilation airflow load is around 60-70% of the maximum/nominal load. In reality, especially for spaces with a high peak-load (restaurant, auditorium, etc.), the anecdotal data show that with appropriate control the actual average flow rate can be as low as 15-20% of nominal capacity. For instance, a 300 m² restaurant (around 1000 m³ volume) may have an average 24/24h occupancy of 20 people, with daily peaks at 100 people, but at parties, weddings, etc. it may contain as much as 200 people. And of course the nominal ventilation capacity has to match the 200 people.
- The air-flow is an estimate of the air-flow at current practice when engineers apply standards, but the air-flow does not represent the minimum possible air-flow that is still within those very same standards. The standards first of all concentrate on the determination of the nominal capacity needed. For this, simple design rules with air changes per hour or m³/h per m² for certain activity types are given. Subsequently, given that the majority of systems still work without demand-side control, the ventilation unit is manually set at a mid (65%) or nominal position and –apart from a possible night setback—stays fixed. However, with a good demand-control system, once the system is installed, the standards also give the option to regulate on a minimum air-flow per person (e.g. 10 l/s/pp) with a minimum for emissions from building materials. In that case, the ventilation rate might even be higher on peak-occasions but in general is much lower. Anecdotal data show that energy savings of over 40%, which implies that –given that heat loss is not only due to ventilation but also in part due to transmission and infiltration losses which do not change-- the average ventilation air flow may be >60% less.[15]

[15] Of course, this is very difficult if the ventilation unit is combined with an air-based air conditioning (air heating/cooling) function.

ANNEX II : Case study: Hotel (Elementa Consulting)

ANALYSIS HOTEL (150 ROOMS)

Elementa Consulting, OUTLINE PROJECT DESCRIPTION OF VRF VERSUS HYDRONIC COST ESTIMATION TASK FOR CARRIER, Hersham (Surrey, UK), 2006.

The project is a medium/large hotel with 150 guest rooms, restaurant, kitchen, gym, shop, reception/lobby and staff offices. Estimated heated floor area is ca. 5000 m², with public and staff areas on the ground floor and guest rooms on the floors above.[16] The climate is characterized by a design outdoor temperature of -8 °C for heating in winter and 30 °C for cooling in the summer (35 °C for VRF). Design heat loss of the building through fabric and infiltration is 171 kW (at -8 °C) in winter, divided between ground floor 33 kW and guestrooms 138 kW. The design heat gain at 30 °C is 333 kW in summer, split between groundfloor 86 kW and guestrooms 247 kW. The design indoor temperature is 21 °C for heating and –on average 22-23 °C—for cooling.

Two separate installation solutions and their respective costs are calculated:

- one 'hydronic' solution with a central chiller (255 kW), a central boiler (318 kW + 318 kW back up), an air-based VAV system (with water-based heating coil) for the ground-floor, water-based fan coil units (FCU's) for the guest rooms;
- another 'VRF' solution with 28 VRF ceiling & wall units at ground floor level (1 external VRF unit) and refrigerant-based FCU's for the guest rooms (5 external VRF units).

Costs are similar, at £ 472.418 equipment costs and 7.358 labour hours for the hydronic solution and £ 506.785 equipment costs and 7.417 labour hours for the VRF solution (cost data Oct. 2006).

Ventilation of the guest rooms with both design solutions is identical: 1 AHU of 2,4 m³/s (8600 m³/h) supplies and extracts ca. 60 m³/h to every room, whereby the (oversized, to keep air velocity within comfort limits) supply grille is in the bedroom area and the extract grille is in the bathroom. The 60 m³/h ventilation rate is determined by the requirements for the bathroom when in use; for a single room and at the requirements of a hotel room in the EU (25 m³/h pp) it is oversized.

The guestroom AHU does not have a cooling coil and only a relatively small (pre/post 13-21 °C regime) heating coil (26 kW). The pre-heating may serve comfort-purposes (no cold draft) in the winter or provide heat in cold hours during the half-season. Basically the unit can be considered as a dedicated ventilation AHU. This AHU has a heat recovery unit with an efficiency of 55%.

Ventilation of the ground floor area is realized through another AHU. For the hydronic solution maximum AHU supply-side capacity is 7,2 m³/s (ca. 26.000 m³/h), but for the design calculations with VAV boxes a speed capacity of 4,5 m³/s (16.200 m³/h) is used. The cooling is fully realized through the distribution of cold air by the AHU, which contains a cooling coil of 105 kW for this purpose. In other words, the ventilation rate and the cooling capacity are coupled. In the hydronic solution this AHU has a mixing box but not a 'recouperator' , whereas with the VRF solution –where the ventilation is decoupled-- it has.

