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Supplements

to Preparatory Study on Residential Ventilation LOT 10 :

(i.e. mechanical ventilation units with fans < 125 W)

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Sponsored by
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Annexes

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1. DEFINITIONS OF PRODUCT, STANDARDS AND LEGISLATION

1.1 Product function, definitions and classifications

1.1.1 Definition Residential Ventilation

The term “Residential ventilation” refers to the process of exchanging indoor air by fresh outdoor air in residential dwellings for the purpose of obtaining an acceptable Indoor Air Quality (IAQ). It is hereby assumed that the outside air is of reasonable quality
Or - formulated in more ‘pollutant-related’ terms – ventilation is the process of exchanging air for the following purposes:

a. provision of air for occupants respiration
b. control of internal humidity
c. dilution and/or removal of background pollutants (metabolic CO2, vapours, odours, emission from building-, furnishing- and cleaning materials)
d. dilution and/or removal of specific pollutants from identifiable local sources: toilet and cooking odours, water vapour from bathing / cooking / washers & driers, tobacco smoke, combustion products from fuel burning appliances
e. provision of air for fuel burning appliances and dilution of related emissions

1.1.2 Mechanisms for air-exchange

There are three different mechanisms through which the indoor air is exchanged by outdoor air:

1. **Infiltration** : air exchange through leakages in building envelope (to be measured acc. EN 13829). The infiltration rate is determined by the air tightness of the building envelope and the pressure difference over the building. Infiltration is an uncontrollable air exchange process.

2. **Ventilation** : purpose provided air exchange between the inside and the outside of a dwelling, through the (for this purpose specifically designed and installed) ventilation system by means of a range of natural and/or mechanical devices. Depending on type of ventilation system, the air-exchange rate is more or less controllable.

3. **Airing** : air exchange induced by opening windows (also referred to as *Purge ventilation* (UK), *Stoß lüften* (GE), *Spuiventilatie* (NL))

Note:
In the context if this study, when we talk about *ventilation systems*, we refer to systems according to the 2nd mechanism: “purpose provided air exchange through a - *for this purpose specially designed and installed* - ventilation system”.

Looking at the history of ventilation, the IAQ in older houses (before 1960) mainly depended on infiltration and airing. The *purpose provided air-exchange* through ventilation systems became necessary, when people could no longer rely on infiltration alone as the key parameter for achieving an acceptable IAQ.
Due to energy conservation and EPBD-legislation, newly built residential dwellings have increased air tightness. Infiltration can no longer guarantee acceptable indoor air qualities. But also in refurbished houses, where additional insulation and increased air tightness are applied, indoor air quality levels can no longer be guaranteed. Additional ventilation systems are necessary to secure – on a long term basis - the requested indoor air quality levels in all the (habitable) rooms of the residential building.

1.1.3
Product scope

The residential ventilation products that are the scope of this study, are defined here as the energy using residential ventilation products that make - or are part off - a mechanical version of the above mentioned Ventilation Systems, providing the necessary air exchange.
Contrary to natural ventilation systems, the mechanical ventilation systems use a mechanically powered device (ventilation unit containing one or more fans) as core component to initiate the air transport necessary for the requested air-exchange. These mechanical ventilation units are the key subject of this study.

They include:

1) Dedicated ventilation exhaust units, including roof fans (from 25 to 2000 m3/h and <125 W?) (for single rooms, dwellings and multiple dwellings, apartment blocks)
2) Dedicated ventilation supply units (from 25 up to 2000 m3/h and < 125W) (for single rooms, dwellings and multiple dwellings)
3) Combined mechanical supply and exhaust ventilation units (from 25 to 500 m3/h, < 125 W per fan) (for single rooms & dwellings, both with and without heat recovery)
4) Units acc. nrs 1 to 2, incorporating the capability of switching from mechanical to natural mode
5) Controls used to optimize ventilation rates
6) Electrically operated inlet/outlet openings/grids

Obviously, these energy using residential ventilation products are not the only products necessary to build a full and proper functioning ventilation system. Additional components like ducts, orifices, air transfer devices, ventilation grids etc. are generally used to build a complete mechanical ventilation system.

Not included:
Not included are range hoods that have the sole function of directly discharging contaminated air from cooking appliances.

Energy performance scope
The energy performance of these mechanical ventilation units will be assed on the basis of their ventilation function in the context of a complete residential ventilation system. This means that this study will not only look at the electrical performance of these units, but also at the air exchange performance and the thermal energy content of the air exchange (either heating or cooling) in relation to the requested IAQ. As far as the other (passive) components of the ventilation system have an influence on the air exchange performance, default values will be defined for these parameters to ensure a neutral and objective comparison.

Note
The thermal energy content related to air exchanges caused by *Infiltration* and *Airing* are not in the scope of this study. They are subject to EPBD-legislation.

1.1.4 Definitions

This paragraph gives an overview of ventilation definitions and categories found in existing EN-product and building standards. As such, it can serve as a summary of generally accepted terms, definitions and classifications that are used in the EU standards that are further discussed in paragraph 1.2.
These terms, definitions and classifications will be used throughout this study.

1.1.4.1 Definitions of ventilation systems

Ventilation system
Combination of appliances designed to supply interior spaces with outdoor air and to extract polluted indoor air

Natural ventilation system
Ventilation system which relies on pressure differences without the aid of powered air movement components. These pressure difference mechanism are:

> ***Stack effect***
> Movement of air or gas in a vertical enclosure (e.g. duct, chimney, building) induced by density difference between the air or gas in the enclosure and the ambient atmosphere (due to temperature differences).
>
> ***Cross ventilation***
> Natural ventilation in which air flow mainly results from wind pressure effects on the building facades and in which stack effect in the building is of less importance.

Fan assisted exhaust air ventilation
Ventilation which employs powered air movement components (fans) in the exhaust air side only

Fans assisted supply air ventilation
Ventilation which employs powered air movement components in the supply air side only

Fan assisted balanced ventilation
Ventilation which employs powered air movement components in both the supply and the exhaust air sides in order to achieve a design flow rate/pressure ratio

Demand controlled ventilation
Ventilation systems where the ventilation rate is controlled by air quality, moisture, occupancy or some other indicators for the need of ventilation

Ventilation flow rate
Volume flow rate at which ventilation air is supplied and removed

1.1.4.2 Definitions of performance parameters

Ventilation effectiveness *(source EN13779)*
Ventilation effectiveness is the relation between the pollution concentrations in the supply air, the extract air and the indoor air in the breathing zone (within the occupied zone). It is defined as

$$\varepsilon_V = \frac{C_{ETA} - C_{SUP}}{C_{IDA} - C_{SUP}}$$

Where : ε_V is the ventilation effectiveness

C_{ETA} is the pollution concentration in the extract air in mg/m^3

C_{IDA} the pollution concentration in the indoor air (breathing zone) in mg/m^3

C_{SUP} is the pollution concentration in the supply air in mg/m^3

Maximum and minimum air volume flow *(source EN 13142)*
For central mechanical ventilation units with or without heat recovery (to be used with ducts), the maximum air volume flow of the mechanical ventilation unit is the maximum flow at a reference pressure difference (e.g. ΔP = 100 Pa for single dwellings), that can be achieved with integrated and/or separately co-supplied controls (at standard air conditions: 20°C and 101325 Pa).

The minimum air volume flow is the minimum flow that can be achieved with integrated and/or separately co-supplied controls (at standard air conditions : 20°C and 101325 Pa).

For room based mechanical ventilation units the maximum and minimum are the volume flows that can be achieved with the unit when installed according manufacturer instructions (with wall- ducts and grills) with the integrated and/or separately co-supplied controls (at standard air conditions: 20°C and 101325 Pa).

Reference air volume flow *(source EN 13142)*
Reference air volume flow is 70% of the maximum air volume flow (at standard air conditions: 20°C and 101325 Pa).

Specific Power Input (SPI) *(source EN 13142)*
The Specific Power Input for mechanical ventilation units is the power input at reference air volume flow and reference pressure difference and includes the electrical demand for fans, controls (including remote controls) and (if integrated) any heat pump.

In formula : $SPI = P_E / q_{v;ref}$

Standby Power Consumption in Fan-off Mode
Standby power consumption in fan-off mode is the power consumption in the mode during which the fans are not working, but the controls and any sensors are active in order to monitor the functional parameters and determine a possible switch-on of the fans.

Standby Power Consumption in switched-off Mode
Standby power consumption in off mode is the power consumption in the mode during which the unit is switched off manually or with any remote control system. Switching the unit on again is only possible with the same remote or manual action.

Acoustics
Sound power levels of mechanical ventilation units shall be given at declared maximum air volume flow and reference air volume flow. Depending on the type of product the following noise level data may be requested:

Casing radiated sound power level *(source En 13142)*
Noise radiated through the casing at maximum and reference air volume flow must be measured according to EN 13141-6 (for exhaust only central mechanical ventilation units) or EN 13141-7 (for central mechanical ventilation units with heat recovery) or EN 13141-8 (for room based mechanical ventilation unit with heat recovery)

Duct radiated sound power level *(source En 13142)*
The noise radiated from the duct connected to the central mechanical ventilation unit (exhaust only, or balanced with heat recovery / with default length) at maximum and reference air volume flow, shall be measured according to EN 13141-7

Sound transmitting resistance (Dn,e,w) *(source En 13142)*
The sound transmitting resistance Dn,e,w for room based mechanical ventilation units with heat recovery at reference air volume flow shall be measured according to EN 20140.

ADDITIONAL PERFORMANCE PARAMETERS FOR MECHANICAL VENTILATION UNITS WITH HEAT RECOVERY

External leakage
Leakage to or from the air flowing inside the casing of the unit to or from the surrounding air, to be tested according to EN13141-7 and -8

Internal leakage
Leakage inside the unit between the exhaust and the supply air flows, to be tested according to EN13141-7 and -8.

Mixing or short circuiting
Mixing of the two air flows external to the unit under test, between discharge and intake ports at both indoor and outdoor terminal ports, to be tested according to EN13141-8

Filter bypass leakage
Air flow around filter cells, to be tested according to EN13141-7 and -8

Humidity Ratio
Difference of water content between inlet and outlet of one of the air flows, divided by the difference of water content between the inlets of both air flows, to be tested according to EN13141-7 and -8.

Temperature ratio
Temperature difference between inlet and outlet of one of the air flows, divided by the temperature difference between the inlets of both airflows (to be tested according to EN13141-7 and -8)

Nominal Temperature Performance factor
The Nominal Temperature Performance Factor (NTPF) is defined as:

$$NTPF = (\eta_{\theta;su} * \rho * c_p * \Delta t) / SPI \qquad [-]$$

Where:	$\eta_{\theta;su}$	=	Temperature ratio (EN 13141-7 / -8) at reference air volume flow
	ρ	=	Air density : 1,2 [kg/m3]
	C_p	=	Heat capacity air : 1007 [J/kg.K]
	Δt	=	Nominal temperature difference at 13 [K] (EN 13141-7 mandatory point 1 table 6)
	SPI	=	Specific Power Input [W/m^3/s]

1.1.4.3
Definitions of room types

Activity room
Room used for activities such as cooking, washing and bathing which is characterized by relatively high pollutant emission (which may be intermittent), e.g. kitchen, bathroom, laundry/utility room, WC.

Low pollution room
Room used for dwelling purposes which is characterized by relatively low pollution emission, e.g. a bedroom, living room, dining room, study, but not a space used only for storage

Common space
Corridor, stairway or atrium used for access to a dwelling or dwellings

1.1.5
Classifications

1.1.5.1
Classification of types of air *(according EN 13779:2007)*

Type of air	Abbreviation	Colour	Definition
Outdoor air	ODA	Green	Air entering the system or opening from outdoors before any air treatment
Supply air	SUP	Blue	Airflow entering the treated room, or air entering the system after any treatment
Indoor air	IDA	Grey	Air in the treated room or zone
Extract air	ETA	Yellow	The airflow leaving the treated room
Exhaust air	EHA	Brown	Airflow discharges to the atmosphere
Transferred air	TRA	Grey	Indoor air which passes from the treated room to another treated room
Secondary air	SEC	Orange	Airflow taken from a room and returned to the same room after any treatment
Leakage	LEA	grey	Unintended airflow through leakage paths in the system

1.1.5.2
Classification of extract air (ETA) and exhaust air (EHA) *(according EN 13779:2007)*

Category		Pollution level	Description
ETA1	EHA1	Low	Air from rooms where the main emission sources are the building materials and structures, and air from occupied rooms where the main emission sources are human metabolism and building materials and structures. Rooms where smoking is allowed are excluded.
ETA2	EHA2	Moderate	Air from occupied rooms, which contain more impurities than category 1 from the same sources and/or also from human activities. Rooms which shall otherwise fall in category ETA1 but where smoking is allowed.
ETA3	EHA3	High	Air from rooms where emitted moisture, processes, chemicals etc. Substantially reduce the quality of the air.
ETA4	EHA4	Very high	Air which contains odours and impurities in significantly higher concentrations than those allowed for indoor air in occupied zones.

1.1.5.3
Classification of outdoor air (ODA) *(according EN 13779:2007)*

Category	Pollution level	Description
ODA1	Low	Pure air which may be only temporarily dusty (e.g. pollen). ODA1 applies where the WHO (1999) guidelines and any National air quality standards or regulations for outdoor air are fulfilled.
ODA2	High	Outdoor air with high concentrations of particulate matter and/or gaseous pollutants. ODA2 applies where pollutant concentrations exceed the WHO guidelines or any national air quality standard or regulations for outdoor air by a factor of up to 1,5
ODA3	Very high	Outdoor air with very concentrations of particulate matter and/or gaseous pollutants. ODA3applies where pollutant concentrations exceed the WHO guidelines or any national air quality standard or regulations for outdoor air by a factor greater than 1,5

1.1.5.4
Classification of indoor air quality (IDA) for residential buildings *(according EN 13779 and EN15215)*

Category	IAQ level	Related default CO2 value acc. EN15251	Related recommended default ventilation rates acc. EN15251 either per person *or* per m2 floor area	
			Airflow pp	Airflow per m2 floor area
		Corresponding CO2 concentration above outdoors [ppm]	l/s/p	[l/s/m2]
IDA1	High	350	10	1,4
IDA2	Medium	500	7	1,0
IDA3	Moderate	800	4	0,6
IDA4	Low	>800		

1.1.5.5
Categories of heat exchangers

Category I heat exchangers
Recuperative heat exchangers (e.g. air-to-air plate or tube heat exchangers)

Recuperative heat exchangers are designed to transfer thermal energy (sensible or total) from one air stream to another without moving parts. Heat transfer surfaces are in form of plates or tubes. This heat exchanger may have parallel flow, cross flow or counter flow construction or a combination of these. Plate and tube heat exchangers with vapour diffusion (e.g. cellulose) are also in this category.

Category II heat exchangers
Regenerative heat exchangers (e.g. rotary or reciprocating heat exchangers).

A rotary heat exchanger is a device incorporating a rotating “thermal wheel” for the purpose of transferring energy (sensible or total) from one air stream to the other. It incorporates material allowing latent heat transfer, a drive mechanism, a casing or frame, and includes any seals which are provided to retard bypassing and leakage or air from one stream to the other. Regenerative heat exchangers have varying degrees of moisture recovery, depending on the material used (e.g. condensation non hygroscopic rotor-, hygroscopic rotor-, and sorption rotor- heat exchangers)

1.1.5.6
Classification leakage rates

There are two test methods for rating leakages: pressure testing and tracer gas testing. The pressure method applies to Category **I** type heat exchanger units and the tracer gas method applies to the Category **II** type heat exchangers.

a. Leakage classification *mechanical ventilation units with heat recovery for single dwellings*

a.1)
According the pressurisation test method (EN 13141-7)

Class*	**Pressurisation test**	
	Internal Leakage (at 100 Pa)	**External Leakage (at 250 Pa)**
A1	≤ 2%	≤ 2%
A2	≤ 5%	≤ 5%
A3	≤ 10%	≤ 10%
Not classified	> 10%	> 10%

* Class is determined on the bases of the highest leakage value

a.2)
According to tracer gas method (EN 13141-7)

Class	**Chamber method**	**Class***	**In-duct method**	
	Total Recirculated fraction in supply air		Internal Recirculated fraction from extract to supply air	Pressurization test (at 250 Pa)
B1	≤ 1%	C1	≤ 0,5%	≤ 2%
B2	≤ 2%	C2	≤ 2%	≤ 2%
B3	≤ 6%	C3	≤ 4%	≤ 2%
Not classified	> 6%	Not classified	> 4%	> 2%

* Class is determined on the bases of the highest leakage value

b. Leakage classification *mechanical ventilation units with heat recovery for single rooms*

Leakage rates to be tested according to En 13141-8

Class*	**Internal Leakage (at 20 Pa)**	**External Leakage (at 50 Pa)**	**Mixing**
U1	≤ 2%	≤ 2%	≤ 2%
U2	≤ 5%	≤ 5%	≤ 5%
U3	≤ 10%	≤ 10%	≤ 10%
U4	≤ 15%	≤ 15%	≤ 15%
U5	≤ 20%	≤ 20%	≤ 20%
U6	> 20%	> 20%	> 20%

* Class is determined on the bases of the highest leakage value

1.1.5.7
Classification of filter bypass leakage

Filter bypass leakage to be tested according EN 1886 (at 200 Pa). Due to the fact that filter bypass leakage measurements can be a difficult tast to perform, it is also possible to give a classification on the basis of a visual inspection of the design details.

Class	Leakage rate	Proof	Method
FBL 1	< 2%	Measured	EN 1886 (at 200 Pa)
FBL 2	< 4%	Measured	EN 1886 (at 200 Pa)
FBL 3	< 6%	Measured	EN 1886 (at 200 Pa)
FBL 4	Approved	Visual inspection	1. Design & construction of air filter and frames allow easy assembly and tight fit 2. Tight fit shall not be affected under the impact of humidity.
-	Not classified	Not classified	

Note: FBL classes 1 to 3 will not be used for residential systems.

1.1.5.8
Filter classification

a. Mechanical <u>coarse</u> filters shall be tested according to EN-779 and classified accordingly.

Key particle size	Classification acc. EN779		Examples of matter retained per filter class
Coarse > 1 µm	G1	EU1	Leaves, insects, textile fibres, human hairs, sand, fly ash, water droplets
	G2	EU2	
	G3	EU3	Beach sand, plant spores, pollen, fog
	G4	EU4	
Fine : 0,4 µm	F5	EU5	Spores, cement dust (coarse fraction), sediment dust
	F6	EU6	Bigger bacteria, germs or carrier particles, PM10
	F7	EU7	Agglomerated soot, lung damaging dust (PM2,5), cement dust
	F8	EU8	
	F9	EU9	Tobacco smoke (coarse fraction), oil smokes, bacteria

b. Mechanical <u>fine</u> filters shall be tested according to EN-1822 and classified accordingly.

Key particle size	Classification acc. EN1822-1		Examples of matter retained per filter class
HEPA 0,3 µm	H10	EU10	Germs, tobacco smoke, metallurgical fumes, viruses, radioactive particles, carbon black
	H11	EU11	
	H12	EU12	Oil fumes, metallurgical fumes, sea salt nuclei, viruses, radioactive particles, all air suspended PM
	H13	EU13	
	H14	EU14	Filter cleanroom ISO 4, operating theatres etc.
ULPA 0,12	U15	EU15	Filter cleanroom ISO 3
	U16	EU16	Filter cleanroom ISO 2
	U17	EU17	Filter cleanroom ISO 1
	U18	EU18	

Note: EN-1822 filter classes will not be used for residential systems.

c.
Test methods for Electrostatic filters are not defined in EN-standards.
They shall be tested for their filter effectiveness by measuring the particle removal efficiency at the maximum volume flow rate and related reference pressure drop of the mechanical ventilation unit.
Test method and results must be reported.

d.
Gas adsorption filters (or activated carbon filters) shall be tested according EN ISO 10121-1 and 2, and classified accordingly.

1.1.5.9
Classification of Specific Power Input *(accortding EN 13142)*

Class	Dedicated mechanical ventilation Exhaust- or supply units		Combined mechanical exhaust and supply ventilation units with heat recovery	
	Single room * [W/m³/h]	Dwelling * [W/m³/h]	Single room [W/m³/h]	Dwelling [W/m³/h]
SPI 1	≤ 0,10	≤ 0,10	≤ 0,25	≤ 0,25
SPI 2	≤ 0,15	≤ 0,15	≤ 0,35	≤ 0,35
SPI 3	≤ 0,20	≤ 0,20	≤ 0,45	≤ 0,45
SPI 4	≤ 0,25	≤ 0,25	≤ 0,55	≤ 0,55
SPI 5	≤ 0,30	≤ 0,30	≤ 0,65	≤ 0,65
SPI 6	≤ 0,35	≤ 0,35	≤ 0,75	≤ 0,75
SPI 7	> 0,35	> 0,35	> 0,75	> 0,75
-	Not classified	Not classified	Not classified	Not classified

* figures to be discussed with CEN/TC ad hoc WG on classification (revision 13142)

1.1.5.10
Classification of temperature ratio *(according EN 13142)*
(measured acc. EN13141-7 /-8)

Classification of the temperature ratio on the supply side of the unit measured at reference- air volume flow and pressure difference and at nominal temperature difference (ΔT = 13 K).
(measured according EN13141-7 /-8)

Class	**Temperature ratio** (measured on supply side at reference air volume flow and nominal ΔT)
1	≥ 90%
2	80 – 89%
3	70 – 79%
4	60 – 69%
5	50 – 59%
6	< 50 %
-	Not classified

1.1.5.11
Classification of humidity ratio *(according EN 13142)*
(measured acc. EN13141-7 /-8)

Classification of the humidity ratio on the supply side of the unit, measured at reference- air volume flow and pressure difference and at nominal temperature difference (ΔT = 13 K)
(measured according EN13141-7 /-8)

Class	**Humidity ratio** (measured on supply side at reference air volume flow and nominal ΔT)
I	≥ 90%
II	80 – 89%
III	70 – 79%
IV	60 – 69%
V	50 – 59%
VI	< 50 %
-	Not classified

1.1.5.12
Classification of Nominal Temperature Performance Factor (NTPF) *(according EN 13142)*

Classification of nominal temperature performance factor NTPF, determined according to EN 13142.

Class	**Nominal Temperature Performance Factor NTPF** (with η measured on supply side at reference air volume flow and nominal ΔT)
1	≥ 15
2	≥ 12
3	≥ 10
4	≥ 8
5	≥ 5
6	< 5
-	Not classified

1.1.5.13
Classification of power consumption in standby modes

Class	**Standby power consumption in *fan-off* mode**	**Standby power consumption in *switched-off* mode**
1	≤ 2 W	≤ 0,5 W
2	≤ 5 W	≤ 1 W
3	≤ 10 W	≤ 2 W
4	≤ 15 W	≤ 5 W
5	> 15 W	> 5 W
-	Not classified	Not classified

1.1.5.14
Classification of control types

Control types		Description
Parameter	**Class**	
Flow Rate Variations FRV	FRV 1	Fixed flow (no variation)
	FRV 2	Multiple preset flow rates
	FRV 3	Variable flow
	-	Not classified
Flow Rate Control FRC	FRC 1	None (no control or operation possible; runs constantly)
	FRC 2	Manual
	FRC 3	Time controlled (runs according a given time schedule)
	FRC 4	Occupancy control (switched on/off or high/low on the basis of occupancy)
	FRC 5	Presence control (flow rate controlled on basis of number of people)
	FRC 6	IAQ sensor control (flow rate controlled on basis of IAQ sensors (CO2, VOC RV)
	-	Not classified
Flow Balance Control FBC *(only for units with heat recovery*	FBC 1	No flow balance control
	FBC 2	Flows are manually balanced
	FBC 3	Fan speed control (on basis of rpm)
	FBC 4	Dynamic flow control
	-	Not classified
Bypass Options BPO	BPO 1	No bypass option
	BPO 2	On or off
	BPO 3	Partly
	BPO 4	By pass with Variable flow rate
	-	Not classified
Bypass Flow rate Control BFC	BFC 1	None
	BFC 2	Manual
	BFC 3	Time controlled
	BFC 4	Temperature controlled
	BFC 5	Humidity controlled
	-	Not classified
Type of Frost Protection TFP	TFP 1	None
	TFP2	Electric preheating
	TFP3	Mixing air
	TFP 4	Lowering air supply flow rate (or shut off)
	TFP 5	Increasing exhaust air flow rate
	TFP 6	Bypass for defrosting
	TFP 7	Not classified
	-	
Combination with Fireplace	CRF	Suited for combination with room air dependent fireplace. *Declaring this means that the system takes into account national and local building and combustion regulation on this topic.*
Filter Indicator Type FIT	FIT 1	Time controlled
	FIT 2	Pressure controlled
	FIT 3	Optical control
	FIT 4	Air volume controlled
	-	Not classified

1.5.1.15
Classification of sound power levels

Classification of “casing radiated sound power level” and “in-duct radiated sound power level” at declared maximum air volume flow, determined according EN13141 -7/ -8; classification according EN 13142.

Class	Casing radiated sound power level [dB(A)]	In-duct radiated sound power level
	Applicable for mechanical ventilation units for dwellings and single room	*Applicable for mechanical ventilation units for dwellings (centralized systems)*
1	< 35	< 35
2	35 – 40	35 – 40
3	40 -45	40 -45
4	45 – 55	45 – 55
5	55 – 65	55 – 65
6	> 65	> 65
-	Not classified	Not classified

1.5.1.16
Classification of sound-damping performance (sound transmitting resistance) Dn,e,w

Classification of sound-damping performance (sound transmitting resistance) $D_{n,e,w}$ for single room mechanical ventilation units, measured at reference air volume flow with a unit installed according manufacturer installation instructions and measured according EN 20140-10.
Classification according EN 13142

Class	sound-damping performance (sound transmitting resistance) $D_{n,e,w}$ [dB]
1	≥ 55
2	≥ 50
3	≥ 45
4	≥ 40
5	< 40
-	Not classified

1.2 EN Product Standards

1.2.1 Introduction

For possible new legislation, the collection of existing product test standards for residential ventilation is very important. The following paragraphs summarize and give detail of the most relevant existing standards. The table below gives an overview of the standards discussed.

Table 1.2-1 . Overview of EN design- performance-and test standards on Ventilation

<table>
<tr><th rowspan="2">Purpose of
EN standard</th><th colspan="2">Building type</th></tr>
<tr><th>Residential</th><th>Non residential</th></tr>
<tr><td>Criteria for
Indoor Environment</td><td colspan="2">EN 15251: 2007</td></tr>
<tr><td>Design and dimensioning
of ventilation systems</td><td>CEN/TR 14788 : 2006</td><td>EN 13779 : 2007</td></tr>
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<tr><td rowspan="2">Calculation
Ventilation rates</td><td colspan="2">EN 15242 : 2007</td></tr>
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Ventilation energy</td><td colspan="2">EN 15241 : 2007</td></tr>
<tr><td>Rating and performance characteristics</td><td>prEN 13142
on components/products for residential ventilation</td><td>EN 13053 : 2006
on air handling units</td></tr>
<tr><td>Performance testing of components and products</td><td>EN 13141-1 / air transfer devices
EN 13141-2 / exh. & supply air terminal devices
EN 13141-4 / fans
EN 13141-5 / cowls and roof outlets
EN 13141-6 / exh. ventilation system packages
EN 13141-7 / mech. supply & exh units + HR for dwellings
EN 13141-8 / mech. supply & exh units + HR for rooms
EN 13141-9 / ext. mounted RV-controlled air transf. device
EN 13141-10 / hum. controlled extract air terminal device
EN 13141-11 / positive pressure ventilation systems</td><td>EN 1886:2007 / Mech. performance air handling units
ISO 5801:1997/ Industrial fans, performance testing
ISO 12248 / Ind.fans, tolerances& conversion methods
ISO 5221 / Methods for measuring air flow rates
ISO 5136 / Acoustics, induct radiated sound power level
ISO 3746 / Acoustics, casing radiated sound power level
EN 1751 / Aerodynamic testing of dampers & valves
EN 1216 / Performance testing heating/cooling coils
EN 779 / Determination of filtration performance
EN 308 / Performance testing air-to-air HR-devices</td></tr>
<tr><td>Inspection of
installed systems</td><td>EN 14134</td><td>EN 12599 : 2000 (for AC : 2002)
(standard is under revision)</td></tr>
</table>

1.2.2
EN 15251:2007

Full title: *Indoor environmental input parameters for design and assessment of energy performance of buildings, addressing indoor air quality, thermal environment, lighting and acoustics. June 2007*

This European Standard describes the indoor environmental parameters which have an impact on the energy performance of buildings, being: *indoor air quality*, *thermal environment*, *lighting* and *acoustics*. As such, this standard:

- specifies how to establish indoor environmental input parameters for building system design and energy performance calculations
- specifies methods for long term evaluation of the indoor environment obtained as a result of calculations or measurements
- specifies criteria for measurements that can be used if required to measure compliance by inspection
- specifies how different categories of criteria for indoor environment *can be* used (but is does not require certain criteria to be used; this is up to national regulations or individual project specifications)
- does not include criteria for local discomfort factors (like draught, radiant temperature asymmetry, vertical temperature gradient and floor surface temperatures).

This standard is applicable mainly in non-industrial buildings where criteria for indoor environment are set by human occupancy and where production processes does not have a major impact on indoor environment. The standard is thus applicable to the following building types:

- single family houses
- apartment buildings
- offices
- educational buildings
- health care buildings
- hotels and restaurants
- sports facilities
- wholesale and retail trade service buildings

This standard is very important because it gives a fairly detailed description of what is considered an acceptable or good indoor air quality (IAQ) and how it can be achieved. Where most of the national building codes go no further than descriptions like “the ventilation system must be able to achieve an IAQ that is not detrimental to the health of the inhabitants” , followed by requirements to the installed air exchange capacity of the ventilation system, this standard is a first European Standard that specifies the actual IAQ goal that is behind the requested air exchanges. For the purpose of Ecodesign Legislation and related energy declaration this is crucial because – as formulated in the introduction of this standard – “an energy declaration without a declaration related to the IAQ makes no sense”

Informative Annex B
Informative Annex B of this standard gives methods for specifying ventilation rates for IAQ-classes and different types of buildings.
Section B.1 of this Annex gives recommended design ventilation rates for non-residential buildings.
Section B.2 of the Annex describes the recommended design ventilation rates for residential buildings
The following tables give an overview of the recommended ventilation rates for different IAQ-categories.

CO_2 concentrations
The required ventilation rates can also be calculated based on a mass balance equation for the CO_2 concentratio (acc EN 13779) taking into account the outdoor CO_2 concentration. Recommended criteria for the CO_2 – calculation are given in table 1.2.2.3 (see below). The listed CO_2 values can also be used for demand controlled ventilation. If the ventilation rate is controlled automatically (DCV) the maximum design ventilation rate has to correspond to the calculated maximum concentration of pollutant.

Table 1.2.2-3 Examples of recommended CO2 concentrations above outdoor concentrations for energy calculations and demand control (acc. Table B.4 of annex B)

IAQ category	Corresponding CO2 concentration above outdoors in PPM for energy calculations
I	350
II	500
III	800
IV	> 800

Recommended ventilation rates residential buildings

The recommendations in annex B for residential ventilations relate to both the direction of the ventilation air flow and the ventilation rate.

Air flow direction
It is recommended that all habitable rooms of a dwelling (living room, bedrooms, study etc.) are directly supplied with fresh air from outside, and that polluted air in wet room or utility rooms (bathroom, kitchen, toilets) are directly expelled to the outdoor atmosphere. Common spaces (corridor, staircase, etc) may be ventilated with overflow air from the habitable rooms, meaning that air is transferred from the living spaces to the common spaces and then expelled through the wet or utility rooms. This ultimately means that the supply air for the wet rooms is the exhaust air from the habitable rooms, after having passed the common spaces. (Some national regulation consider the overall ventilation rate in the building (air changes per hour or ach.), while others emphasize the minimum fresh air supply into the habitable rooms. This addition allows for a better control of the indoor air quality in the rooms where the real occupation is).

Recommended Air flow rates (in case of overflow principle)

Table 1.2.2-4 Example of ventilation rates for residences (assuming complete mixing and at continuous operation of ventilation during occupied hours) (acc. Table B.5 of annex B)

Category	Total air exchange rate house		Air exchange rate habitable rooms (living, bedrooms, study)		Related exhaust airflow from wet rooms		
	Per m^2 dwelling **1** [l/s/m^2]	Ach (at ceiling height of 2,5m)	Per person **2** [l/s/pp]	Per m^2 **3** [l/s/m^2]	Kitchen 4a [l/s]	Bathroom **4b** [l/s]	Toilet **4c** [l/s]
I	0,49	0,7	10	1,4	28	20	14
II	0,42	0,6	7	1,0	20	15	10
III	0,35	0,5	4	0,6	14	10	7

Example of procedure for determining ventilation rates
1. Calculate total ventilation rate dwelling based on
    a. Total floor area dwelling (column 1)
    b. Number of occupants or total surface of all habitable rooms (column 2 or 3)
2. Select the higher value from above a) of b) for the total ventilation rate of the dwelling
3. Adjust the exhaust air flows from the kitchen, bathroom and toilets (column 4) accordingly
4. Outdoor air should be supplied primarily to habitable rooms

Recommended ventilation rates during un-occupied hours

For *Non-Residential Buildings*, an outdoor air flow equivalent to 2 air volumes of the ventilated space shall be delivered to the space before occupancy (e.g. if the ventilation rate is 2 ach, the ventilation is started one hour before the occupancy). Infiltration can be calculated as a part of this ventilation (leakage assumptions must be described).
Instead of pre-start of the ventilation system, buildings can be ventilated during unoccupied periods with lower ventilation rates than during occupied hours. The minimum ventilation rate shall be defined based on building type and pollution load of the spaces. A minimum value of 0,1 to 0,2 l/s/m^2 is recommended if national requirements are not available.

For *residential buildings* a ventilation rate between 0,05 and 0,1 l/s/m^2 is recommended if no value is given on a national level.

Recommended criteria for (de-)humidification

If humidification or dehumidification is used, the values in the table below are recommended as design values. Usually (de-)humidification is needed only in special buildings like museums, some health care facilities, process control, paper industry etc.

Table 1.2.2-5 Example of recommended design criteria for the humidity in occupied spaces if (de-) humidification systems are installed (acc table B.6 annex B)

Type of building/space	Category	Design limit value RH for dehumidification in [%]	Design limit value RH for humidification in [%]
Spaces where humidity criteria are set by human occupancy *(Special spaces (e.g. museums) may require other limits)*	I	50	30
	II	60	25
	III	70	20
	IV	>70	<20

Informative Annex E

For the design of ventilation systems, the required maximum allowable sound levels shall be specified in the design documents based on national requirements. If these are not available the recommended values listed in this standard (Annex E) may be applied if appropriate. Noise from the ventilation (or HVAC-) system may disturb the occupants and prevent the intended use. The noise in a space can be evaluated using A-weighted equivalent sound pressure.

The table below is based on noise from service equipment and not on outside noise. These figures should be used to limit the sound pressure level from mechanical equipment and to set sound insulation requirements for the noise from adjacent rooms and buildings

Table 1.2.2-6 Examples of recommended design A-weighted sound pressure levels (acc. Table E.1, annex E)

Building	Type of space	Sound pressure level [dB{A}]	
		Typical range	Default design value
Residential	Living room	25 to 40	32
	Bed room	20 to 35	26
Child care institutions	Nursery schools	30 to 45	40
	Day nurseries	30 to 45	40
Places of assembly	Auditoriums	30 to 35	33
	Libraries	28 to 35	30
	Cinemas	30 to 35	33
	Court rooms	30 to 40	35
	Museums	28 to 35	30
Commercial	Retail shops	35 to 50	40
	Department stores	40 to 50	45
	Supermarkets	40 to 50	45
	Computer rooms, large	40 to 60	50
	Computer rooms small	40 to 50	45
Hospitals	Corridors	35 to 45	40
	Operating theatres	30 to 48	40
	Wards	25 to 35	30
	Bedrooms night time	20 to 35	30
	Bedrooms daytime	25 to 40	30
Hotels	Lobbies	30 to 45	40
	Reception rooms	30 to 45	40
	Hotel rooms night rime	25 to 35	30
	Hotel rooms daytime	30 to 40	35
Offices	Small offices	30 to 40	35
	Conference rooms	30 to 40	35

	Landscaped offices	35 to 45	40
	Office cubicles	35 to 45	40
Restaurants	Cafeterias	35 to 50	40
	Restaurants	35 to 50	45
	Kitchens	40 to 60	55
Schools	Classrooms	30 to 40	35
	Corridors	35 to 50	40
	Gymnasiums	35 to 45	40
	Teacher rooms	30 to 40	35
Sport	Covered sport stadiums	35 to 50	45
	Swimming baths	40 to 50	45
General	Toilets	40 to 50	45
	Cloakrooms	40 to 50	45

1.2.3
EN 13779 : 2007

Full title: *Ventilation for non-residential buildings; Performance requirements for ventilation and room-conditioning systems. May 2007*

This standard provides guidance especially for designers, building owners and users, on ventilation, air-conditioning and room conditioning systems in order to achieve a comfortable and healthy indoor environment in all seasons with acceptable installation and running costs. The standard focuses on the system-aspects for typical applications and covers the following:

1. Aspects important to achieve and maintain a good energy performance in the systems, without any negative impact on the quality of the internal environment
2. Relevant parameters of the indoor environment
3. Definitions of data design assumptions and performances

(Natural ventilation systems are not covered by this standard).