The heating solution for the ground-floor is different from the cooling solution. A part is realized by pre-heating the air (to 13 °C) through the AHU heating coil (nominal 44 kW) and then the rest is realized by the 40 VAV boxes with individual heating coils, linked to a low temperature hot water (LTHW) network. Nominal VAV box coil capacity is dimensioned to enable chilling, the design chilling capacity per unit is 2,15 kW but the

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[16] At floor height 4 m for groundfloor and 3,2 m for 5 upper floors, the total building height is around 20 m (interior). Assuming a free-standing rectangular hotel with corridor + 15 rooms left and 15 rooms right, the footprint will be 15 x 60 m. This results in a total heated building volume of 60(w) x 15(d) x 20 (h)= 18.000 m³ and a building shell surface of around 5000 m². The AV ratio is thus 0,28.

design heating capacity needed is only 0,825 kW heat loss/unit. This means the VAV heating coils will operate at around low system temperature even in design conditions. The hot water for the central AHU heating coil, the LTHW network with VAV heating coils, the FCU's in the rooms (nominal 1,7 kW, design 0,9 kW per unit) and the 2 x 1000 ltr. sanitary hot water tanks is supplied by a 318 kW gas-fired boiler (with a 318 kW back-up).

Table II.1 . Hotel characteristics, hydronic VAV & FCU solution, summary (source: Elementa Consulting for Carrier, 2006)

	heated building volume	design heat loss (winter)	design heat gain (summer)	no. VAV	nom. flow rate per VAV	total max vent.	total design vent.
	m^3	kW	kW	#	m^3/h	m^3/h	m^3/h
offices	401	3,7	7,9	10	250	2.500	1.563
meeting rooms (2)	423	3,9	7,9	4	940	3.760	2.350
kitchen	163	1,5	3,2	4	280	1.120	700
reception	76	0,7	1,6	2	250	500	313
shop	293	2,7	5	2	880	1.760	1.100
gym	239	2,2	7,9	2	1.155	2.310	1.444
lobby	510	4,7	7,9	2	1.350	2.700	1.688
restaurant	1334	12,3	43,7	10	1.240	12.400	7.750
WC & locker-rooms	163	1,5	3,2	4	466	1.864	1.165
TOTAL [AVG] GROUNDFLOOR	**3.600**	**33**	**88**	**40**	**[723]**	**28.914**	**18.071**
of which	*fabric -->*	*10,2*	*68,3*	*<--sensible*			
of which	*infiltr.-->*	*23*	*20*	*<--latent*			

	volume	heat loss	heat gain	no. FCU	per FCU	vent.	vent.
	m^3	kW	kW	#	kW	m^3/h	m^3/h
TOTAL GUESTROOMS (incl. corr.)	**12.960**	**138**	**247**	**150**	**0,9/ 1,6**	**9.000**	**9.000**
TOTAL HOTEL	**16.560**	**171**	**335**			**37.914**	**27.071**

In the VRF solution for the ground floor the ventilation function is largely decoupled from the heating/cooling function. There is an AHU with <u>maximum</u> supply air flow capacity of 4,34 m³/s (15.600 m³/h), i.e. similar to the <u>design</u> capacity of the hydronic AHU. The AHU does not have a cooling coil and only a relatively small (pre-) VRF heating coil that heats up the air to 18 °C. The rest of the heating (and the cooling) is realized through the 28 VRF ground-floor indoor units and 40 VRF FCU's units in the guest rooms. In this case the ground floor AHU has a heat recovery unit.

Both the hydronic and VRF solution show an very high ventilation capacity for the ground floor. At ventilation rates for a building with low-polluting materials and IAQ III (1200 ppm), the EN 15251: 2007 prescribes ventilation rates of 0,8 $l/s/m^2$ (office), 1,7 (shop), 2,4 (meeting room), up to 3,2 $l/s/m^2$ for a restaurant . With these standard values the AHU design capacity should be somewhere around 9000 m³/h, a factor 2,5 the heated volume. Instead they are approximately twice as high, i.e. a factor 4,5 (VRF) to 5 times the volume. And –for statistics—the ratio between the nominal AHU airflow in the hydronic solution is even 7,7 times higher than the building volume.

Instead, for the guest rooms the ratio is a 'normal' factor 0,7. Overall, for the whole hotel –with a hydronic solution the total air flow capacity is a factor 2,3 times the building volume; with a VRF solution it is 1,6 times the building volume. In other words, an average AHU capacity of 14.000 m³/h relates to a built volume of 6.000 m³ (1600 m²). At 20.000 m³/h the likely surface is 8.700 m³/h.

How will statistics interpret the cooling and ventilation equipment data for this hotel? For the hydronic solution it will count 1 chiller, 2 AHU's (of which one 'heating only' and 1 'cooling and heating'), 40 VAV boxes, etc.. For the VRF solution, the installation will be counted by their external units, i.e. 6 VRF units and 2 AHU's for this building.

The table below gives a summary of costs by products.