The standard applies to the design and implementation of mechanical ventilation and room conditioning systems for non-residential buildings subject to human occupancy (excluding applications like industrial processes). It focuses on the definitions of the various parameters that are relevant for such systems.

Where EN 15251 gives general guidance related to indoor environmental design criteria, this standard focuses on the design criteria for mechanical ventilation and room conditioning systems for non-residential buildings. As such it contains more detailed design criteria for the ventilation systems that are topic of this study. The aspects that are relevant for residential ventilation systems are briefly summarized in this paragraph.

Chapter 5 of this standard describes what type of information & design specifications are necessary to be able to design a proper ventilation and/or air-conditioning system.
Chapter 6 deals with classification of the various design parameters, making is more easy to specify what quality is requested for the different IAQ- and system performance parameters.
Finally chapter 7 explains how these performance parameters can be met and on what design assumptions it is founded. (Most of these classifications and design assumptions are also described in paragraph 1.1.3 of this report)

Informative Annex A
Informative Annex A of this standard contains “Guidelines for Good Practice”. This annex reveals a lot of detailed and practical information useful for the design of mechanical ventilation and/or air-conditioning systems for buildings subject to human occupancy. The Guideline for Good Practice gives guidance concerning the following topics:

A.2 Intake and exhaust openings

This paragraph of the annex contains guidelines for:

- classification of the extract or exhaust air (ETA1, ETA2, ETA3 and ETA4)
- the location of air intake openings
- the location of the exhaust openings (airflow rate, air velocity, distance to adjacent buildings, etc)
- distance between intake and exhaust openings (among others: dilution factor $f \leq 0{,}01$, with

$$f = \sqrt{q_v} \, / \, (C1 \times l + C2 \times \Delta h)$$

where:

f = *dilution factor*
q_v = *discharge airflow rate in [l/s]*
l = *length of a direct line between inlet and outlet provision in [m]*
Δh = *difference in height between inlet and outlet provision in [m]*
$C1, C2$ = *dilution coefficients, depending on situation*

A.3 Outdoor air quality considerations and the use of air filters

A.3.1 Contains proposal for a method on how to classify the outdoor air quality (see table with examples of key air pollutants and their guideline values)

Table 1.2.3-1 Key outdoor air pollutants

Pollutant	Averaging time	Guideline value	Source
Sulphur dioxide SO_2	24 h	125 µg/m^3	WHO 1999
Sulphur dioxide SO_2	1 year	50 µg/m^3	WHO 1999
Ozone O_3	8 h	120 µg/m^3	WHO 1999
Nitrogen dioxide NO_2	1 year	40 µg/m^3	WHO 1999
Nitrogen dioxide NO_2	1 h	200 µg/m^3	WHO 1999
Paticulate matter PM_{10}	24 h	50 µg/m^3 (max 35 days exceeding)	99/30/EC
Paticulate matter PM_{10}	1 year	40 µg/m^3	99/30/EC

Step 1. Determine key pollutants
Step 2 Search for available actual and periodical measurement data of outdoor AQ (see http://air-climate.eionet.europa.eu/databases/airbase/)
Step 3. Classify pertaining outdoor air

A.4 Heat recovery: pressure conditions to avoid contaminant transfer

This part of the annex gives information on the preferred arrangement of fans in a mechanical ventilation unit with heat recovery, for the purpose of achieving the right pressure conditions in the unit to avoid contaminant transfer from the extract air channel to the supply air channel.

A.7 Thermal insulation of the system

Guideline: All ducts, pipes and units with a significant temperature difference between the medium and the surrounding should be insulated against heat transfer, in a way that:

- condensation does not occur in the construction itself nor on the surface
- the insulation is protected against damage
- proper cleaning of ducts is still possible
- production and disposal causes as little harm to the environment as possible

A.8 Air-tightness of the system

This paragraph gives guidance to the design, the classification and testing of the air tightness of the ventilation system.
The air-tightness class of a ventilation system should be selected so that neither infiltration into an installation operating at negative pressure, nor exfiltration from an installation operating at positive pressure, exceeds a

defined percentage of the total system flow rate under operating conditions (this percentage should normally be less than 2%, corresponding class B according to EN 12237 and EN 1507).
Guidance for estimating leakage rates and its influence on air flows and energy consumption is presented in EN 15242 and EN 15241.

A.9 Airitightness of the building
The air tightness of the building should be suitable for the kind of ventilation system installed.
Buildings with balanced ventilation systems (mechanical supply and extract air) should be as airtight as possible with a n_{L50}-value below 1,0 /h for high buildings (above 3 stories) and below 2,0 /h in case of low buildings. The method to measure n_{L50}-values is specified in ISO 9972 or EN13829. The values given here describe the overall air tightness of the building structure. Accordingly all windows, doors and intentional openings as well as supply and extract air vents should be closed during such measurements.

A.11 Demand controlled ventilation
Practical experience shows that adapting the ventilation to the actual requirements can very often substantially reduce the energy consumption.
In situations with variable demand, the ventilation system can be operated in such a way that given criteria in the room are met. In rooms for the occupancy of people, the following sensors can be adopted for ventilation control according actual demand:

- movement sensors
- counting sensors
- CO2 sensors
- mixed gas sensors
- infrared sensors

In rooms with known emissions, the concentration of the most important pollutant can be used as input signal. Further information and references are available in prEN 15232.
But also more simple methods are available to adjust the ventilation according demand, amongst which:

- manual switch
- combination with light switch
- time controlled switch
- switch at the window

A.13 Space requirements for components and systems
This paragraph gives initial guidance for the space requirements necessary to facilitate easy cleaning, maintenance and repair operations.

A.14 Hygienic and technical aspects to installation and maintenance
Al components installed in a ventilation system and room conditioning system should be suitable, i.e. corrosion resistant, easy to clean, accessible and hygienically unobjectionable. Moreover, they should not encourage the growth of micro-organisms.
The basic requirements for ductwork components to facilitate maintenance are given in EN12097. But this standard also applied to all ductwork components and other equipment of ventilation systems.

Outdoor air rates by CO2 level
CO2 levels may be used for the design of a demand controlled system. Typical ranges and default values are in the table below

Table 1.2.3-8 CO2-levels in rooms

IDA Category	**CO2 level *above* level of outdoor air in [ppm]**	
	Typical range	Default value
IDA 1	≤ 400	350
IDA 2	400 - 600	500
IDA 3	600 – 1000	800
IDA 4	> 1000	1200

See also paragraph 1.1.5.4

Outdoor air rates per person
The following table presents recommended minimum air rates per person.

Table 1.2.3-9 Rates of outdoor air per personCO2-levels in rooms

IDA Category	Rate of outdoor air per person (l/s/pp)			
	Non-smoking area		Smoking area	
	Typical range	Default value	Typical range	Default value
IDA 1	>15	20	> 30	40
IDA 2	10 – 15	12,5	20 – 30	25
IDA 3	6 – 10	8	12 – 30	16
IDA 4	< 6	5	< 12	10

A.16 Acoustic environment
See Table 1.2.2-6 “Examples of recommended design A-weighted sound pressure levels”

Informative Annex D
This annex describes a method for assessing the *electric power consumption* of fans and air handling units (AHU) in ventilation systems for buildings.

D.2 SFP of an entire building
The SFP for an entire building is defined as follows: “The combined amount of electric power, consumed by all he fans in the air distribution system divided by the total airflow rate through the building under *design load conditions* in [W/m^3/s] :

$$SFP = (P_{sf} + P_{ef}) / q_{max}$$

Where

SFP = specific fan power demand in [W/m^3/s]
P_{sf} = the total fan power of the supply air fans at the design air flow rate in [W]
P_{ef} = the total fan power of the extract air fans at the design air flow rate in [W]
q_{max} = the design airflow rate through the building, which should be the extract air flow in [m^3/s]

Design load condition is the condition when the filter drop is the average of the clean filter and recommended maximum (dirty filter) pressure drops. Also the pressure drops for other components (heat exchanger, cooling coil, humidifier) is the mean of start- and end values.

D.3 SFP of individual air handling units or fans (SFP_E)
To enable the designers of building projects to quickly determine whether a given air handling unit will comply with the requirements on power efficiency, a SPF_E for the individual fan or AHU has been defined.
In a constant air volume flow system, the demands on SPF_E shall be met at the design airflow and at design external pressure drop (pressure drop in ducting). In a variable air volume flow system, the demands on SPF_E shall be met at the partial air flow and the related external pressure drop. If data on partial air flow rate and related external pressure is not specified, 65% of the maximum design airflow rate and external pressure will be used.
The specific fan power, SPF_E is the total amount of electric power in W, supplied to the fans in the AHU, divided by the largest of either supply air or extract air flow rates (i.e. not the outdoor air or the exhaust air flow rates) expressed in [m^3/s] under design load conditions.

D.3.2 SFP of heat recovery AHU:

$$SFP_E = (P_{sfm} + P_{efm}) / q_{max}$$

Where

SFP_E = specific fan power of a heat recovery AHU in [W/m^3/s]
P_{sfm} = the total fan power of the supply air fans at the design air flow rate in [W]
P_{efm} = the total fan power of the extract air fans at the design air flow rate in [W]
q_{max} = the design airflow rate through the AHU (largest of supply or extract air flow rate) in [m^3/s]

D.3.3 SFP of separate supply air or extract air handling units (AHU's) and individual fans

$$SFP_E = P_{mains} / q$$

Where

SFP_E = specific fan power of the AHU / fan in [W/m^3/s]
P_{mains} = the power supplied to the fans in the AHU in [W]
q = the design airflow rate through the AHU / fan in [m^3/s]

1.2.4
CEN/TR 14788:2006

Full title: *Ventilation for buildings – Design and dimensioning or residential ventilation systems. April 2006*

This Technical Report specifies recommendations for the performance and design of ventilation systems which serve singe family, multi family and apartment type dwellings, both during summer and winter. It is of particular interest to architects, designers, builders and those involved with implementing national, regional and local regulations and standards.

Four basic ventilation strategies are covered: natural ventilation, fan assisted supply air ventilation, fan assisted exhaust air ventilation and fan assisted balanced air ventilation, including combinations of these systems.
The Technical Report describes in detail the need for ventilation in dwellings (Chapter 5) and the design assumptions that need to be specified in order top be able to design a proper working ventilation system (Chapter 6) , such as air-tightness of the building, outdoor meteorological conditions, pollutant level outdoors, outdoor noise levels, noise characteristics of the building, etc.
Chapter 7 deals with the performance requirements for ventilation systems and represents - together with Chapter 8 that covers the design rules for ventilation systems - the core of this Technical Report on residential systems. The key elements of these two chapters will be summarized here.

§ 7.1 Ventilation air volume rate
General
For all residential ventilation systems it is necessary to specify ventilation air volume flow rates such that assumed or predicted concentrations of certain known indoor pollutants are not exceeded. The ventilation air volume flow rate is specified in many different ways in the regulations and standards of different countries and unfortunately this TR does not give an overview of the different national regulations, nor does it give the common denominator of these national regulations. However, this Technical Report (TR) does describe a method of establishing the required ventilation air volume flow rate by calculation, using pollutant production rates and defined indoor and outdoor air conditions. Examples of the ventilation air flow rates resulting from such calculations are given in Annex F of this TR.

Pollutant groups
The most common pollutants occurring in dwellings may be grouped into three different groups which can lead to different but complementary ventilations strategies:

a)
Group of background pollutants
The first type includes a large number of pollutants emitted by materials, furnishings and products used in the dwelling. They are generally not perceivable by the occupants and their sources are at a relatively low but continuous rate.
The second type includes metabolic products from occupants mainly represented by water vapor and carbon dioxide from respiration, and odours.

b)
Group of specific pollutants
This group is mainly represented by water vapor, carbon dioxide and odours. Their production is related to specific human activities in the dwelling such as cooking, washing, bathing etc. whose duration is relatively short, resulting in high pollutant production in a specific location of the dwelling.

c)
Group of combustions products
Combustion products from fuel burning appliances for space and water heating, the most dangerous of which is carbon monoxide. These should be dealt with by a chimney or flue system which carries the pollutant directly to the outside.

Ventilation strategies
One of the following two ventilation strategies is normally used:
Either a continuous and normally constant ventilation air flow rate is provided and deals with both the specific and the background pollutants together. Or a continuous (relatively low) background ventilation air flow rate is provided to deal with the background pollutants, together with a higher intermittently operated ventilation air flow rate in the rooms with the high specific pollutant production. This intermittent operation may be controlled manually (by the occupant), or automatically by suitable sensors.

Direction of the airflow
If the ventilation system allows for air transfer between rooms, the direction of this air flow between rooms should be from low polluting rooms to activity rooms. Air should be supplied and extracted in such a way as to restrict the movement of air from activity rooms to low pollution rooms. Low pollution rooms therefore usually have an outside air supply, whilst activity rooms have an air extract device. This intended air flow direction between rooms must be achieved with windows and all doors closed, meaning that air transfer openings between rooms are necessary to achieve the design air flow rates.

Energy
The main purpose of a residential ventilation system is to provide adequate indoor air quality for the occupants and to protect the dwelling fabric from damage due to high indoor humidity. It is desirable to minimize the effect on energy consumption by a ventilation system (heat load, cool load, electrical consumption) but it is important that this strive for energy savings does not adversely affect the IAQ. Ventilation systems may be controllable (e.g. running time and/or flow rate) to eliminate or reduce the occurrence of high ventilation air flow rates when they are not needed. The control can be automatic (DCV) or manual. It is possible to use automatic controls which ensure ventilation is provided where and when occupants actually need it. For activity rooms (e.g. bathrooms, kitchens) the ventilation demand is best evaluated on bases of the relative humidity instead of presence or occupancy.

§ 8. Design rules for residential ventilation systems
General
The design process of residential ventilation systems consists of the five following basic steps:
- i) specify the required design assumptions according to chapter 6
- ii) determine the design performance requirements in accordance with chapter 7
- iii) select the ventilation strategy (natural, mechanical) and control strategy (automatic, manual, continuous, intermittent)
- iv) plan the layout of the system (locations air supply, transfer and extract devices
- v) determine size and performance specifications of all components involved

System layout
Each low pollution (habitable) room should be equipped with at least one fresh air supply device. Precautions should be taken to ensure that the source of the outside air is not contaminated due to the proximity of an exhaust air outlet, flue terminal, or other avoidable sources of polluted air. The location of air inlets in rooms should be chosen or designed to minimize the risk of draughts (location on top level of occupied zone or following calculations based thermal comfort criteria in national regulations)
Air supply devices may also be fitted in activity rooms to provide adequate air supply when the extract system is running on boost setting, but these supply devices should not adversely affect pattern of air flows in the other rooms when running on a normal setting.
Each activity room should be outfitted with at least one extract device. Extract devices are usually placed at high level and as close to the pollutant source as possible.
Internal air transfer devices are used to allow air to move between rooms in a dwelling. They are best located near the floor to avoid transfer of smoke.
Ventilation systems should not allow significant re-entry of exhaust air into the dwelling or adjacent building. Arrangements should be made to avoid re-entry through outdoor air intakes and windows. This may be achieved by a careful design of terminals or by adequate special separation.

Where the systems uses ducts, the duct runs should be kept as short as possible to reduce heat losses, leakage and flow resistance.

System design
The ventilation system should be subjected to a schedule of periodic cleaning and maintenance to ensure it continues to meet the required performance. Therefore it should be possible to gain acces to clean and maintain any parts of the ventilation system which could adversely effect the performance, the IAQ, or safety of the system if they were not cleaned or maintained. This includes air terminal devices, air transfer devices, ductwork, heat exchangers , fans and filters.
The thermal energy involved in establishing the requested IAQ with the requested air volume flow rates can be calculated with the following formula:

$$P = c_{air} * Q * \Delta t \quad \text{in [W]}$$

Where

c_{air} = specific heat of air : 1,224 [J/dm^3.K]
Q = the air flow rate in [dm^3/s]
Δt = the indoor/outdoor air temperature difference in [K]

Informative Annex F
Examples of calculated values for ventilation air flow rates

F.3 Bedroom

Assumptions for calculation:
- CO2 production per human adult while sleeping : 12 l/h
- Water vapor production per human adult while sleeping : 40 g/h
- Room temperatures : 16 °C
- Rooms size: floor area 9 m^2, ceiling height 2,5 m.
- Occupancy : 2 adults
- Ventilation air enters the room from outside

Table 1.2.4-1 Calculated ventilation air flow rates for CO_2 removal from a bedroom and related humidity /condensation risk at bedroom air temperature of 16 °C

Max CO2 level at equilibrium	Recom. vent. air flow rate		Outdoor temperature -5 °C				Outdoor temperature 0 °C				Outdoor temperature +10 °C			
			Humidity		Risk ?		Humidity		Risk ?		Humidity		Risk ?	
	[m^3/h]	[l/s]	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould
1000	36,4	10,1	3,8	34	N	N	5,0	44	N	N	8,8	78	N	N
1500	20,7	5,8	4,5	40	N	N	5,6	50	N	N	9,5	83	N	Y
2000	14,4	4,0	5,0	45	N	N	6,2	55	N	N	10,0	88	Y	Y
2500	10,8	3,0	5,6	50	N	N	6,8	60	N	N	10,6	93	Y	Y
3500	6,9	1,9	6,8	60	N	N	7,9	70	Y	Y	11,6	100	Y	Y
5000	3,8	1,1	8,7	77	Y	Y	9,7	86	Y	Y	13,2	100	Y	Y

F.4 Living room

Assumptions for calculation:
- CO2 production per human adult while active : 18 l/h
- Water vapor production per human adult while active : 45 g/h
- Water vapor production from plants : 30 g/h
- Room temperatures : 20 °C
- Rooms size: floor area 20 m^2, ceiling height 2,5 m.
- Occupancy: room occupied by all persons living in dwelling for 6 h.
- Number of occupants 2, 4 and 6 persons
- Ventilation air enters the room from outside

Table 1.2.4-2 Calculated ventilation air flow rates for CO_2 removal from a living room and related humidity /condensation risk at bedroom air temperature of 16 °C

Max CO_2 level after 6 hours	Recom. vent. air flow rate	Outdoor temperature -5 °C		Outdoor temperature 0 °C		Outdoor temperature +10 °C	
2 person occupancy		*Humidity*	*Risk ?*	*Humidity*	*Risk ?*	*Humidity*	*Risk ?*

[ppm]	[m³/h]	[l/s]	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould
1000	54,5	15,1	4,0	28	N	N	5,1	36	N	N	9,0	62	N	N
1500	30,2	8,4	4,8	33	N	N	6,0	41	N	N	9,8	67	N	N
2000	19,6	5,4	5,8	40	N	N	6,9	43	N	N	10,8	74	N	Y
2500	13,3	3,7	6,9	48	N	N	8,1	56	N	N	11,9	81	Y	Y
3500	5,5	1,5	11,2	76	Y	Y	12,2	84	Y	Y	15,8	100	Y	Y
5000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4 person occupancy			*Humidity*		*Risk ?*		*Humidity*		*Risk ?*		*Humidity*		*Risk ?*	
[ppm]	[m³/h]	[l/s]	[g/kg]	%RH	Cond	Mould	[g/kg]	%RH	Cond	Mould	[g/kg]	%RH	Cond.	Mould
1000	109	30,3	3,9	28	N	N	5,1	35	N	N	8,9	61	N	N
1500	62	17,2	4,7	33	N	N	5,9	40	N	N	9,7	66	N	N
2000	43,1	12,0	5,4	37	N	N	6,6	45	N	N	10,4	71	N	N
2500	32,6	9,1	6,1	43	N	N	7,2	50	N	N	11,1	76	N	N
3500	20,9	5,8	7,5	52	N	N	8,6	59	N	N	12,5	85	Y	Y
5000	11,5	3,2	10,3	71	Y	Y	11,3	78	Y	Y	15,2	100	Y	Y

Max CO_2 level after 6 hours	**Recom. vent. air flow rate**		**Outdoor temperature -5 °C**				**Outdoor temperature 0 °C**				**Outdoor temperature +10 °C**			
6 person occupancy			*Humidity*		*Risk ?*		*Humidity*		*Risk ?*		*Humidity*		*Risk ?*	
[ppm]	[m³/h]	[l/s]	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould	[g/kg]	%RH	Cond.	Mould
1000	163,5	45,4	3,9	27	N	N	5,1	35	N	N	8,9	61	N	N
1500	93,0	25,8	4,7	33	N	N	5,9	41	N	N	9,7	67	N	N
2000	65,0	18,1	5,5	38	N	N	6,6	46	N	N	10,5	72	N	N
2500	49,8	13,8	6,1	42	N	N	7,3	50	N	N	11,1	76	N	N
3500	33,5	9,3	7,4	51	N	N	8,5	59	N	N	12,4	84	Y	N
5000	21,3	5,9	9,2	63	Y	N	10,4	71	Y	N	14,3	97	Y	N

F.5 Bathroom

Assumptions for calculation:

- CO_2 production not relevant
- Water vapor production from shower : 10 minutes at 3000 g/h = 500 g/shower
- Water vapor production from clothes drying: 15 h at 100 g/h per person in dwelling
- Room temperature : 22 °C
- Rooms size: floor area 6 m^2, ceiling height 2,5 m.
- Occupancy : All occupants take a shower every day. Number of occupants: 2, 4 or 6
- Extracted air is at 22°C and either 70% RH or 100% RH
- Ventilation air enters the room from outside, or from other rooms (at 19 °C and 50% RH
- Assume that condensation is unavoidable but that it all evaporates and is totally removed by ventilation each day over a period of 14 h.

Table 1.2.4-3 Calculated ventilation air flow rates for a bathroom; Extracted air at 100% RH and 22 °C

Time for removal of water vapor	**Required ventilation air volume flow rate**							
	Outdoor temp. -5 °C		**Outdoor temp. 0 °C**		**Outdoor temp. +10 °C**		**Air from dwelling at 19°C and 50% RH**	
h	m³/h	l/s	m³/h	l/s	m³/h	l/s	m³/h	l/s
2 person occupancy								
14	16,8	4,7	18,3	5,1	26,1	7,2	24,2	6,7
20	11,8	3,3	12,8	3,6	18,2	5,1	16,9	4,7
24	9,8	2,7	10,7	3,0	15,2	4,2	14,1	3,9
4 person occupancy								
14	33,7	9,4	36,5	10,1	52,1	14,5	48,4	13,4

20	23,6	6,6	25,6	7,1	36,5	10,1	33,9	9,4
24	19,7	5,5	21,3	5,9	30,4	8,4	28,2	7,8
6 person occupancy								
14	50,5	14,0	54,8	15,2	78,2	21,7	72,6	20,2
20	35,4	9,8	38,3	10,7	54,7	15,2	50,8	14,1
24	29,5	8,2	32,0	8,9	45,6	12,7	42,3	11,7

Table 1.2.4-4 Calculated ventilation air flow rates for a bathroom; Extracted air at 70% RH and 22 °C

Time for removal of water vapor	**Required ventilation air volume flow rate**							
	Outdoor temp. -5 °C		**Outdoor temp. 0 °C**		**Outdoor temp. +10 °C**		**Air from dwelling at 19°C and 50% RH**	
h	m^3/h	l/s	m^3/h	l/s	m^3/h	l/s	m^3/h	l/s
2 person occupancy								
14	26,5	7,3	30,1	8,4	59,5	16,5	50,7	14,1
20	18,5	5,1	21,1	5,9	41,7	11,6	35,5	9,0
24	15,4	4,3	17,6	4,9	34,7	9,6	29,6	8,2
4 person occupancy								
14	52,9	15,0	60,3	16,8	119,0	33,0	101,3	28,1
20	37,0	10,3	42,2	11,7	83,3	23,3	70,9	19,7
24	30,9	8,6	35,2	9,8	69,4	19,3	59,1	16,4
6 person occupancy								
14	79,4	22,0	90,4	25,1	178,6	49,6	152,0	42,2
20	55,6	15,4	63,3	17,6	125,0	34,7	106,4	29,6
24	46,3	12,9	52,7	14,6	104,2	28,9	88,7	24,6

F.6 WC

Assumptions for calculation:

- odor produced at pollutant at a rate of 2 l/s for 1 min.
- odor to be reduced to 10, 20, 30, 40, 50, 60% of its initial concentration within 15 min. for each use
- Rooms size: floor area 3 m2; ceiling height 2,5 m.
- Zero odor in air entering the room

Table 1.2.4-5 Calculated ventilation air flow rates for a WC

% of initial concentration after 15 min.	10%	20%	30%	40%	50%	60%
Air flow rate [m3/h]	69,5	48,6	36,4	27,4	20,9	15,5

1.2.5
EN 15665:2009

Full title: *Ventilation in buildings – Determining performance criteria for residential ventilation systems April 2009*

Scope:
This European Standard sets out criteria to assess the performance of residential ventilation systems (for new, existing and refurbished buildings) which serve single family and apartment type dwellings throughout the year. This standard specifies ways to determine performance criteria to be used for design levels in regulations and/or other standards. It is meant to give guidance and support to those who develop new regulations or standards for residential ventilation.

Interesting in the introduction is the acknowledgement that, although all ventilation requirement nowadays are based on airflow rates, there is limited knowledge about the basis for these airflow rates. This standard therefore proposes a more detailed approach to assess the way air exchange and dilution change human exposure to pollutants.

The standard is meant to be applied to, in particular:
- mechanically ventilated buildings (mechanical exhaust, supply or both)
- natural ventilation with stack effect or passive ducts
- hybrid systems, switching between mechanical and natural modes
- windows opening by manual operation for airing or summer comfort issues

The parts that are considered relevant for this Preparatory Study are summarized in this paragraph 1.2.5

Chapter 5. Needs for residential ventilation
This chapter explains the need for residential ventilation systems. It summarizes the sources of pollutants, acknowledges that these source related pollutants represent a risk for both human health &comfort and the building and finally describes the purpose of residential ventilation systems; so far no new elements.

Chapter 6. General approach

§ 6.1 Way of proceeding
This paragraph describes the following six steps that in general need to be used to determine the requested airflow rates:
Step 1: verify what national regulations/standards are applicable that lead to certain limits in airflows
Step 2: identify the pollutants that are considered relevant
Step 3: for each pollutant, make a detailed description of the nature, sources and distribution (in dependency of time); choose the appropriate criteria for each pollutant (according to chapter 7 of the standard). And finally describe the ventilation system, the occupancy patterns, the outdoor conditions and the relevant building parameters that are applicable.
Step 4: select and use the appropriate calculation method able to handle the chosen criteria and assumptions
Step 5: formulate requirements on the selected criteria and verify the performance of the calculation results with other applicable requirements (health, fire protection, noise, gas, etc.)
Step 6: present the results which can be expressed as an equivalent airflow

§ 6.2 Requirements for designing ventilation systems
The paragraph describes what the requirements are to design a ventilation systems and discriminates three different levels for calculation:

Level 1: Assumptions and criteria chosen for ventilation airflow rates
The design specification shall describe the following items:
a) Type of room, natural or mechanical supply or extract, floor level or the room
b) Ventilation regime: continuous (min, max), intermittent (min, max, time schedule), air inlets closable or not.
c) Air flow rates, expressed either in l/s per m^2, l/s per person, l/s per room
d) Global airflow rates
e) Global air infiltration

At the level of components (exhaust and supply air terminal devices, air transfer devices) requirements can be expressed in equivalent area mm^2, in airflow at a certain ΔP, etc. Pressure loss due to closed inside doors between air inlets and air exhaust shall be taken into account.
All in all resulting in a table giving the design airflow rates per individual room of the dwelling.

Level 2: Assumptions and criteria chosen for "a single calculation representing point"
This single calculation representing point can e.g. be used for designing or specifying a specific component in a certain (critical) point; for example an average point in winter time to roughly design a natural shaft (passive stack). The table containing the necessary assumptions could then look like the table below.

Table 1.2.5-1 Assumptions for level 2 (Table 2, page 10 of EN 15665)

Assumptions	Case under consideration	Default value	Unit
Indoor temperature		19	°C
Outdoor temperature		8	°C
Wind speed		1	m/s
Wind direction*		60° windward	-
Shielding*		Shielded	-
Air leakage class		N_{50} = 1	1/h
Air leakage splitting		See table 4 of EN 15665	-
Outdoor humidity		optional	% RH
* According to EN 15242			

Level 3: Assumptions and criteria chosen for a yearly calculation done for design days
For this level of calculation, assumptions shall be made for one day, at a suitable frequency for all patterns concerning occupancy, outside conditions, ventilation system use and pollutant sources (see table below). This level shall be used for daily or yearly calculations. Each day can have the same or different patterns if needed, e.g. week-end patterns are often used and are different from week patterns.
Airflow rates shall be calculated according to chapter 6 of EN 15242:2007

Table 1.2.5-2 Assumptions for level 3 (Table 3, page 14 of EN 15665)

Assumptions	Case under consideration	Default value[3]	Unit
Thermal and meteorological assumptions			
Indoor temperature			°C
Outdoor temperature			°C
Wind speed		1	m/s
Wind direction[1]		60° windward	-
Shielding[1]		Shielded	-
Outdoor humidity			% RH
Building assumptions			
Air leakage classes		N_{50} = 1	
Air leakage splitting		See table 4 of EN 15665	
Occupancy pattern			
Ventilation assumptions			
Ventilation system use pattern			
Pollutant emission[2] (water)			
Water vapour awake		55	g/h/pp
Water vapour sleeping		40	g/h/pp
Breakfast		50	g/pp
Lunch		75	g/pp
Dinner		300	g/pp
Natural gas cooking		350	g/day
Shower[4]		300	g/shower
Washing drying inside		1200	g/washing
Frequency of showers/person		1	shower/pp/day

Frequency of washing/person		1	washing/pp/day
Pollutant emission[2] (metabolic CO2)			
CO2 awake		16	l/h/pp
CO2 sleeping		10	l/h/pp

1. According to EN 15242
2. In case of calculations, assumptions of one or more pollutants is needed, in relation with the criteria chosen for the requirements
3. If the parameter is used
4. Drying towels is included in the shower (default value): it is a 6 minutes shower

Chapter 7. Criteria

§ 7.1 General
The starting point for the calculation method is to define the most important or key pollutant in each type of room in the dwelling. It is assumed that if the key pollutant is adequately controlled, then other pollutants in that room are also adequately controlled. For some rooms calculations might be necessary to determine what the key pollutant is. The following key pollutants shall be taken into account:

- metabolic CO_2 emissions and water vapour for low polluting rooms
- water vapour, odours and CO_2 from combustion of fuels in kitchens
- water vapour in bathrooms and laundry/utility room
- odours in WC

Pollutant emission rates shall be calculated for each room separately based on either known emission rates or data given as assumptions in the standard frame defined in chapter 6. This may require assumptions about the number of occupants and their presence in the various room of the dwelling, the type and rating of combustions appliances, and occupant habits (clothes washing, cooking, bathing, etc.)
Humidity is taken into account in a separate way due to the fact that it impacts on building independent of occupancy and external value is varying in large proportion. Another particularity of humidity is that both toom high levels and too low levels can induce discomfort or impact the building.

The actual criteria used to value pollutant levels can be one of the following (§ 7.2 - § 7.7):

§ 7.2 Threshold or limit of the level
The criteria is the threshold of the pollutants concentration. It shall be associated with one or more of the following:

- time above threshold during a reference period
- maximum continuous duration above this threshold during the reference period

The reference period can be for example the occupied period (e.g. for CO2) or the whole year (for humidity). Criteria can e.g. be the average concentration during a reference period.

§ 7.3 Weighted average concentration
Here different concentration classes are weighted (continuous function or discrete classes). In the following example C is the original concentration, C’ = value after discrete weighting, C’’ = value after continuous weighting. Example discrete weighting:

C < 1000	C’ = C
1000 < C < 1500	C’ = 2 x C
1500 < C < 2000	C‘ = 3 x C
2000 < C	C’ = 4 x C

Example continuous weighting:
C’’ = C x (C/500)

§ 7.4 Average concentration above a threshold with limited compensation
This method does not compensate values that are higher than the limit with values that are lower than the limit values. All values that are lower than the limit are considered equal to the limit. On this basis, the average concentration is calculated.

§ 7.5 Average concentration above a limit
This method sets criteria for the average value above a limit value, calculated with the time during which this value is exceeded.

§ 7.6 Dose above a given value
This method sets criteria on the basis of the time integral of the concentration above a certain limit value

§ 7.7 Decay criteria
The decay method is based on defining a time limit that is necessary for the ventilation system to achieve a given reduction in concentration levels

Which of these methods should be used depends on the type of pollutant.

§ 7.8 Use of criteria depending on pollutant
Three families of criteria are considered:

1. criteria for humidity
   - number of hours under a certain limit
   - max. duration under a certain limit
   - number of times the level is under the limit for more than a certain duration
   - number of hours above a certain limit
   - max. duration above a certain limit
   - number of times the level has exceeded the limit for more that a certain duration
2. criteria for specific activities such as cooking, showers/bathing, odours in toilets, hobbies
   - time to obtain a given percentage of the max. value
   - value after a certain time
   - dose above a certain value
   - average
   - average above a threshold
3. criteria for background pollutants (CO2, VOC from furniture and building materials)
   - maximum limit
   - average
   - weighted average
   - average above a certain limit
   - dose above a certain limit

1.2.6
EN 15242 : 2007

Full title: *Ventilation for buildings – Calculation methods for the determination of air flow rates in buildings including infiltration. June 2007*

This standard defines the way to calculate the airflows due to the ventilation system and due to the infiltration. The calculation of the airflows through the building envelope and the ventilation system for a given situation is described in chapter 6. Applications depending on the intended use are described in chapter 7
These calculated airflow rates can be used for applications such as energy calculations, heat and cooling load calculations, summer comfort and indoor air quality evaluation.

The results provided by this standard are 'the building envelope flow either through leakages or purpose provided openings and the air flows due to the ventilation system, taking into account the product and system characteristics'.

Note:
In the context of this Supplementary Preparatory Study we will only look at the airflow rates that are induced by the dedicated ventilation system. Airflow rates caused by infiltration and airing are the domain of the EPBD (see also § 1.1.3 Scope). Only the parts of the standard that are relevant for determining the airflow of the ventilation system will be summarized here.

Chapter 5. General approach

The airflows are calculated for a building or a zone in a building. A building can be separated in zones if:
- the different zones are related to different ventilation systems
- the zones can be considered as more or less airflow independent (e.g. air leakage between two adjacent zones are negligible and there is no air transfer between the zones)

The best way to do the calculation is to consider the air mass (dry air) flow rate balance, but it is also allowed to consider the volume flow rate when evident. For air heating and air-conditioning systems however the use of mass flow rate is mandatory.
The INPUT data are the ventilation system airflows and the airflows vs pressure characteristics of openings (vents) and leakages. The OUTPUT data are airflows entering and leaving the building through:
- leakages
- openings (vents)
- airing (windows opening)
- ventilation systems, including duct leakages

Air entering the building/zone is counted positive; air leaving is counted negative.