Table II.2. Costing of HVAC installation for hotel

HYDRONIC (VAV & FCU)				VRF			
	units	**material**	**labour**		**units**	**material**	**labour**
	#	euro	h		#	euro	h
chiller (255 kW, incl. pumps)	1	53.520	258	VRF ext unit GF (101 kW)	1	24.090	
LTHW boiler (318 kW, incl. pumps)	2	22.411	405	VRF ext unit UF (76 kW chill)	5	78.199	
				VRF main	1	13.633	
CHW buffer vessel	1	3.211		VRF main	5	84.871	
CHW pumps (external)	2	3.905					
		0					
LTHW plate heat exch.	2	9.006					
HWS buffer vessel	2	9.334		HWS buffer+gen	2	27.374	75
LTHW pumps (external)	3	2.850					
LTHW pressure vessel	1	2.847					
AHU GF (for VAV heat&cool, mix box)	1	22.234	49	AHU GF (preheat, HR)	1	18.907	49
AHU UF (for FCU preheat, HR)	1	13.806	49	AHU UF (preheat, HR)	1	15.100	49
AHU attenuators	8	6.447		AHU attenuators	8	4.363	
GF air-ductwork	40	60.320	896	GF air-ductwork	40	59.651	880
VAV box ass. materials GF	40	32.500		VRF ass mat. GF	28	2.610	596
UF air-ductwork	150	132.925	2.320	UF air-ductwork	150	132.925	2.320
FCU ass. materials UF	150	74.409	1.662	VRF ass mat UF	150	13.763	2.720
FCU valves & controls	150	19.500	150				
FCU condensate drains	150	3.927	480	condens. drains		4.369	523
VAV box	40	14.594	425	VRF int. units GF	28	21.926	
FCU	150	48.750	337	VRF int. units UF	150	93.709	
supply/extract grilles	380	28.012		grilles	380	25.362	
control equipment		49.635	327	control equipment		37.969	205
TOTAL		**614.143**	**7.358**	TOTAL		**658.821**	**7.417**

labour in equivalent skilled technician hours (assistant valued at 0,5)

material costs originally in £ Oct. 2006; conversion to Euro 2009 by using factor 1,3 (2006 exchange rate + 2% inflation)

'associated materials' is piping, clamps, etc.

abbreviations:

VRF = Variable Refrigerant Flow; LTHW=Low Temperature Hot Water; CHW= Chilled Water; HWS= Hot Water Service; GF=groundfloor; UF=Upper Floors; VAV=Variable Air Flow terminal unit; FCU= Fan Coil (terminal) unit

description	units	material	labour	labour cost	TOTAL mat. & labour
	#	euro	h	euro	euro
AHU groundfloor, 15.650 m³/h, supply & exhaust fan, frost coil, pre-filter EU4, secondary filter EU7, heat recovery, VRF pre-heating coil module	1	18.907	49	2.205	21.112
AHU upper floors, 8.640 m³/h, supply & exhaust fan, frost coil, pre-filter EU4, secondary filter EU7, heat recovery, VRF pre-heating coil module	1	15.100	49	2.205	17.305
subtotal		*34.007*	*98*	*4.410*	*38.417*

AHU attenuators (silencers)	8	4.363	incl. in ductwork		4.363
air-ductwork to 900 m² (3600 m³) groundfloor with 40 air out/inlets	40	59.651	880	39.600	99.251
UF air-ductwork to 150 rooms on upper 5 floors (total ca. 4.100 m², 13.000 m³)	150	132.925	2.320	104.400	237.325
supply/extract grilles	380	25.362	incl. in ductwork		25.362
30% of control equipment		11.391	205	9.225	20.616
subtotal		*233.692*			
TOTAL Ventilation only (excl. air-conditioning)		**267.699**	**3.503**	**157.635**	**425.334**
TOTAL whole ventilation and VRF air-conditioning installation		658.821	7.417	333.765	992.586

description	units	material	labour
	#	euro	h
AHU groundfloor, 25.920 m³/h, supply & exhaust fan, frost coil, pre-filter EU4, secondary filter EU7, mixing box, hydronic pre-heating coil (44 kW) & cooling coil(105 kW)	1	22.234	49
AHU upper floors, 8.640 m³/h, supply & exhaust fan, frost coil, pre-filter EU4, secondary filter EU7, heat recovery, hydronic pre-heating coil	1	13.806	49
VAV box, incl. recirc. fan, heating battery, damper, sensor, etc.	40	14.594	425
30% control equipment		14.890	327

The VAV Box unit price is € 365, where a significant part goes to the heating battery (a convector coil connected to the Low Temperature heating network) and the recirculation fan. The unit price of a traditional VAV box is estimated at € 150.

The AHU for the upperfloors in both example is identical, except for the fact that uses a VRF heating coil and the other an hydronic heating coil. This causes the VRF to be € 1294 (9,3%) more expensive.

The ground floor AHU is € 3.327 more expensive in the hydronic version, due to the extra 10.000 m³/h nominal capacity and a 105 kW hydronic cooling coil, in part compensated by the relatively lower cost of the hydronic heating coil versus the VRF version. VHK estimates that the hydronic cooling coil may account for € 2.500 in the total AHU price. For the smaller hydronic heating coil costs of € 2.000 are assumed and thus the bare 'ventilation only' (with heat recovery) price of the hydronic groundfloor AHU (25.920 m³/h) is around € 17.700.