Chapter 6. Instantaneous calculation (iterative method)

§ 6.1 Basis of the calculation method
An iterative method is used to calculated the air handling unit air flow, and the air flow through envelope leakages and openings for a given situation of:
- outdoor climate (wind and temperature)
- indoor climate (temperature)
- system running

This chapter explains the different steps of calculation:
1. Calculation airflow rate of mechanical ventilation
2. Passive duct for residential and low rise non-residential buildings
3. Calculation of infiltration and exfiltration
4. Combustion air flow
5. Calculation of additional airflow through windows (airing)
6. Overall airflow

§ 6.2 Mechanical airflow calculation
The ventilation is based on required airflow (either supplied or extracted in each room) which is defined at national level, assuming in general perfect missing of the air. To pass from these room-based values to an overall figure for the mechanically induced airflow, the following coefficients (and impacts) shall be taken into account:
1. C_{use} : coefficient corresponding to switching on (C_{use} = 1) or off (C_{use} = 0) the fan
2. ε_v : local ventilation efficiency
3. C_{cont} : coefficient depending on local air flow control
4. C_{syst} : coefficient depending on inaccuracies of the components and system (adjustment…etc)
5. C_{leak} : due to duct and AHU leakages
6. C_{rec} : recirculation coefficient, mainly for VAV system

The mechanical airflows supplied to or extracted from *the zone* are calculated by:

$$q_{v;sup} = \frac{q_{v;sup;req} * C_{cont} * C_{indoorleak} * C_{rec}}{\varepsilon_v}$$

$$q_{v;exh} = \frac{q_{v;exh;req} * C_{cont} * C_{indoorleak} * C_{rec}}{\varepsilon_v}$$

With:

$q_{v;sup;req}$ = supply airflow according to building design and national regulations

$q_{v;sup;req}$ = exhaust airflow according to building design and national regulations

$C_{indoorleak}$ = $C_{ductleak}$

Where

$$C_{ductleak} = 1 + \frac{q_{v;ductleak}}{\frac{q_{v;req} * C_{cont} * C_{syst}}{\varepsilon_v}}$$

In which

$q_{v;ductleak}$ = $A_{duct} * K * dP_{duct}{}^{0,65} / 3600$ = air through the duct leakages in m3/h

A_{duct} = duct area in m^2 (to be calculated according to **EN 14239**)

K = air tightness of duct in $m^3/s/m^2$ at 1 Pa; the duct leakage shall be determined according to **EN 12237** (for circular ducts) ; **EN1507** (rectangular ducts)

dP_{duct} = pressure difference between duct and ambient air in Pa

§ 6.3 Passive and hybrid duct ventilation

This paragraph presents formulas for calculating the cowl airflow in a natural ventilation system with a ducted natural exhaust, depending on:

- wind velocity
- pressure loss coefficient
- roof angle and position and height of cowl
- duct pressure drop

The other airflows that are calculated in this chapter relate to airflows that are not within the scope of this preparatory study (domain of EPBD); these are the following:

§ 6.4 Combustions air flows
§ 6.5 Air flow due to window openings
§ 6.6 Exfiltration and infiltration using iterative method
§ 6.7 Exfiltration and infiltration using direct method

Chapter 7. Applications

§7.1 General

The airflows that are calculated according to this standards can be applied for:

- energy calculation
- determining heating load
- determining cooling load
- determining summer comfort
- determining IAQ

§7.2 Energy calculation

For energy calculations it is allowed to neglect the internal partition in each zone.

Note:
An assessment that does not look into the airflows per individual room however, is not sufficient for assessing the energy rating of the ventilation function on the basis of the IAQ-performance. To compare energy performance of the ventilation function in a correct manner, it is also necessary to look at the airflows (IAQ) per individual room.
For this Preparatory Study we will have to try to link the IAQ and the related airflows in separate rooms with the energy use. § 7.6 of this standard give some leads for such an assessment, since it states that for IAQ-purposes, not only the overall air exchange needs to be looked at, but also the fresh supply air for all habitable rooms, and the exhaust air for all service/utility/wet rooms.

Default values for C_{use} , ε_v , C_{cont} , C_{syst} C_{airing}
The following default values are proposed for calculating airflow rates (can be modified in national annexes)

C_{use} = 1 for occupied hours, 0 for unoccupied hours

ε_v = 1
C_{cont} = 1
C_{syst} = 1,2
C_{airing} = 1,8

In other words, it is assumed here that:
- ventilation airflows are only applied when rooms are occupied (fans are switched on during occupancy and switched off when no one is present
- the ventilation effectiveness of the applied ventilation system is always 1 (the extracted air has the same pollutant concentration as the indoor air)
- the coefficient for local airflow control is 1, which implies that the airflow per room is exactly tailored to the actual need
- the inaccuracies of the ventilation system and its components are within the 20% range.

The default values that are assumed here, highly overestimate the performance of ventilation systems and their components. Accepting these default values implies that further differentiation between ventilation systems is no longer possible. The energy saving potential related to ventilation systems that have better ventilation effectiveness, better controls, less system inaccuracies etc. can not be assessed when these default values would be accepted for this Preparatory Study.

Note:
In order to be able to differentiate between the ventilation performance and related energy use of different ventilation systems, the technical analysis of this Preparatory Study will assess the differences in **C_{use} , ε_v , C_{cont} , C_{syst}** for the various ventilation systems and their components.

1.2.7
EN 13465 : 2004

Full title: *Ventilation for buildings – Calculation methods for the determination of air flow rates in dwellings. January 2004*

This European Standard specifies methods to calculate basic whole house air flow rates for single family houses and individual apartments p to the size of approximately 1000 m3. Tis European standard may be used for applications such as energy loss calculations, heat load calculations and indoor air quality evaluations.
The Standard covers natural, mechanical extract and balanced ventilation systems. Flows due to window opening are also considered, but only as a single sided effect (i.e. no cross ventilation). Therefore, the application is limited mainly to the heating season.

The ventilation air flow rates that are topic of this supplementary Preparatory Study are discussed in paragraph 6.3.1 System flow (page 11 of the standard) and paragraph 7.5 to 7.7 (page 14 of the standard).

Informative Annex A gives a selection of input data values, amongst which leakages values for different buildings construction types and different age of dwellings are given ($q_{infiltration}$).

1.2.8
prEN 13142

Full title: *Ventilation for buildings – Components/products for residential ventilation – Required and optional Performance Charateristics. January 2010*

This European Standard specifies and classifies the component/product performance characteristics which may be necessary for the design and dimensioning of residential ventilation systems to provide the pre-determined comfort conditions of temperature, air velocity, humidity, hygiene and sound in the occupied zone.
It defines those performance characteristics (mandatory or optional) which shall be determined and measured and presented according to relevant test methods. It will provide a classification scheme which lead to a full definition of product properties based on European test methods described in various EN standards and gives an overview of the Test Standards in various CEN TC´s. Distinction between mandatory and optional requirement is left to each national regulations. This standard gives an informative national annex in which the member states define the valid parameters.
The codification part in Clause 8 and the classification part in Clause 9 of this standard applies to the following products: “mechanical supply and exhaust unit according to EN 13141-7 and EN 13141-8”.
This standard does not apply to other products such as filters, fire dampers, ducts, control devices, sound attenuators, which may also be incorporated in residential ventilation.

All classifications that are considered relevant for this study are summarised in Chapter 1 of this report.

1.2.9
EN 13141-4

Full title: *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 4: Fans used in residential ventilation systems. January 2004*

This European Standard specifies aerodynamic, acoustic and electrical power performance test methods for fans used in residential ventilation. These methods primarily concern:

- ventilation fans installed on a wall or in a window without any duct;
- ventilation fans installed in the downstream of a duct;
- ventilation fans installed in the upstream of a duct;
- ventilation fans installed in a duct;
- encased ventilation fans having several inlets.

For acoustic performance testing one of the following methods is be used:
- in duct method;
- reverberant field method;
- free field or semi-reverberant method.

1.2.10
EN 13141-6

Full title: *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 6: Exhaust ventilation system packages used in a single dwelling.*
January 2004

This European standard provides test methods for a system package to help the designer, and avoid the necessity of testing each component separately.
If however a component of the package is not physically linked to the others (e.g. externally/internally mounted air transfer devices), then it is assumed to have been tested according to the test method related to this component.

The European standard specifies laboratory methods for measuring the aerodynamic and acoustic performance characteristics and energy consumption of assembled exhaust ventilation system packages for a single dwelling. The object of this standard is to provide tested characteristics for a system package in worst case conditions so that the user be confident that better values will be achieved on site when the system package is installed in accordance with the manufacturer's instruction and within these limits of the test conditions.

1.2.11
prEN 13141-7

Full title: *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 7: Performance testing of components/products of mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings.*
December 2009

This European Standard specifies methods for the performance testing of components used in residential ventilation systems to establish the performance characteristics as identified in EN 13142.
The standard does not contain any information regarding ductwork and fittings, which are covered by other EU standards.

This particular part of the EN 14141 specifies the laboratory test methods and test requirements for the testing of aerodynamic, thermal and acoustic performance characteristics of a mechanical supply and exhaust ventilation unit used in a single dwelling.
It covers units that contain at least, within one or more casings:
- supply and exhaust air fans
- air filters
- air-to-air heat exchangers and/or extract-air to outdoor-air heat pump for extract air heat recovery
- control system

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

The standard supplied test methods for:
- Performance testing of aerodynamic characteristics (chapter 6.2):
  i.e. Leakages / airflow/pressure curves and filter bypass

- Performance testing of thermal characteristics (chapter 6.3):
  i.e. Temperature & humidity ratio's and heat pump performance

- Performance testing of acoustic characteristics (chapter 6.4)
  i.e. noise radiated through the casing; sound power levels in duct connections of the unit

- Electric power input (chapter 6.5)

1.2.12
prEN 13141-8 (Currently being revised)

Full title: *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 8: Performance testing of unducted mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for a single room.*
March 2006

This European Standard specifies methods for the performance testing of components used in residential ventilation systems to establish the performance characteristics as identified in EN 13142.

This particular part of the EN 14141 specifies the laboratory test methods and test requirements for the testing of aerodynamic, thermal and acoustic performance characteristics of a mechanical supply and exhaust ventilation unit used in a single room.
It covers units that contain at least, within one or more casings:

- supply and exhaust air fans
- air filters
- air-to-air heat exchangers and/or extract-air to outdoor-air heat pump for extract air heat recovery
- control system

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

The standard supplied test methods for:

- Performance testing of aerodynamic characteristics (chapter 6.2):
  i.e. Leakages and mixing; airflow/pressure curves and filter bypass

- Performance testing of thermal characteristics (chapter 6.3):
  i.e. Temperature & humidity ratio's; operation at low outdoor temperatures

- Performance testing of acoustic characteristics (chapter 6.4)
  i.e. radiative sound power in the indoor or outdoor space

- Electric power input (chapter 6.5)

2. ECONOMIC AND MARKET DATA

2.1 Generic Economic Data

2.1.1 Introduction

This section intends to present the production, import and export data as extracted from the Eurostat COMTEXT database, using PRODCOM categorization.
Official statistics on the production, sales and trade for ‘ventilation units’ or ‘ventilation systems’ do not exist. Eurostat and the national statistics offices classify only ‘fans’, characterized by their technical typology (axial, centrifugal, etc.) or a size characteristic (>125 W ; < 125 W ; > 300 Pa ; < 300 Pa). This implies a complete mix-up of ventilation units with fans intended for end-users for other OEM-applications (eg. for boilers, chillers, laundry driers, ovens, fancoils etc.)

This supplementary LOT10 study does not extend upon the Eurostat data presented in the Final Report of the official Preparatory Study on Residential Ventilation by Armines, France. The data from this LOT 10 Armines study is simply copied here.

2.1.2 EU25 Production

PRODCOM category 29.71.15.30 covers *“Table, floor, window, ceiling and roof fans, with a self contained electric motor of ≤ 125W “*.
This category also contains “comfort fans”. In the table below the PRODCOM 29.71.15.30 figures are corrected for comfort fans by Armines, and therefore represent the ventilation fans only.

Table 2.1.2-1 Production of fans for ventilation purposes ≤ 125 W

Country	2000		2001		2002		2003		2004		2005	
	#k units	million €	#k units	million €	#k units	million €	#k units	million €	#k units	million €	#k units	million €
Italy	1.716	39,403	1.927	46,154	1.062	48,102	2.339	46,169	2.338	51,808	2.184	49,906
Poland	200	?	300	?	637	3,758	1.059	6,963	1.423	8,485	1.800	?
United Kingdom	3.074	105,412	3.014	101,171	2.848	95,114	3.897	96,834	3.790	105,222	2.707	95,715
Portugal	0	0	0	0	0	0	0	0	0	0	24	5,757
Sweden	171	12,820	168	12,841	181	14,095	0	0	0	0	0	0
Spain	1.500	?	1.470	18,993	1.483	19,613	1.671	18,293	1.641	20,273	1.922	20,470
Germany	4.000	198,221	4.000	?	4.000	150,783	4.000	139,903	4.000	130,404	3.859	116,392
Total	10.661	355,856	10.879	179,159	10.211	332,320	12.966	308,162	13.192	316,192	12.696	288,240

Production : around 12.700.000 units per year
Production value : approximately 288 million euro (appr. € 23,- per unit)

Armines estimates that around 50% of these numbers is used in non residential applications (offices, workshops, etc), leaving around 6.350.000 units for residential purposes.

2.1.3 EU25 Trade

Preparatory Study LOT 10 estimates an extra-EU export of around 33%, and does not mention any import of residential ventilation fans.

Given the fact that especially these smaller wall/window-fans are ideal products for far east manufacturing and extra EU-import, it is estimated that at least also 33% (probably more) of the above mentioned numbers are imported. This results in an apparent EU-consumption of at least 6,5 million units per year.

2.1.4 EU27 Apparent Consumption

Although the accuracy of the PRODCOM data is limited, and figures on actual extra EU import and export are missing, it is estimated that the EU27 apparent consumption is around 6,5 to 7 million units per year.

2.2 Market and Stock data

2.2.1 EU27 Stock of ventilation systems for residential dwelling

Since little quantitative data is available, the EU-stock of ventilation systems can only be 'derived' from the housing stock (top-down approach) in combination with the scarce anecdotal data that is available for individual countries and years (bottom-up approach).
Annex 2 shows a first draft table with data that resulted from this approach.

Table 2.2.1-1 Summarizing table 2003 EU27 Stock of ventilation systems/products in residential dwellings (see Annex 2)

No.	Type of ventilation systems & products		*k#*	% of prim. dwellings
1.	No. of prim.dwellings without dedicated supply & exhaust provisions *(i.e. fully depending on infiltration and airing)*		**67.654**	**41%**
2.	No. of prim.dwellings with originally no dedicated provisions and afterwards installed retrofit exhaust wall- / window- fans (e.g. bathroom, kitchen)		**28.994**	**18%**
		Related No. of fans if average installed number = 1,6	*46.391*	
3.	No. of prim. dwellings with dedicated natural supply & exhaust provision *(system A)*		**37.357**	**24%**
4.	No of prim.dwellings with mechanical supply and natural exhaust provisions *(system B)*		**716**	**0,5%**
5.	No. of prim. dwellings with natural supply and mechanical exhaust provisions (*system C)*		**26.389**	**16%**
		Of which dwellings with centralized extract fans	*21.882*	*13%*
		Related No. of centralised exhaust fans if average installed number = 0,8	*17.506*	
		Of which dwellings with room based extract fans	*4.567*	*3%*
		Related No. of centralised exhaust fans if average installed number = 2,6	*11.874*	
6.	No. of prim.dwellings with mechanical supply and exhaust provisions *(system D)*		**451**	**0,3%**
		Of which dwellings with centralized HR units	*428*	
		Related No. of centralised HR-units if average installed number = 1,0	*428*	
		Of which dwellings with room based HR units	*14*	
		Related No. of centralised HR-units if average installed number = 2	*28*	
		Of which dwellings with mech. supply and exhaust without HR	*9*	
		Related No. supply and exhaust units if average installed number is 3	*27*	

From this approach we may conclude that the majority (41 + 18 = 59%) of the dwellings have no dedicated and proper designed ventilation systems. Approximately a quarter (24%) has a dedicated natural ventilation system. Only 16% uses mechanical exhaust systems and only around 0,3% of the dwellings have system D with heat recovery.

The 2003 installed stock of mechanical ventilation units is estimated at:

Rooms based extract fans	: appr. 59.000.000
Centralized exhaust fans	: appr. 17.500.000
Centralized mech. HR-units	: appr. 428.000
Room based mech. HR-units	: appr. 28.000
Centr. or room based supply fans	: appr. 720.000

Total stock of mech. ventilation units : 77.676.000

2.2.2
EU27 Market for mechanical ventilation units

The annual market for mechanical ventilation units is also constructed on the basis of the housing stock. Educated assumptions have been made for New Built Market, the Replacement Market (like for like) and the Renovation Market (first time installation). See Appendix 3 for an overview of all assumptions and the resulting market figures. The table below gives a summary of the annual sales figures for the three market segments

Table 2.2.2-1 Summarizing table EU27 Market for Mechanical Ventilation Systems/Units in residential dwellings anno 2003 (see Annex 3)

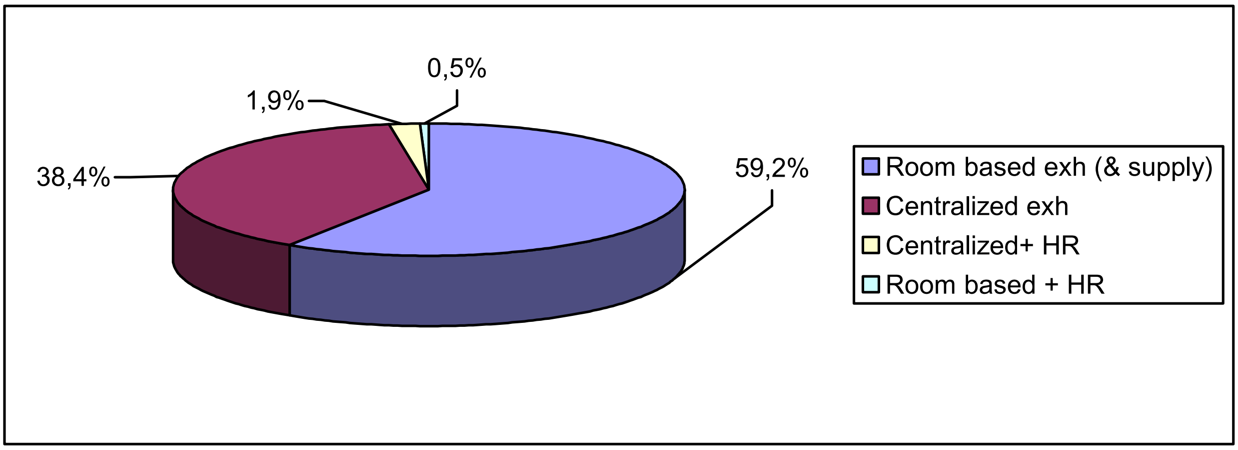
No.	Market segment		*k#/yr*
1.	**Total New Built Market**		**1.933**
	1.1	Room based mech. ventilation units / wall fans (mainly exh., some supp.)	413
	1.2	Centralized mech. ventilation units (mainly exhaust)	1.406
	1.3	Centralized mech. ventilation units with HR	103
	1.4	Room based mechanical ventilation units with HR	11
2.	**Replacement Market (like for like)**		**4.844**
	2.1	Room based mech. ventilation units / wall fans (mainly exh., some supp.)	3.578
	2.2	Centralized mech. ventilation units (mainly exhaust)	1.241
	2.3	Centralized mech. ventilation units with HR	25
	2.4	Room based mechanical ventilation units with HR	-
3.	**Renovation Market (first time installation) at 0,05% Renovation**		**156**
	3.1	Room based mech. ventilation units / wall fans (mainly exh., some supp.)	110
	3.2	Centralized mech. ventilation units (mainly exhaust)	17
	3.3	Centralized mech. ventilation units with HR	6
	3.4	Room based mechanical ventilation units with HR	23

Total market is estimated at 6.933.000 mechanical ventilation units per year. The new built market represents around 28% of this number, the replacement market around 70% and the renovation market is estimated around 2%. This renovation market is small but could become the biggest growth market for mechanical ventilation systems. It is also the segment with he biggest saving potential.