The price of the bare 15.650 m³/h AHU in the VRF version is € 15.613,- . (price minus 1294 and 2000 Euro). The bare 8.640 m³/h upper floor AHU with heat recovery is probably some € 12.000 (smaller heating coil). The price difference between the two suggests that the capacity difference in m^3/h is discounted at 0,55 Euro per m^3/h.

From the comparison between the hydronic and VRF version of the AHU in terms of nominal capacity it can be assumed that some 40% of the capacity of the former is due only to the air handling function for heating/cooling and 60% is designed for ventilation + air handling.

ANNEX III: Ventilation Costs: Case Studies

The following case studies were published in the UK 'Building' magazine and give the overall cost estimate of HVAC systems, including ventilation.

The original amounts were converted to Euro 2010, taking the inflation and exchange rate as presented below. Furthermore a 10% correction for the location UK was assumed.

Exchange rate Euro/GBP

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
€ 1,60	€ 1,57	€ 1,61	€ 1,53	€ 1,42	€ 1,42	€ 1,48	€ 1,50	€ 1,30	€ 1,10	€ 1,20
Discounted to 2010 at 2% inflation										
€ 1,95	€ 1,88	€ 1,89	€ 1,76	€ 1,60	€ 1,57	€ 1,60	€ 1,59	€ 1,35	€ 1,12	€ 1,20
Correction factor for location UK (costs 10% below EU average)										
€ 2,15	€ 2,06	€ 2,08	€ 1,93	€ 1,76	€ 1,72	€ 1,76	€ 1,75	€ 1,49	€ 1,23	€ 1,32

Further education facility 14.000 m² (UK)

The cost breakdown is based on a four-storey college building with space arranged around an atrium.

The scheme has a number of sustainability features including displacement ventilation, a high-performance external envelope and a green roof.

The building is specified to be highly robust and the rates for partitions, doors, finishes and building services reflect this.

The rates are based on a design-and-build contract, procured via a two-stage tender. Rates are current in 2nd quarter 2007 for a south-east England location.

HVAC installation	***Euro 2010****
Space heating, boilers, flues, pumps, distribution in plantrooms and risers: Item @ £200,000	350.000
Distribution pipework and radiators: 14,000m^2 @ £25	612.500
Extra for underfloor heating to atrium: Item @ £31,000	54.250
Air handling units; ductwork in plantrooms and risers: 11,200m^2 @ £25	490.000
Chillers, pumps and pressurisation units, distribution in plantrooms and risers: 11,200m^2 @ £30	588.000
Local supply and extract distribution; displacement ventilation with high level extract: 11,200m^2 @ £40	784.000
Ventilation installation to laboratories; vacuum system and fume cupboard extract: Item @ £70,000	122.500
Toilet extract ventilation: Item @ £75,000	131.250
Kitchen supply and extract ventilation: Item @ £50,000	87.500
Allowance for localised cooling to equipment rooms: Item @ £50,000	87.500
TOTAL Space heating, air treatment and ventilation	**3.307.500**
of which ventilation/air handling	*1.702.750*
HVAC £/m^2 gifa	236,25
HVAC % of total building costs	6,72%

*= at 1,75 Euro/GBP (1,50 exchange rate 2007 + discount at 2 % inflation +overall correction 1,1)

Table . How a college floor plan should be divided up (Source: Management of Floorspace, LSC 2007)

Description	**% of gross internal area**
Teaching/learning, Excludes admin, social, catering, communal, storage and balance space	**50%**
Other, All usable space excluding teaching and learning space. Typically includes rooms for admin, social, catering, communal, storage and assembly rooms	**20%**
Balance"Non-usable" space, typically includes corridors, stairwells, lifts, plant rooms and space occupied by internal walls and services	**30%**
Atriums: Fully enclosed, usually glass-covered spaces that are a minimum of double-floor height and of sufficient width to be used as multi-functional space	**10%**

New-build theatre cost breakdown (3150 m²)

The cost model is based on a new-build theatre scheme, which has a 500-seat courtyard style auditorium and associated studio and workshop space. The two-storey 3150 m², building also contains bars and accommodation for a resident company. Project costs include demolitions and the full theatre equipment fit-out, but exclude external works and services, the client's fit-out and loose furniture and fittings. Professional fees and VAT are also excluded from the cost analysis.The unit rates are current in April 2005, for a competitively tendered scheme, and are based on a location in outer London. Adjustments to the unit rates should be made for the cost implications of programme, procurement route, location and site access.