Table 2.2.2-2 Estimate on annual sales per type of ventilation unit 2003

Room based mech. ventilation units	4.101.000
Centralized mech. ventilation units (mainly exhaust)	2.664.000
Centralized mech. ventilation units with HR	134.000
Room based mech ventilation units with HR	34.000

Figure 2.2.2-3 Annual Market for mechanical ventilation units divided to type of unit



Almost 60% of the total market (in numbers) for mechanical ventilation units relates to single room units (i.e. wall and window fans mainly exhaust and some supply). Around 38% of the numbers are central exhaust units and only around 2,5% related to mechanical ventilation units with heat recovery (mainly centralized units and some room based units).

2.2.3
EU27 Forecast and Market Trends

Members of the EVIA, European Ventilation Industry Association (in statu nascendi) did a survey amongst their members to assess to total number of mechanical HR-units in the past and to forecast the future sales of these HR-units, given the trends in national EPBD legislation.

Table 2.2.3-1 Long term series of annual sales Mechanical HR-units 1985 – 2025 (achieved sales and forecast)

Year	Total number EU27	Cold Climate MS	Medium Climate MS	Warm Climate MS
1985	5.500	5.000	500	0
1986	13.100	11.600	1.500	0
1987	20.700	18.200	2.500	0
1988	28.300	24.800	3.500	0
1989	35.900	31.400	4.500	0
1990	43.500	38.000	5.500	0
1991	48.926	40.245	8.656	25
1992	54.353	42.490	11.813	50
1993	59.779	44.735	14.969	75
1994	65.206	46.980	18.125	101
1995	70.632	49.225	21.281	126
1996	76.210	51.470	24.589	151
1997	81.788	53.715	27.897	176
1998	87.366	55.961	31.204	201
1999	92.944	58.206	34.512	226
2000	98.522	60.451	37.820	252
2001	107.037	62.696	44.064	277
2002	115.551	64.941	50.308	302
2003	131.425	67.543	63.369	513
2004	147.299	70.145	76.430	724
2005	163.173	72.747	89.491	935
2006	179.047	75.350	102.552	1.145
2007	190.421	80.383	108.440	1.597
2008	200.294	79.417	118.579	2.298

2009	221.100	77.700	140.000	3.400
2010	265.417	83.717	175.367	6.333
2011	342.473	89.773	239.223	13.467
2012	419.730	95.830	303.300	20.600
2013	498.820	101.887	369.200	27.733
2014	577.910	107.943	435.100	34.867
2015	657.000	114.000	501.000	42.000
2020	844.935	125.457	635.268	84.210
2025	937.500	131.100	701.400	105.000

TO DO

2.2.4
Average age and product life

The average product life is the essential parameter in a stock model, linking sales and park data. In a sense this average product life is a reflection of the history of all the ventilation units installed in the past and this 'historical' product life should not be confused with the product the product life that is used in a Life Cycle Cost calculation, which is directed towards the future.

The following parameters determine the average product life of a mechanical ventilation units:

1.
Technical lifetime.
The technical lifetime of a fan is limited by its bearing. The bearings for a medium sized fan is typically selected to give a basic rating life-time of 40.000 hours at maximum rpm. Bearings of residential fans are normally not replaced. When failure occurs the whole fan, and sometimes even the whole mechanical ventilation unit is replaced.

2.
Operating time
The number of operating hours of a fan is the life-time determining factor.
Centralized mechanical ventilation units operate 24 hours per day, of which only a couple of hours at full speed. It is estimated that during 60 – 80% of it operating time the fan is working in low speed, which increases the rated life-time of the fan 2 or 2,5 (resulting in 80.000 to 100.000 hours). This would result in an average technical life-time of 10 – 14 years.
Local mechanical ventilation units (wall or window mounted fans) are often manually controlled, in which case they only operate a couple of hours (2 -4) per day, resulting in a technical life time of approximately 20 – 25 years.

3.
Renovation
Renovation activities, like re-arranging the bathroom, toilet, kitchen etc. in most cases also leads to replacing the ventilation provisions. It is estimated that once every 20 to 25 years such a replacement occurs.
In consultation with the representatives of the ventilation industry supporting this supplementary study, it is decided to set the average product life for mechanical ventilation units at **17 years**.

2.3 Prices and Rates

2.3.1
Consumer prices and installation costs

For several of the archetype mechanical ventilation products involved in this supplementary study, product prices and installation costs for have been collected from several countries and several manufacturers. The 'archetype' products that are selected here are:

1. Centralized mechanical exhaust unit, 200 - 250 m3/h, AC or DC-fan
2. Room based extract fan, wall mounted, 75 -100 m3/h, AC or DC-fan
3. Centralized mech. ventilation unit with 70% -90% heat recovery, 200 - 250 m3/h, AC or DC-fans
4. Room based mech. ventilation unit with 60% - 90% heat recovery, 60 -100 m3/h, AC or DC-fans
5. Controls (amongst which: speed control, programmable clock, humidity sensor, CO_2 sensor,etc.)

Around these archetype products complete ventilation systems for an average 100 m^2 dwelling are constructed, including all necessary passive components (ducts, orifices, grids, air inlet provisions, overflow provisions, etc.). Prices and installation costs for these components are also assessed, so that the costs of the complete ventilation systems around the different archetype mechanical ventilation units become transparent.

Note: Room based supply fans and centralized mechanical supply units are not treated separately here. Their market share is considered too small and their differences with the exhaust type negligible to justify a separate group. They are considered comparable to the room based and centralised exhaust units.

a.
Ventilation system with centralized mechanical exhaust

Table 2.3.1-1 Centralized mechanical exhaust ventilation system for av. (100 m2) dwelling, appr. 200 - 250 m3/h AC/DC-fan

	U.K.	Germany	Netherlands	France
Product price centralized exhaust unit - AC fan - DC fan Consumer List Price in € (VAT incl) per unit	€ 160,- € 210,- (ScrewFix.com)	€ 423,- € 576,- (list price manuf.)	€ 250,- € 320,- (list price manuf.)	€ 370,-
Installation kit exhaust system Consumer List Price (VAT incl)	€ 300,- Source: ScrewFix.xom	€ 200,-	€ 300,- Estimate	€ 200,-
Supply & overflow provisions (vents, grills)	€ 320,- Estimate: 8 x €40,-	€ 332,-	€ 375,- Estimate: 5 x €75,-	€ 300,-
New built Installation costs (VAT incl.)	€ 330,- Estimate: 6h. x € 55,-	€ 330,- Estimate: 6h. x € 55,-	€ 330,- Estimate: 6h. x € 55,-	€ 330,- Estimate: 6h. x € 55,-
Renovation installation costs (VAT incl.)	€ 825,- Estim.:15h. x € 55,-	€ 825,- Estim.: 15h. x € 55,-	€ 825,- Estim.: 15h. x € 55,-	€ 825,- Estim.: 15h. x € 55,-
TOTAL price system components	€ 780 - 830,-	€ 955 - 1108,-	€ 925 - 995,-	€ 870,-
TOTAL installed New Built	€ 1110 - 1160,-	€ 1285 – 1438,- € 1500,- [1]	€ 1255 - 1325,-	€ 1200,-
TOTAL installed Renovation	€ 1605 - 1655,-	€ 1780 – 1933,-	€ 1750 -1820,-	€ 1695,-

1). Source: Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e.V.

For a lot of fan-manufacturers the manufacturing costs of DC versus AC-fans have diminished over the years, making it more interesting for end customers to apply the more efficient DC-fans.

The following average consumer prices (VAT included) will be used for a reference 100 m^2 four room dwelling, to be used in LLCC-calculations:

- Centralized mechanical exhaust unit AC : € 260,-
- Centralized mechanical exhaust unit DC : € 310,-
- Installation kit exhaust system (3 wet rooms) : € 300,-
- Supply and overflow provisions for 4 rooms : € 325,-

- Installation costs new built : € 330,-
- Installation costs renovation : € 825,-

b.
Ventilation system with room based mechanical exhaust

Table 2.3.1-2 Room based extract fans for av. (100 m2) dwelling, appr. 60 - 100 m3/h, AC/DC-fan

	U.K.	Germany	Netherlands	France
Product price room-based extract fans - AC fan - DC fan Consumer List Price in € (VAT incl) per unit	€ 60 - 150,- € 80 - 180,- (ScrewFix.com)	€ 80 – 180,- € 100 – 200,- (list price manuf.)	€ 70 - 140,- € 90 - 180,- (list price manuf.)	€ 70 - 125,- € 95 – 160,- (list price manuf.)
Supply & overflow provisions for 4 rooms (vents, grills, etc.)	€ 320,- Estimate: 8 x €40,-	€ 370,- (4 x80 +5x10,-)	€ 375,- Estimate: 5 x €75,-	€ 300,-
New built Installation costs for 3 units (VAT incl.)	€ 165,- Estimate: 3h. x € 55,-	€ 165,- Estimate: 3h. x € 55,-	€ 165,- Estimate: 3h. x € 55,-	€ 165,- Estimate: 3h. x € 55,-
Renovation installation costs for 3 units (VAT incl.)	€ 275,- Estimate: 5h. x € 55,-	€ 275,- Estimate: 5h. x € 55,-	€ 275,- Estimate: 5h. x € 55,-	€ 275,- Estimate: 5h. x € 55,-
Total product price system with 3 units	€ 620 - 720,-	€ 760 – 820,-	€ 690 - 780,-	€ 600 - 685,-
TOTAL installed New Built	€ 785 - 885,-	€ 925 – 985,-	€ 850 - 930,-	€ 760 - 835,-
TOTAL installed Renovation	€ 895 - 995,-	€ 1035 – 1095,-	€ 965 - 1055-	€ 875 - 960,-

The following average consumer prices (VAT included) will be used for a reference 100 m^2 four room dwelling, to be used in LLCC-calculations:

- Room based mech. exhaust unit DC for 3 wet rooms : € 375,-
- Supply and overflow provisions for 4 rooms : € 325,-
- Installation costs new built : € 155,-
- Installation costs renovation : € 275,-

c.
Ventilation system with centralized mechanical balanced ventilation unit with heat recovery

Table 2.3.1-3 Centralized mech. ventilation units with 70% & 90% HR, 200 - 250 m3/h, AC or DC-fans

	U.K.	Germany	Netherlands	France
Product price centralized HR unit - AC fan 70% - AC fan 90% - DC fan 90% incl bypass & electr pre-htr Consumer List Price in € (VAT incl) per unit	€ 750,- - € 1620,- (Dealec.co.uk)	- - € 2480,- (shop.strato.de)	- - € 2300,- (list price manuf.)	- € 2660,- € 3100,- (list price manuf.)
Installation kit Consumer List Price in € (VAT incl)	€ 600,- Source: ScrewFix.xom	€ 600,- Estimate	€ 600,- Estimate	€ 600,-
Overflow provisions	€ 90,- Estimate: 3 x €30,-	€ 150,- Estimate: 3 x €50,-	€ 0,- Estimate	€ 0,-
Controls: Provisions for manual control included	-	-	-	-
New built Installation costs in € (VAT incl.)	€ 1320,- Estimate:24h x € 55,-	€ 1320,- Estimate:24h x € 55,-	€ 1320,- Estimate:24h x € 55,-	€ 1320,- Estimate:24h.x € 55,-
Renovation installation costs in € (VAT incl.)	€ 2200,- Estimate: 40h. x € 55,-	€ 2200,- Estimate:40h. x € 55,-	€ 2200,- Estimate:40h. x € 55,-	€ 2200,- Estimate:40h. x € 55,-
TOTAL price system components (DC – 90%)	€ 2310,-	€ 3230,-	€ 2900,-	€ 3700 ,-
TOTAL installed New Built (DC – 90%))	€ 3630,-	€ 4550,- € 5000,-[1]	€ 4220,-	€ 5020,-
TOTAL installed Renovation (DC – 90%)	€ 4510,-	€ 5430.-	€ 5100,-	€ 5900,-

1). Source: Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e.V.

The following average consumer prices (VAT included) will be used for a reference 100 m^2 four room dwelling, to be used in LLCC-calculations:

- Centralized mechanical AC ventilation unit with 70% HR : € 1000,-
- Centralized mechanical DC ventilation unit with 90% HR : € 2300,-
- Installation kit (3 wet rooms, 4 habitable rooms) : € 600,-
- Overflow provisions for 4 rooms : € 100,-
- Installation costs new built : € 1320,-
- Installation costs renovation : € 2200,-

d.
Ventilation system with room based mechanical balanced ventilation units with heat recovery

Table 2.3.1-4 Room based mech. ventilation units with 70% & 90% HR, 60 - 100 m3/h, AC or DC-fans

	U.K.	Germany	Netherlands	France
Product price room based HR-unit - AC fan 70% - AC fan 90% - DC fan 90% incl bypass CO²&RH sensor Consumer List Price in € (VAT incl) per unit	€ 200,- * - - (Dealec.co.uk)	€ 760 - € 1300,- (no sens.) (shop.strato.de)	- - € 1300,- (list price manuf.)	-
Installation kit Consumer List Price in € (VAT incl)	€ 100,-	€ 100,-	€ 100,-	-
Controls	manual	manual	CO2 & RV	-
Room based Extract units in wet rooms	€ 60 (ScrewFix.com)	€ 80 (list price manuf.)	€ 70 (list price manuf.)	-
New built Installation costs for 4 HR units (VAT incl.)	€ 440,- Estimate:8h. x € 55,-	€ 440,- Estimate:8h. x € 55,-	€ 440,- Estimate:8h. x € 55,-	-
Installation costs for 3 room based extract units (VAT incl.)	€ 165,- Estimate:3h. x € 55,-	€ 165,- Estimate:3h. x € 55,-	€ 165,- Estimate:3h. x € 55,-	-
Renovation installation costs for 4 HR units (VAT incl.)	€ 440,- Estimate:8h. x € 55,-	€ 440,- Estimate:8h. x € 55,-	€ 440,- Estimate:8h. x € 55,-	-
TOTAL price system components (4 x HR-unit + 3 x extract unit)	€ 1380,- (AC - 70%)	€ 3760,- (AC - 70%)	€ 5810,- (DC - 90%+ sensors)	-
TOTAL installed New Built (DC – 90%))	€ 1985,-	€ 4365,-	€ 6415,-	-
TOTAL installed Renovation (DC – 90%)	€ 1985,-	€ 4365.-	€ 6415,-	-

* Products may show huge differences in quality and product features (recirculation, flow variations, flow balance, ventilation effectiveness, heat recovery); product in question is a complete HR-unit with two axial fans placed in a single short tube; a slight pressure difference (5 Pa) over the façade directly reduces one of the flows and with it the balance. Comparison between products is therefore not always possible. The revision of EN 13142-8 should identify and measure these differences.

The following average consumer prices (VAT included) will be used for a reference 100 m^2 four room dwelling to be used in LLCC-calculations:

- Room based manually controlled mech. AC vent. unit with 70% HR for 4 rooms : € 1200,-
- Room based manually controlled mech. AC vent. unit with 90% HR for 4 rooms : € 3440,-
- Room based CO^2 & RH controlled mech. DC vent. unit with 90% HR for 4 rooms : € 5600,-
- Purchase & Installation 3 mechanical extract units (3 x (€ 60 + € 55) = € 345,-) : € 345,-
- Installation costs new built & renovation for 4 room based HR-units : € 440,-

e.
Controls for residential ventilation systems

Table 2.3.1-5 Room based mech. ventilation units with 70% & 90% HR, 60 - 100 m3/h, AC or DC-fans

Controls	Consumer prices, VAT included			
	U.K.	Germany	Netherlands	France
Multiple position switch	€ 35,-	€ 95,-	€ 25,-	
Speed controller DC-fans			€ 50,-	
RF-transmitter RF-receiver		€ 184,-	€ 75,- € 60,-	
Programmable clock switch		€ 180,-	€ 35,-	€ 40,-
Movement detector	€ 115,-			
RH-sensor	€ 110,-	€ 95,-		€ 40,-
CO^2 sensor	€ 300,-	€ 200,-	€ 295,-	

The following average consumer prices (VAT included) will be used for LLCC calculations

- Multiple positions switch or speed controller : € 0,- ; default included in the product
- RF-communication : € 150,-
- Programmable clock switch : € 50,-
- Movement detector : € 100,-
- RH-sensor : € 75,-
- CO2 sensor : € 250,-

2.3.2
Energy prices

In accordance with the Preparatory Study LOT 1 and the related Impact Assessment study, the following EU-average energy prices will be used in the LLCC-calculations:

Table 2.3.2-1 Energy prices per GJ anno 2005

Energy type	Euro/GJ	Euro/MJ	Euro/kWh
Electricity (grid)	41,60	0,042	0,15
Gas (GCV)	13,-	0,013	0,047
Oil (GCV)	17,-	0,017	0,061

The energy price that will be used for calculating the energy costs for heating will be a mix of the above figures. The mix in the table below is based on the breakdown of the boiler stock by fuel type (Task 3, chapter 5 of the Preparatory Study of boilers):

Gas	: 0,76 x 13,-	= € 9,88
Oil	: 0,21 x 17,-	= € 3,57
Electricity	: 0,03 x 41,60	= € 1,25
Price for EU-heating mix		= € 14,70 per GJ = 0,0147 €/MJ = 0,053 €/kWh

Latest Eurostat data are from 1st semester 2009 and for EU-27 (15.000 kWh/a) indicate € 16,21 per GJ by 1.7.2009. The average annual price increase over the period 1.1.2006-1.7.2009 is thus 9%.
Eurostat excludes the higher increases over the period 1.1.2006-1.7.2007 and reports an annual increase of 7,3% over the last 2 years. We will use this lower estimate.

Given a product life of 16-17 year, a 1.7.2009 price of € 16,21 per GJ and an average annual price increase, the non-discounted price halfway product life (in 2018) will be € 28,50 per GJ.

2.3.3
Servicing maintenance and repair

From the Industry Association in formation (EVIA), the following data was gathered:

Table 2.3.3-1 Annual costs for maintenance

	Centralized mechanical exhaust (supply) system	Room based mechanical exhaust (supply) unit	Centralized mechanical Heat Recovery system	Room based mechanical Heat Recovery unit
Duct cleaning, once every 10 yr (hour tariff € 50,- includes equipment)	(3 hours x € 50,-) 150,-	-	(4 hours x € 50,-) 200,-	-
Cleaning of air supply provisions (External ATD;s, grids, trickle vents, orifices etc.) *Performed by consumer*	-	-	-	-
Filter replacement supply side Cost central unit: - *€ 35,- per filter* - *replaced by consumer* Costs room based unit - *€ 15,- per filter* - *replaced by consumer*	(only for supply-units 2 repl. ad € 35,-) € 70,-	(only for supply-units 2 repl. ad € 15,-,-) € 30,-	(for supply-side 2 repl. ad € 35,-) € 70,-	(for supply-side 2 repl. ad € 15,-, € 30,-
Filter replacement exhaust side Cost central unit: - *€ 25,- per filter* - *simult. replaced with supply filter.* Costs room based unit - *€ 10,- per filter* - *replaced by consumer*	-	-	(for exhaust-side 2 repl. ad € 25,-) € 50,-	(for exhaust-side 2 repl. ad € 10,-) € 20,-

Over the lifetime of the four/(six) selected archetype products the results in the following overall service and maintenance costs:

Table 2.3.3-2 Lifetime service and maintenance costs

Archetype ventilation product/system		Lifetime service- and maintenance costs	
		All mech. supply with filtering	Only centr.mech. supply and all HR-units with filtering
1.	Room based mechanical exhaust unit	-	-
2.	Room based mechanical supply unit	510,-	-
3.	Centralized mechanical exhaust system (incl.ductwork)	255,-	255,-
4.	Centralized mechanical supply system (incl.ductwork)	1445,-	3315,-
5.	Centralized mechanical HR system (incl.ductwork)	2380,-	2380,-
6.	Room based mechanical HR unit	850,-	850,-

2.4 Industry, Distribution and Costs

2.4.1 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. 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 2.4.1-1 . 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
LITHUANIA				
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				
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 (preassembled 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, optimization 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 built 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.

2.4.2 Associations

Industry Associations for *Residential 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 transboundary 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.

Other relevant EU-associations and organisations:

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, founded in 2001
NIVE is a registered European Economic Interest Grouping (EEIG), whereby 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 all leading 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 - the development of new knowledge will always be important for INIVE members.
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.

EUROVENT
The European Committee of Air Handling and Refrigeration Equipment Manufacturers
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.

2.4.3
Distribution

For the more complex ventilation products (mechanical ventilation units for centralized systems and units with heat recovery), the prevalent form of distributions is:

Manufacturer/importer > wholesaler > installer/contractor

For the simpler wall- and window fans there is an important second distribution channel that is generally used:

Manufacturer/importer > DIY > installer/consumer

A growing phenomenon related to the sales of mechanical ventilation units is the “online sales”. Although factual data is lacking, the growth in the number of websites offering these products is typical for this trend.

2.4.4
Manufacturing costs

In order to evaluate the impact of specific design options, it is needed to clarify mark-ups and margins on manufacturing costs. The estimates in this paragraph are based on analogies with similar sectors and on existing costing and engineering experience.
A first step in the split-up, is the calculation of the manufacturing selling price from the consumer price. For this we assumed wholesale margins of ca. 20% and installer margins of 20% and VAT of 19%.

Table 2.4.4-1 Assessment of EU-average Manufacturing Selling Price

		Av. list price Incl. 19% VAT	Consumer street price Incl. 19% VAT	Consumer street price excl. 19% VAT	Wholesale price	Manufacturing selling price (msp)
Centralized exhaust unit (DC)	€	325,-	283,-	237,-	198,-	165,-
Factor of msp	-	1,97	1,71	1,44	1,20	1
Mark-up	%	15%	19%	20%	20%	
Room based extr./supp fans (DC)	€	100,-	87,-	73,-	61,-	50,-
Factor of msp	-	1,97	1,71	1,44	1,20	1
Mark-up	%	15%	19%	20%	20%	
Centralized HR unit (90%,by-pass, el pre.htr)	€	2500,-	2174,-	1827,-	1522,-	1269,-
Factor of msp	-	1,97	1,71	1,44	1,20	1
Mark-up	%	15%	19%	20%	20%	
Room based HR unit (90%, by-pass)	€	1200,-	1043,-	877,-	731,-	609,-
Factor of msp	-	1,97	1,71	1,44	1,20	1
Mark-up	%	15%	19%	20%	20%	

Table 2.4.4-2 Assessment of EU-average Manufacturing Selling Price split up

		MSP	Overhead Manuf.	Labour	Subassemblies & components
			Marketing administration amortisation, margin	Finishing assembly, testing packaging	Including OEM-components
Centralized exhaust unit (DC)	€	165,-	58,-	25,-	82,-
	%	100%	35%	15%	50%
Room based extr./supp fans (DC)	€	50,-	17,50,-	7,50,-	25,-
	%	100%	35%	15%	50%
Centralized HR unit (90%,by-pass, el pre.htr)	€	1270,-	508,-,-	254,-	508,-
	%	100%	40%	20%	40%
Room based HR unit (90%, by-pass)	€	609,-	244,-	122,-	243,-
	-	100%	40%	20%	40%

3. USER REQUIREMENTS

3.1 Introduction

Task 3 deals with real-life energy consumption of ventilation systems, in relation to consumer behaviour, system designers and installer, building characteristics and service and maintenance. All these aspect have an influence on the energy consumption of the products concerned. This chapter attempts to assess and to quantify the nature of these relations.
Main topic in this chapter will be the housing stock, since it represents the key link to the ventilation need but also the key link to the market analysis of chapter 2. Given the fact that statistical data on these products are scarce and incomplete, the housing stock will be the anchor for quantitative projections concerning market data on ventilation

3.2 Characteristics residential dwelling

Annex 1 contains data on the EU27 housing stock in 2003. The table is a VHK compilation of Housing Statistics of the European Union, based on the Boverket 2005 report. The table discriminates:

- Dwelling stock (primary, secondary and vacant dwellings)
- Age of dwelling stock
- Changes to the buildings stock (new built and demolished)
- Type of dwelling

for the EU-27 member states.

Table 3.2-1 Summarizing table EU27 Housing Stock (see Annex 1)

Parameter		**unit**	**EU27 numbers**
Population 2010		k#	489.071
Dwelling Stock 2003		k#	215.056
	Primary (= ca. # households)	k#	194.559
	Secondary	k#	
	Vacant dwellings	k#	
Age of dwelling stock			
	Year of built < 1919	%	15
	Year of built 1919 – 1945	%	12
	Year of built 1946 – 1970	%	32
	Year of built 1971 – 1980	%	20
	Year of built > 1980	%	22
	of which > 1990	*%*	*13*
Changes to Building Stock			
	New built per year : period >1980	%	0,96
	New built per year : period >1990	%	1,00
	New built 1990	k#	2.169
		%	1,01
	New built 2003	k#	2.174
		%	1,01
	Demolished 2003 (incomplete data)	k#	133
		%	0,062
Type of dwellings			
	One & two family dwellings	%	54
	Multi family dwellings	%	46
	of which high rise (> 4 storeys)	%	16
	Floor area per dwelling: stock	m^2	87
	Floor area per dwelling: new built	m^2	103
	Floor area per person: stock	m^2	35
	Nr. of rooms per dwelling: stock	#	4,0
	Nr. of rooms per dwelling: new built	#	4,5
	Persons per household (stock)	#	2,5

The total amount of primary residential square meters that need ventilation is around 17 billion m2, resulting is a reference total ventilation airflow of around 22,1 billion m3/h (reference continuous ventilation air volume flow is 1,3 m3/m3/h, see paragraph 4.4.2) and a total annual air volume flow of 22,1 x 8760 = 193 Tm3 per year

In the heating season this ventilation airflow represents an EU-average total amount of <u>thermal energy</u> of:

$$Q_{vent;therm;hhs} = q_{vent} * \Delta T * C_p * \rho * h_{hs} \text{ [kJ / heating season]}$$

$$22{,}1 * 10^9 * 9{,}5 * 1{,}007 * 1{,}230 * 5112 = 1.329 \text{ petajoule/yr} = 369 \text{ TWh/yr}$$

The market for residential mechanical ventilation systems with fans < 125 W, mainly pertains to the one and two family dwellings and the multi family dwellings in low rise buildings (< 4 storeys). The high rise residential buildings (> 4 storeys) – as far as mechanical ventilation systems are applied – will mostly use centralised (exhaust) system with fan power of over 125 W.

3.3 Consumers, Installers and other Stakeholders

3.3.1 Who decides when what Ventilation Systems is installed?

New built / major renovation
In the current market, the key moment for choosing the right ventilation system is during the construction stage of new building projects and major renovation projects.
In this phase the Housing Developer or Building Contractor makes plans for the new or to be renovated dwellings and needs to comply with national building codes concerning ventilation. Because of EPBD-legislation, Member States no longer allow natural infiltration being the key mechanism for supplying ventilation air. New dwellings (and major renovated ones) need to achieve certain air tightness- and insulation values to reduce heat losses, preventing infiltration to be the driving mechanism behind ventilation supply air. As a result, dwellings need to have at least dedicated air supply provisions in habitable rooms and dedicated air exhaust provisions in the wet rooms, which together are capable of achieving the building code ventilation rates concerning extract airflow rates from the wet rooms and supply airflow rates for the habitable rooms.
The Housing Developer / Building Contractor will generally instruct their installation- or system designers to opt for the cheapest solution. Other constraints that the Housing Developer may encounter before receiving his building permit, are the national EPBD standards on the overall energy-performance of the dwelling, in which ventilation systems may play a considerable part.

First time installation
A large number of older dwellings (60%) date before 1970. A part of these dwellings have been subjected to some insulation measures (cavity wall insulation, double glazing, etc.) which generally also influences the overall air tightness of the building. In such cases indoor air quality problems may occur. If these problems are becoming obvious and urgent (moulding and/or damage to the building) to the householder or renter/landlord, one might decide to install ventilation provisions, which usually implies that room based wall or window fans are installed in the wet rooms.

Replacement
House owners that have a dedicated ventilation system installed, will replace the mechanical components (mechanical ventilation units) when it reaches the end of its life-time. With the current perception on ventilation, house owners will choose for the cheapest replacement. Most of the time this means replacing like-for-like.

Consumer
(No knowledge, attitude, behaviour, interaction with ventilation system is very limited, perceived resistance to certain type of ventilation systems)

Installers
(Limited knowledge and experience; are not aware of the fact that in well insulated and airtight houses a good operation of ventilation systems is essential); no checks upon final completion; no maintenance contracts, no maintenance awareness; etc.)

System designers
(Conservative (they design the well known traditional ventilation systems), limited knowledge about new systems and their specifications; limited knowledge about actual performance in the field)

Housing Developers
Only look at short term financial side of ventilation systems (must be cheap).
No awareness of the relation between well insulated airtight buildings and proper functioning ventilation systems!

Local authorities
Only check whether building codes are respected and general EPBD requirements are fulfilled.
No awareness of the relation between well insulated airtight buildings and proper functioning ventilation systems! No other involvement

Manufacturers
Large number of small and medium sized manufacturing companies, mainly European.
Imports where the simple products are concerned (wall and window fans). Central exhaust and Heat Recovery Systems are predominantly EU-made.

Organization of the sector
No or limited organization on eu-level; EVIA in preparation amongst others to deal with Ecodesign issues related to dedicated ventilation systems.
On a national level, ventilation industry is more or less organised

Training, certificates, qualifications
In some countries schemes in preparations; other countries no such schemes.

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4. TECHNICAL ANALYSIS

4.1 Introduction

The purpose of residential ventilation systems is to exchange sufficient air with the outside so that the Indoor Air Quality (IAQ) is secured (see chapter 1). The degree to which ventilation systems succeed in achieving this purpose will vary and largely depends on the type of ventilation system used.

Ideally, only the necessary amount of air in each separate room is exchanged to achieve the requested IAQ, or in other words: ‘providing the requested air exchange in the right room on the right time’. For *unoccupied* rooms this means that only a basic ventilation rate is applied to compensate for emissions building- and furnishing materials. For *occupied* habitable rooms the air exchange rate can best be based on the carbon dioxide concentration, which is internationally considered the key indicator for all possible pollutants in IAQ. For utility (wet) rooms, humidity and malodorous air (toilets) are considered the key pollutant, whereby in addition a number of operating hours beyond the point where the acceptable relative humidity is reached, is necessary to compensate for the moisture that absorbed by building materials and fabric.

Current practice however relates to ventilation systems that are far from achieving these ideal performance levels. In 2003 about 60% of the dwelling stock (< 1970) relies on infiltration and airing which generally implies that air exchange rates per room are either too high (wasting energy) or to low (inadequate IAQ). Around one third of these dwellings have later on installed room based manually operated mechanical extract fans, solving the major IAQ-problems in the wet rooms (kitchen and bathroom).
Another 24% of the dwellings (in 2003) have fully natural ventilation systems (dedicated passive air supply and air exhaust provisions). These dwellings in general have an overall better IAQ than the first group, but – depending on wind pressure and temperature difference between inside and outside – still suffer from the fact that air exchanges per room are either too high or too low.
The remaining part of the 2003 dwellings stock (around 16%) has mechanical ventilation systems, of which the majority (approximately 15,8 % of the dwellings) have mechanical exhaust systems and about 0,02% have systems with both mechanical exhaust and supply with heat recovery; (the percentage of systems with mechanical supply is even smaller than that). And even for these dwellings with mechanically driven ventilation systems, air exchange rates per room are not optimised.

The general approach in national member state legislation is one where the overall air exchange of the total dwelling achieved by the ventilation system in its maximum capacity is assessed and must comply with a minimum air exchange rate of around 0,70 (figures may slightly vary per member state). Whether air exchanges actually occur ‘on the right time in the right place’ is not so much an issue in current performance assessments. Given the fact that far-out the largest part of mechanical ventilation systems are mechanical exhaust systems, the air exchanges over the total dwelling are induced through in the wet-rooms. This indeed secures the humidity rates in the dwelling, but does not necessarily secures the IAQ in the habitable rooms during occupancy.

For the purpose of this study we have to compare energy performance of ventilation products and systems on the basis of their IAQ-performance in both the utility and the habitable rooms. Or at least make a serious attempt to do this in order to compare apples with apples. Over-ventilation is not so much an issue for heat recovery systems, but a big energy-issue for systems without heat recovery and therefore must be assessed. Under-ventilation implies that IAQ-performance standards are not met and ventilation systems need to be corrected for that. Otherwise, system with under-ventilation would rank under the best energy-performing systems.
The fact that EPBD-legislation will lead to better insulated and airtight dwellings strongly increases the need for ventilation systems that actually deliver the requested air exchange and the related IAQ-levels in all individual rooms. Inhabitants can no longer rely on infiltration to compensate for inadequate ventilation systems or systems that temporarily or locally cannot deliver the requested air exchange rate. Ventilation systems therefore must also be assessed on the basis of their ability to deliver the requested air exchange under all circumstances.

This chapter 4.Technical Analysis discusses all available and not available passive and active components that are used in mechanical ventilation systems. It not only covers the basic technical features of these components, but also their effect on over- and under-ventilation and energy consumption.

In that respect both heat recovery and controls will play a key role in this chapter. Paragraph 4.2 deals with all relevant already available components. Paragraph 4.3 covers the components or product features that are not yet available but topic of future and current innovation projects.
The last paragraph 4.4 contains the proposal to convert this knowledge into a System Model for comparing Energy Consumption in the Use Phase on the basis of equal or at least similar IAQ-performances.

4.2 Best Available Technologies

4.2.1
Categorization of Ventilation Systems

Residential ventilation systems have in common that they all at least have air supply provisions in all habitable rooms supplying fresh air directly from outside, and air exhaust provision in all utility (wet) rooms emitting humid and/or malodorous air directly to the outside. Apart from this shared feature, the variations in ventilation systems can best be described by the following five characteristic properties:

1. Ventilation system operates with or without **air-overflow**
   - *With overflow* : air supplied in habitable rooms is extracted to the outside through the wet rooms
   - *Without overflow* : air supplied in habitable rooms is also extracted to the outside from that same room

2. **Driving force** behind the supply provisions and exhaust provisions:
   - *Naturally* induced ΔP, either by wind pressure or by thermal buoyancy
   - *Mechanically* induced ΔP (by fans)

3. **Location** of the mechanical ventilation unit
   - *Centralized* : air is supplied and/or extracted through a centralized mechanical unit, using ducts to guide the exhaust and/or supply air from and to the rooms
   - *Room based* : air is supplied and/or extracted through a room based mechanical unit that is mounted on an external wall supplying and/or extracting the air directly from and to the outside

4. **Type of flow rate controls** used for the exhaust and supply of air
   - No controls
   - Manually controlled
   - Time controlled
   - Occupancy controlled (people present or not)
   - Presence controlled (flow rate based on number of people)
   - IAQ sensor controlled (on basis of e.g. CO_2, RV, VOC etc.)