Description space heating and air treatment	Euro 2010*
Gas installation, including shut-off valve to kitchen Item @ 7,500	12.900
Heating installation; boilers (400 kW), pumps, distribution, flue dilution Item @ 62,500	107.500
LTHW heating installation; distribution, radiators and convectors 3,150 m² @ 32	173.376
Local cooling to technical rooms; DX units 3 @ 3,500	18.060
Mechanical ventilation to performance spaces; supply and extract; LTHW and CW installation to AHUs; chiller; acoustic treatment to ductwork 805 m² @ 530	733.838
Kitchen extract ventilation; extract hood and associated ductwork Item @ 23,000	39.560
Toilet extract ventilation Item @ 14,000	24.080
Laundry supply and extract ventilation Item @ 11,000	18.920
Local extract to miscellaneous areas Item @ 8,000	13.760
Allowance for extract and ductwork to spray booth Item @ 16,000	27.520
Allowance for smoke vents Item @ 40,000	68.800
TOTAL Space heating and air treatment	**1.238.314**
of which ventilation/ air handling	**926.478**
HVAC costs/gifa	393
% of total building costs	8,78%

*= at 1,72 Euro/GBP (1,42 exchange rate 2005 + discount at 2 % inflation +overall correction 1,1)

Laboratory (David Langdon, Building.co.uk, 2008)

Laboratories are among the most energy intensive of buildings. In a typical research university, although laboratories account for only 10% of the space, they can consume up to 30% of the energy used.

The prime reason for this relates to mechanical ventilation, as laboratories typically operate on a five-air-changes-an-hour basis, with specialist areas needing 10 air changes an hour. Laboratories often run 24/7, resulting in a very high level of energy consumption.

The cost model breakdown is based on a university-funded research laboratory. The building has a gross floor area of 12.600m^2, of which 5.750m^2 is laboratory and technical space, and a further 3.200m^2 is write-up, office and collaboration space.

Services distribution to laboratory areas is by a sidestitial strategy. Low energy features in the building include displacement ventilation and use of exposed soffits in write-up areas.

Rates are appropriate for a design and build contract procured on the basis of a two-stage tender. An allowance for the contractor’s pre-construction services is included in the breakdown. Rates are current in the first quarter of 2008, based on an outer London location.

The costs include the full fit-out of laboratory and technical areas, including IT infrastructure. Loose fittings and equipment are excluded from the costs.

Also excluded are the costs of site preparation, external services and external works, professional fees, client’s management costs and VAT.

Costs can be adjusted using the location factors provided. Site conditions and constraints, project size, programme and procurement route should be considered.

Heat source, space heating and ventilation installations	€ 2010
Gas fired and electric boilers, flues, plant room installation: 12.600m^2 @ 35	657.090
LTHW heating installation; including laboratory areas: 12.600m^2 @ 52	976.248
Chillers, plant room installation: 12.600m^2 @ 40	750.960
Chilled water distribution; cooling installation in technical areas: item @ 100.000	149.000
Chilled water distribution to non-technical areas; including multi-service chilled beams: 3.200m^2 @140	667.520
Cross ventilation system to offices ; exhaust to atrium: 3.200m^2 @ 14	**66.752**
Supply and extract installation to general laboratories; air-handling plant, heat recovery, ductwork and diffusers: 5.750m^2 @ 270	**2.313.225**
Extra for dedicated supply and extract to specialist laboratories: item @ 760.000	**1.132.400**
Extra for supply and ventilation systems serving technical areas including containment suites, equipment and preparation rooms, comms rooms etc: item @ 250.000	**372.500**
Toilet extract: item @ 70.000	**104.300**
Allowance for ventilation to seminar and teaching spaces: item @ 50.000	**74.500**
TOTAL Heat source, space heating and ventilation installations	**7.264.495**
of which ventilation/ air handling	4.063.677
/gifa	577
% of total building costs	10,30%

*= at 1,49 €/£ (1,30 exchange rate 2008 + discount at 2 % inflation+overall correction 1,1)

Sports & Leisure Centre

The cost model is based on the analysis of a new sports facility in the South of England.

The facility is split over thee levels with a gross floor area of 6090 m². It comprises a sports hall capable of meeting the playing requirements of a wide range of sports and including a viewing gallery

, a 25 m eight lane swimming pool to national standard, wet and dry changing areas, four squash courts, a climbing wall, a multi purpose room, fitness suite, reception/office areas and external activity space.

Ventilation	*Euro 2010**
Supply and extract ventilation, serving pool hall, fitness suite, multi-purpose room, changing areas and ancillary areas; 5nr air handling units (all with heat recovery, pool hall unit also includes gas fired de-humidifier), with a total duty of 23 m³/s;	
dampers, attenuators, ductwork, insulation, grilles, fittings and accessories; all pool hall equipment suitable for swimming pool environment. 2910 m² @ £112/m².	700.728
Roof mounted reversible fans to sports hall. Item @ £20,000.	43.000
High level extract fans to squash courts. Item @ £8,000.	17.200
Kitchen extract installation. Item @ £2,500.	5.375
Controls; Central ddi control system excluding head end. System includes mccs, inverters, local starters/isolators and associated power, control and communication wiring and wire ways Item @ £181,000.; 30% partitioned to ventilation	129.710
TOTAL	**896.013**
Cooling	
VRV cooling system to multi-purpose room, fitness suite and admin areas. 1100 m² @ £118/m². 21.31	**279.070**

*= at 2,10 €/£ (1,60 exchange rate 2001 + discount at 2 % inflation + overall correction factor 1,1)

Table . Sports & Leisure Centre: Typical internal design criteria (UK 2001)

	Internal temperatures		Relative	Ventilation
	Winter	Summer	humidity	
Offices	19°C min	Uncontrolled	Uncontrolled	12 l/s/person
Fitness centre	16°C min	23°C + 3°C	Uncontrolled	12 l/s/person
Sports halls	18°C min	Uncontrolled	Uncontrolled	1 ac/h winter 4 ach/h summer
Swimming pool	29°C ±1°C 2	29°C ±1°C(2)	50% – 70%	10 l/s/m²
Dry changing room	20°C min	Uncontrolled	Uncontrolled	10 ac/h extract 8ach/h supply
Wet changing room	25°C min	Uncontrolled	Uncontrolled	10 ac/h extract 8ach/h supply
Kitchen	18°C min	Spot cooling	Uncontrolled	20 ac/h
WCs	18°C min	Uncontrolled	Uncontrolled	10 ac/h extract
Corridors	18°C min	Uncontrolled	Uncontrolled	–
Cafe/reception	19°C min	Uncontrolled	Uncontrolled	12l/s/person

(2) To be maintained at 1°C above pool water temperature.

Nursing home (650 m²)

This cost model is based on a 16-bedroom extension to a home in the West Midlands, including kitchenettes and dayrooms. Some demolition and alteration was involved. The construction used a facing brick cavity wall on strip footings with precast concrete floors. The roof is constructed of concrete tiles on softwood trusses, windows are uPVC and internal walls are blockwork. Services include gas-fired heating with low surface temperature radiators, lighting and nurse call alarms.

Space heating and ventilation	Euro 2010*
gas-fired heating system with boiler, low temperature surface radiators: 650 m²@70	67.795
mechanical ventilation: 650@10	9.685
total	**77.480**
GBP/m^2	119,2
% of total construction costs	7,04%

Extra care building (1400 m²)

The cost model is for the extra-care building located in the West Midlands features 16 self-contained flats of 10 single-bedroom homes and six two-bedroom homes located as a three-storey separate wing to a care home.

The scheme is developed to housing association standards, and also features a cafe/restaurant with kitchen, residents' lounge, and staff rooms. It is constructed using a traditional facing brick cavity wall on strip footings with reinforced insitu concrete floors. The roof is constructed of concrete tiles on softwood trusses. Windows are softwood and internal division is based on metal stud partitions. Services include gas-fired heating systems with low surface temperature radiators, lighting and nurse call alarms.

Space heating and ventilation	Euro 2010
gas-fired heating system with boiler, low temperature surface radiators: 1400 m²@70	146.020
mechanical ventilation: 1400@10	20.860
total space heating and ventilation	**166.880**
GBP/m^2	119,2
% of total construction costs	7,40%

*= at 1,49 €/£ (1,30 exchange rate 2008 + discount at 2 % inflation+overall correction 1,1)

ANNEX IV: Ventilation units and accessories: List prices

The following is a selection of (rounded) commercial prices of some ventilation units as well as cost related information from manufacturer's brochures. Note that this is commercial information and list prices show a considerable commercial mark-up with respect to actual 'street' prices.

Central exhaust unit, up to 350 m³/h, list prices	**Euro 2010**
Units	
AC , 3 speed (100/150/225 m³/h @60/180/280 Pa and 20/37/62 W electric power input; 4 orefices extracty diam 125 mm)	180
AC, 3 speed ((100/150/225 m³/h @180/310/390 Pa and 34/49/77 W electric power input)	210
DC motor (50-350 m³/h; (50/) 150/225/350 m³/h @ (6/)200 Pa and @ 7, 27, 40, 75 W electric power input)	330
as above, with RF receiver, prepared for CO_2 sensors	410
as above, with main CO_2 sensor, RF transmitter	950
as above, with 3 CO_2 extension sensors	2500
Installation materials	
roof outlet (plastic, diam. 125 mm)	60
extract grille (4 units x 15=)	60
25 m. flex tube (diam. 125 mm)	160
timer controller (incl. RF transmitter) for WC/Bath	85
Accessories (sold separately)	
Manual RF control unit	190
CO_2 sensor	380
CO_2 controller (sensor+RF transmitter)	540
CO_2 extension controllers (sensors + RF transmitter)	510

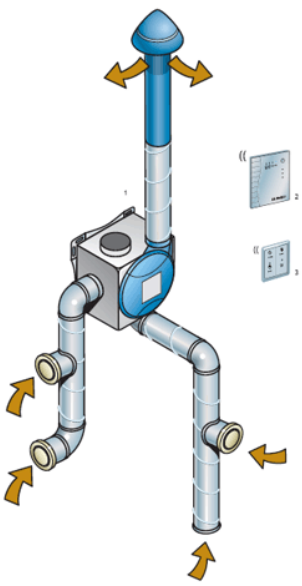


Table . Small commercial Heat Recovery ventilation unit (ceiling mount, 220/240 V, filter G3, 3-speed, AC motor)

Model (nominal capacity)		**350 m³/h**	**500 m³/h**	**800 m³/h**	**1000 m³/h**
Air flow rate, high	l/s (m^3/h)	350	500	800	1000
Air flow rate, low	l/s (m^3/h)	280	370	650	810
Temperature exchange efficiency (EH/H/L)	%	75/75/77	75/75/77	75/75/76	75/75/76
Input power (EH/H/L)	W				
Heat reclaim mode		154/137/128	214/188/166	347/329/327	445/399/367
Bypass mode		151/132/125	210/182/164	337/325/316	438/392/362
Enthalpy exchange efficiency (EH/H/L)					
Heating	%	69/69/71	67/67/71	71/71/74	71/71/73
Cooling	%	66/66/69	62/62/67	65/65/68	65/65/68
Max. external static pressure (EH/H/L)	Pa	95/65/42	105/70/38	140/110/70	90/55/35
Sound pressure level (EH/H/L)	dB(A)				
Heat reclaim mode		32/30/26	34/32/26	39/37.5/34	38.5/37/33
Bypass mode		32/31/27	35/33/27.5	39.5/38/35	39/37.5/33.5
Dimensions h x w x d	cm	27x80x88	27x90x96	39x88x132	39x113x132
Duct diameter	mm	150	200	250	250
List prices, Euro 2010*					
unit	**Euro 2010**	**€ 1.400**	**€ 1.800**	**€ 2.600**	**€ 3.000**
accessories (wall controller, incl. PCB)	**Euro 2010**	**€ 540**	**€ 540**	**€ 540**	**€ 540**

1,23 Euro/GBP 2009

L - Low

H - High

EH - Extra high

Can be integrated into air conditioning systems, reduces size of overall system

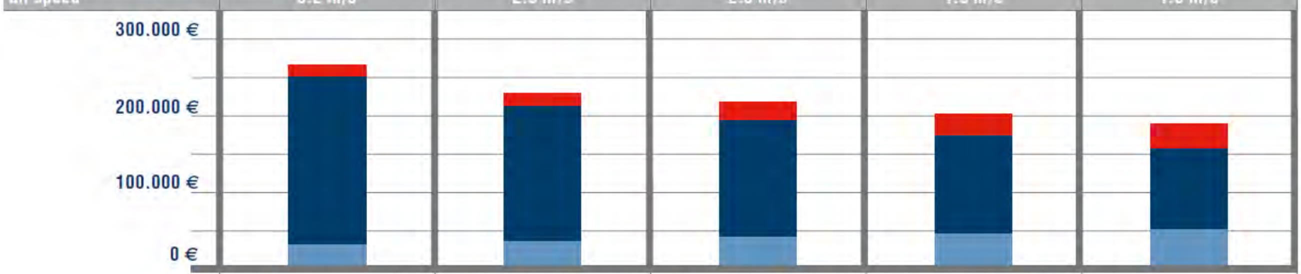
Fan unit 31000 m³/h, 1000 Pa ext. pressure (source: ALKO 2010)

	standard AC	Optimised DC
power costs	355.463	300.347
capital costs	10.694	17.342
price fan	€ 7.400	€ 12.000
kW	14,74	12,64

"Excessive operating costs in air-handling systems are chiefly caused by insufficient device cross sections and excessive flow speeds.
An increase in the unit cross section results in a significant reduction in flow speeds and the accompanying energy costs.
To reduce costs further, it is therefore necessary to adapt the air flow volumes to the actual needs.
Selecting the optimum unit cross section in terms of operating economy and the optimum operating mode enables a significant reduction in life cycle costs." (See tables)

Unit sizes:

Operating time 24 hours per day, 7 days per week:



air speed	3.2 m/s	2.6 m/s	2.3 m/s	1.9 m/s	1.5 m/s
	air-handling unit 1	air-handling unit 2	air-handling unit 3	air-handling unit 4	air-handling unit 5
cost of space reorganisation	14,324 €	16,877 €	19,750 €	23,130 €	29,777 €
power costs	222,444 €	177,232 €	157,338 €	133,828 €	108,509 €
capital costs	32,862 €	39,799 €	42,155 €	45,753 €	52,242 €
sum LCC	269,630 €	233,908 €	219,242 €	202,710 €	190,528 €
initial investment costs	22,740 €	27,540 €	29,170 €	31,660 €	36,150 €

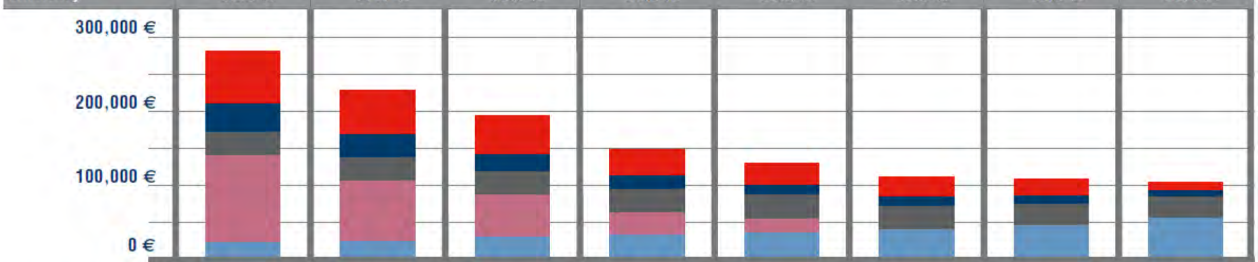
Key data / sample calculation

energy costs (VDI 2067-1)	
heating	0.07 €/kWh
refrigeration	0.025 €/kWh
power customer price	0.100 €/kWh
power annual energy price	0,00 €/kW
energy consumption humidifier	0.070 €/kWh
general data years (VDI 2067-1)	
consideration period	15 Jahre
service life	15 Jahre
effective annual interest	5.00 %
maintenance / service	6.00 %
price change factors (VDI 2067-1)	
capital	1.0 %
energy consumption	5.0 %
operation	1.0 %
repairs	1.0 %

The following shows purchase and operating costs at various sizes of a rotary wheel heat exchanger (commercial information)

Rotor selection:

LCC XT-D19 rotor, operating time 24 hours per day, 7 days per week:



heat recovery efficiency	67.0 %	71.1 %	74.5 %	78.7 %	80.7 %	82.5 %	84.0 %	85.4 %
moisture recovery efficiency	59.9 %	67.1 %	73.1 %	80.0 %	83.2 %	86.0 %	88.3 %	90.4 %
rotor diameter	2,441 mm	2,747 mm	3,053 mm	3,500 mm	3,750 mm	4,000 mm	4,250 mm	4,500 mm
humidifying costs	77,441 €	63,947 €	52,617 €	38,557 €	31,806 €	25,774 €	20,394 €	15,600 €
power costs	33,925 €	26,147 €	20,816 €	15,589 €	13,502 €	11,819 €	10,440 €	9,296 €
refrigeration costs	28,737 €	28,661 €	28,599 €	28,524 €	28,490 €	28,459 €	28,433 €	28,409 €
heating costs	125,505 €	90,068 €	62,540 €	31,213 €	17,290 €	0	0	0
capital costs	22,532 €	24,890 €	29,094 €	36,062 €	40,387 €	45,019 €	49,958 €	55,204 €
sum LCC	288,139 €	233,713 €	193,666 €	149,945 €	131,475 €	111,071 €	109,225 €	108,510 €
initial investment costs	15,591 €	17,224 €	20,133 €	24,954 €	27,947 €	31,152 €	34,570 €	38,200 €

ANNEX V: FGK 2010 Design Option costs

Following design option costs were derived from production costs plus normal mark-up. FGK claims these prices to be representative of residential ventilation unit prices at volume production.

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Table 6.2-1 Costs for the various Design Options

Costs for Design Options (prices per single component)	Subassemblies & components	Labour (finishing,assembly, testing, packaging)	Overhead (marketing, administration, amortisation, margin)	Manufacturing Selling Price MSP	Whole sale price	Consumer street price VAT excl.	Consumer street price VAT incl
Mark-up MSP	50%	15%	35%	100%	20%	20%	19%
Centralized units							
Increased HE-efficiency (from ca. 70 to 90%)	€ 10,00	€ 3,00	€ 7,00	**€ 20,00**	€ 24,00	€ 28,80	34,27
More efficient fan-motor (AC to DC incl.smps)	€ 12,50	€ 3,75	€ 8,75	**€ 25,00**	€ 30,00	€ 36,00	42,84
Decentralized units							
Increased HE-efficiency (ca. 70 - 90%)	€ 5,00	€ 1,50	€ 3,50	**€ 10,00**	€ 12,00	€ 14,40	17,14
More efficient fan-motor (AC to DC incl.smps)	€ 10,00	€ 3,00	€ 7,00	**€ 20,00**	€ 24,00	€ 28,80	34,27
Controls							
RH-sensor	€ 37,50	€ 11,25	€ 26,25	**€ 75,00**	€ 90,00	€ 108,00	128,52
Clock program	€ 25,00	€ 7,50	€ 17,50	**€ 50,00**	€ 60,00	€ 72,00	85,68
CO2 sensor	€ 50,00	€ 15,00	€ 35,00	**€ 100,00**	€ 120,00	€ 144,00	171,36
Presence sensor	€ 40,00	€ 12,00	€ 28,00	**€ 80,00**	€ 96,00	€ 115,20	137,09
Other components							
Add. costs for ΔP controlled supply grid	€ 5,00	€ 1,50	€ 3,50	**€ 10,00**	€ 12,00	€ 14,40	17,14
Add. costs presence sens. contr.sup. grid / VAV	€ 65,00	€ 19,50	€ 45,50	**€ 130,00**	€ 156,00	€ 187,20	222,77
Add. costs for CO2 controlled supply grid / VAV	€ 75,00	€ 22,50	€ 52,50	**€ 150,00**	€ 180,00	€ 216,00	257,04

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List of figures

List of tables