5. With or without **Heat Recovery**
   - Air to air plate heat exchanger (either with or without humidity exchange)
   - Heat pumps, recovering energy from the exhaust air

The first three parameters are crucial for the physical lay-out of the ventilation system; the last two parameters can be added, following remaining possibilities and wishes. The next table describes the commonly used ventilation systems divided into system with permanent air-overflow from habitable to wet rooms and systems without.

Table 4.2.1-1 Classification of Ventilation systems

0. No ventilation system	**No dedicated air supply- and exhaust provisions**			
Driving forces	**Type**	**Habitable rooms**	**Wet rooms**	**Overflow provisions**
Naturally induced ΔP for supply and exhaust	0	Infiltration & exfiltration through cracks & leaks and *Airing* with occasionally opened windows	Infiltration & exfiltration through cracks & leaks and *Airing* with occasionally opened windows	No dedicated provisions

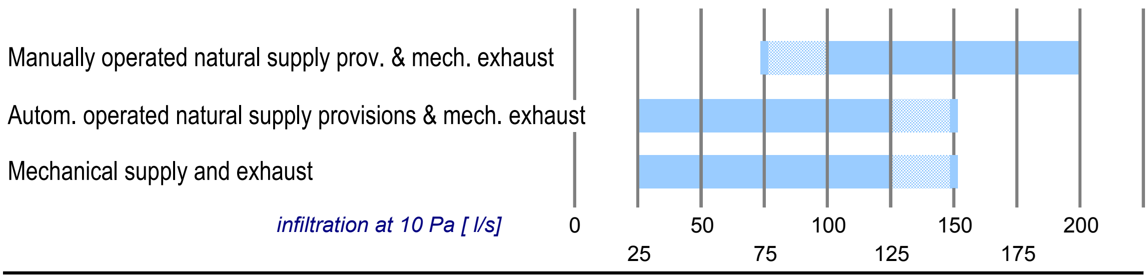
C. Connected	**Ventilation systems where the supply air in the habitable rooms is connected with the exhaust in the wet rooms (i.e. *permanent* air overflow from habitable to wet rooms)**			
Driving forces	**Type**	**Air Supply Habitable rooms**	**Air Exhaust Wet rooms**	**Overflow provisions**
A. Natural supply with natural exhaust	C-A	Passive air supply provision in windows or outside walls (trickle vents, grids, etc.);	Passive stack (vertical duct) or any other passive discharge provision	Overflow provisions in partition walls or doors
B. Mechanical supply with natural exhaust	C-B1	Central mechanical supply unit, ducted to supply all habitable rooms	Passive stack (vertical duct) or any other passive discharge provision	Overflow provisions in partition walls or doors
	C-B2	Room based mechanical supply units		
C. Natural supply with mechanical exhaust	C-C1	Passive air supply provision in windows or outside walls (trickle vents, grids, etc.);	Central mechanical exhaust unit, ducted to extract all utility rooms	Overflow provisions in partition walls or doors
	C-C2		Room based mechanical exhaust units	
D. Mechanical supply with mechanical exhaust	C-D1	Central mechanical supply unit, ducted to supply all habitable rooms	Central mechanical exhaust unit, ducted to extract all utility rooms	Overflow provisions in partition walls or doors
	C-D2	Room based mechanical supply units		
	C-D3	Central mechanical supply unit, ducted to supply all habitable rooms	Room based mechanical exhaust units	
	C-D4	Room based mechanical supply units		
S. Stand-alone	**Ventilation systems where the supply and exhaust of air (to the outside) are achieved in the same room (no or incidental air overflow from habitable to wet rooms).**			
Driving forces	**Type**	**Habitable rooms**	**Wet rooms**	
C. Natural supply with mechanical exhaust	S-C	Passive air supply provision in windows or outside walls of the room *combined with* central mech. exhaust, ducted to extract all habitable rooms	Central mech. exhaust, ducted to extract all wet rooms *combined with* Natural supply coming from provisions in common spaces & incidentally habitable rooms	Overflow provisions in doors and/or partition walls of utility rooms
D. Mechanical supply with mechanical exhaust	S-D1	Room based mechanical supply and exhaust units	Room based mechanical supply and exhaust units	No overflow provisions
X. Mix of driving forces	S-X1	Room based mechanical supply and exhaust units	Central mech. exhaust, ducted to extract all wet rooms *combined with* Natural supply coming from provisions in common spaces (& incidentally habitable rooms)	Overflow provisions in doors and/or partition walls of utility rooms
	S-X2	Room based mechanical supply and exhaust units	Room based mechanical exhaust units *combined with* Natural supply coming from provisions in common spaces (& incidentally habitable rooms)	Overflow provisions in doors and/or partition walls of utility rooms

This Supplementary Study only assesses ventilation systems that apply fan driven ventilation units either for supply, exhaust or both. These are all the ventilation systems mentioned in table 4.2.1-1 expect for the grey ones (type 0 and C-A).

4.2.2
Relation air tightness building and ventilation system

The application of certain ventilation systems is more or less related to the airtighness of the dwelling.
It is not recommended for instance, to install a mechanical ventilation system with heat recovery in a very leak house. The natural air exchange will already be quite high, which makes an additional mechanical air exchange with heat recovery unnecessary. And in a very airtight dwelling, it is not recommended to apply mechanical exhaust systems if supply grids are not automatically controlled one way or the other. Manually operated supply grids could e.g. lead to comfort problems, noise problems and damage to the exhaust system when all the supply grids are closed.
The following figure illustrates the applicability of ventilation systems related to the airtightness of the dwelling.

Table 4.2.2 Relation air tightness dwelling and application of ventilation system



4.2.3
BAT topics

The following items concerning best available technology are considered relevant for the study. They will however not be further discussed, because these topics are considered as available knowledge to the industry. If the industry would opt for additional technical information on these topics, it will be added later.

Ventilation effectiveness
- dilution
- displacement
- everything in between

Fans and motors
- impeller optimization
- motor optimization
- AC/DC and power supplies

Heat recovery
- cross flow
- counter flow
- humidity exchange & hygiene
- pressure drop

Filters
- life time
- pressure drop (begin & end of life time)
- replacement

Hygiene
- accessibility of components that need regular cleaning
- ease of maintenance
- cleaning intervals
- humidity exchange and micro bacterial contamination

Distribution / Ductwork
- resistance
- leakage rate
- ease of maintenance and cleaning

Supply and exhaust grids
- airflow capacity at ΔP
- cleanability
- type of controls

Controls
- Controls on supply provisions (manual, ΔP, RH, presence, CO_2)
- Controls on exhaust provisions (manual, ΔP, RH, presence, CO_2)
- Combined controls
- Room based controls or centralized controls

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4.3 System Modelling Energy Consumption for Ventilation during Use Phase

4.3.1. Annual Energy Consumption for ventilation

$$Q_{vent} = (Q_{th} - Q_{gain}) / \eta_H + (Q_{el} * 3,6) / \eta_{el}$$

Where

Q_{vent} = Total primary energy used for ventilation of the residential dwelling per annum in mega joule [MJ]

Q_{th} = Thermal energy content of the air exchange induced by the ventilation system during heating season in [MJ]

Q_{gain} = Share of Internal and Solar energy gains that is transferred to and lost through related air exchange in the dwelling during heating season

η_H = Specific efficiency for space heating system on GCV according to EuP Regulation LOT 1

Q_{el} = Total power consumption of the mechanical ventilation unit (including controls and other supplementary electric equipment, including preheating) in kWh per annum

η_{el} = Eu-average for power conversion factor (0,40)

With

$$Q_{th} = q_{sys;ref} * \Delta T_{av.} * C_p * \rho * t_{h;hs} / 1000 \quad \text{in [MJ]}$$

In which

$q_{sys;ref}$ = average reference air exchange rate caused by the ventilation system in question in the dwelling during heating season in [m3/h] (see paragraph 4.4.2)

$\Delta T_{av.}$ = weighted average annual temperature difference between indoor (= 19°C) and outdoor for Climate zone "*Cold*", "*Average*" or "*Warm*" (acc. to EuP Reg. Lot 1).
Cold : 17,... [°C]
Average : 13,... [°C]
Warm : 7... [°C]

C_p = heat capacity of air : 1,007 [kJ/kg/K]

ρ = average density of the air in [kg/m^3]
Average : 1,245 [kg/m^3]

$t_{h;hs}$ = duration of the heating season for the appointed climate zone [-] according to EuP Regulation LOT 1 in hours [h]

Cold : *273 x 24 = 6552 [h]*
Average : *213 x 24 = 5112 [h]*
Warm : *183 x 24 = 4392 [h]*

$$Q_{gain} = (P_{int} + P_{sol}) * f_{gain} * A * 3{,}6 * t_{h;hs} / 1000 \quad \text{in [MJ]}$$

In which

P_{int} = Average internal gains due to appliances and people : 5 [W/m^2]

P_{sol} = Average gain due to solar radiation during heating season : 3 [W/m^2]

f_{gain} = Fraction of the heat gains that can be allocated to the ventilation losses is if no heat recovery is applied is : 0,30. With heat recovery this fraction becomes 0,30 * η_{HR} (after all, if there no ventilation losses all gains can be attributed to the transmission losses.

A_H = Heated surface of the dwelling [m^2]

$t_{h;hs}$ = duration of the *h*eating *s*eason for the appointed climate zone according to EuP Regulation LOT 1 in *h*ours (=nr of days in heating season x 24)

Cold : *273 x 24 = 6552 [h]*
Average : *213 x 24 = 5112 [h]*
Warm : *183 x 24 = 4392 [h]*

$$\eta_H = L_h / (L_h + L_{sys} + Q_{gen} + Q_{el}) \quad \text{(according to Regulation for LOT1 appliances)}$$

In which

L_h = the annual net heat demand in kWh per annum

L_{sys} = the annual heat demand caused by system losses, which in part depend on the boiler in kWh

Q_{gen} = the strict heat generator losses per year in kWh

Q_{el} = total auxiliary energy consumption (minus possible gains through CHP) in kWh/a

To calculate the overall EU energy consumption for ventilation, we will use an EU-average figure for this η_H (= specific efficiency for space heating system on GCV) according to EuP Regulation LOT 1. For 2010 this figure is set at **0,60** (see preparatory study LOT 1).
The figure increases with 0,01 point per year (due to an increase of the average efficiency of the installed base), resulting in a figure of **0,70** in 2020.

$$Q_{el} \quad = \quad (P_{fan;sys} + P_{aux;sys}) * t_{h;an} \ /1000 \ + \ q_{sys;ref} * \Delta T_{pr;h.} * C_p * \rho * t_{h;pr;h} \ / \ 3600$$

in kWh

In which

$P_{fan;sys;I}$ = the power consumption of the mechanical ventilation unit at the system specific air flow rate ($q_{ref;sys}$) at the reference system pressure drop of the mechanical ventilation system *i*, in watt [W] (see paragraph 4.4.3)

$P_{aux;sys;I}$ = average power consumption for auxiliary electric equipment (controls, sensors, actuators, etc.) of ventilation system *i*, in watt [W] (see paragraph 4.4.3)

$t_{h;an}$ = total hours per annum : 365 x 24 = 8760 [h]

$\Delta T_{pr;h}$ = weighted average ΔT for preheating purposes for the appointed climate zone:

Cold	: av. ΔT below -4°C =	5,2 °C
Average	: av. ΔT below -4°C =	2,4 °C
Warm	: av. ΔT below -4°C :	n.a.

$t_{h;pr;h}$ = Hours during which in the appointed climate zone pre-heating is required:

Cold	: 1003 hours
Average	: 168 hours
Warm	: n.a.

4.3.2
Determining *system specific* reference ventilation air volume flow rate $q_{sys;ref}$

The key parameter for determining the energy consumption for ventilation during the use phase is $q_{sys;ref}$: “the system specific average reference ventilation air flow rate”. This is the annual average reference flow rate induced by the ventilation system in question, related to the heated surface of the dwelling and corrected for:

- the type of ventilation system
- the type of control that is used
- the possible leakage through duct work (if applicable)
- the share of heat that is recovered from the extracted air

In formula:

$$q_{sys;ref} \quad = \sum_i q_{ref} * A_{H;i} * f_{sys;i} * f_{eff;i} * f_{ctrl;i} * f_{duct;i} * (1-\eta_{HR;sys;i}) \quad \text{in [m3/h]}$$

with

$q_{ref;}$ = the IAQ-specific continuous reference air volume flow rate per m2 of heated space [$m^3/m^2/h$]

$A_{H;i}$ = corresponding heated fraction of the dwelling surface served with ventilation system *i*

$f_{sys;i}$ = correction factor for the type of ventilation system i

$f_{eff;i}$ = effectiveness of the ventilation system i

$f_{ctrl;i}$ = correction factor for the type of control system used for ventilation system i

$f_{duct;i}$ = correction factor for the leakage of the duct work

$\eta_{HR;sys;i}$ = share of the thermal energy that is recovered, related to the system average reference air exchange rate of the pertaining ventilation system i

For dwellings with one type of ventilation system, the calculation can be made in a single run. For dwellings that have more types of ventilation systems installed, the calculation is to be made for each type of ventilation system "***i***" with their corresponding heated ground surface $\boldsymbol{A}_{H;I}$ and then added up to get to dwelling related total $q_{ref;sys}$

4.3.2.1
Determining IAQ-specific continuous reference air volume flow rate $\boldsymbol{q}_{ref}$

q_{ref} is the air flow rate that will be used as basic reference for all calculations. It is based on the average continuous air volume flow rate that is necessary to achieve an *acceptable indoor air quality* in a dwelling with an *average occupancy and activity rate*.

An acceptable IAQ is defined here as IAQ category III, meaning that the indoor CO_2 concentrations will be less that 800 ppm higher than the outdoor concentration and that the humidity rates - especially in activity (or wet) rooms – remain within accepted boundaries. It is assumed that the CO2-concentration is the key indicator for the pollutants, meaning that the building and decoration materials are low or average polluting materials.

An average occupancy and activity rate is defined here as follows and relates to a fictitious average person (the mean of a working man, part-time working wife and two children going to school):
- dwelling surface per occupant : 25 m2 (e.g. a dwelling of 100 m2 accommodates 4 people)
- sleeping : 8 h per day
- activity (i.e. non sleeping) in the dwelling : 8 hours per day
- not present : 8 hours day
- bathroom/shower : 1 per day

The reference air flow rate that is required to achieve the requested IAQ can be determined following different angles:

<u>*Design standards*</u>
The various national standards may differ regarding the supply air flow rate per m^2 of habitable space (e.g. bedroom, living room) that is required, but they all agree upon the principle that fresh air must be supplied in each habitable room and that in the activity rooms (e.g. bathroom, kitchen, toilet) moist and stale air must directly be expelled outside. In the example below we assume a European average for the requested capacity of the supply air flow rate in habitable rooms of 0,8 l/s/m2

Calculation Example:
Heated surface of the dwelling A_H = 100 m2 ; average height of the rooms is 2,7 m
Total surface of habitable rooms (bedrooms, living room, kitchen, study) = 0,65 x 100 = 65 m2
Installed supply air volume flow capacity of the ventilation system is 67 x 0,8 = 52 l/s.
Average reference continuous air flow rate is 70% of 52 = 36,4 l/s ≈ 130 m3/h
Average reference continuous air exchange rate per hour (ach) = 0,48 m^3/m^3 or 1,3 m^3/m^2

This example would therefore result in a q_{ref} of 1,3 $m^3/m^2/h$

The German DIN 1946-6:2009 “Ventilation for residential buildings; General requirements, requirements for measuring, performance and labelling, certification and maintenance” gives the following values for the minimum required air exchange rates (Nennlüftung according to table 5 of the DIN 1946-6)):
Dwelling with A_H = 90 m2 : $q_{v;ges,NE,NL}$ = 1,27 $m^3/m^2/h$
Dwelling with A_H = 110 m2 : $q_{v;ges,NE,NL}$ = 1,23 $m^3/m^2/h$

EU-standards
Informative Annex B of EN 15251, gives in Table B.5 an example of ventilation rates for residential dwelling, assuming complete mixing of the ventilation air and assuming continuous operation of the ventilation:
For IDA category III, the total requested air exchange rate per m^2 of heated space is defined at 0,35 l/s.
For the 100 m2 house given in the calculation example above, this results in a reference continuous air flow rate of 35 l/s or 126 m3/h. With an average height of 2,7 m this corresponds to 0,47 ach.
This results in a a q_{ref} of 1,27 $m^3/m^2/h$

EPBD standards
National EPBD standards calculate with average air exchange rates caused by the ventilation system, in order to be able to calculate the related energy losses.
The ENEV 2009 (Germany) calculates with a total average air exchanger rate (ach) of 0,40 for new dwellings, which corresponds with *a* q_{ref} *of* 1,08 $m^3/m^2/h$ of heated space.
The EPN (Netherlands) calculate with a ventilation air flow rate of 0,36 l/s/m2 of heated space for fan assisted ventilation systems. This corresponds to an average reference continuous air volume flow rate q_{ref} *of* 1,3 $m^3/m^2/h$

In this study we will use for IAQ-specific continuous reference air volume flow rate q_{ref} the figure q_{ref} = 1,3 $m^3/m^2/h$

This figure represents the average continuous air volume flow rate that is necessary to achieve an *acceptable indoor air quality* (IDA III) in a dwelling with an *average occupancy and activity rate*.

4.3.2.2
*Correction factor for type of ventilation system fsys (= fsys;dw * fsys;rm)*

The key assumption behind this q_{ref} figure as determined in the previous paragraph is that the requested supply- and exhaust air flow rate will always be achieved in each habitable room. However, depending on the type of ventilation system corrections to this q_{ref}–figure are necessary to ensure these air flow rates per room and the related IAQ-class. Ventilation systems e.g. that rely on natural forces for the supply or the exhaust of air, will not always exchange the requested total amount of air over the dwelling. Changes is thermal buoyancy and pressure difference over the façade will influence the total air exchange over the dwelling. This effect is addressed with the factor *fsys;dw*
On top of these variations over the dwelling, there will also be variations over the individual rooms. Situations will occur where the overall air exchange rate over the dwelling is okay, but the requested air exchanges per room are not achieved. Depending on pressure differences over the facade, either increased amounts of air will be supplied (windward side of the dwelling) or a minimal amount of fresh air is supplied (leeward side), and of course all the variations in between. This effect is addressed with the factor *fsys;rm*
Also for ventilation systems with provisions for natural exhaust, variations in the thermal buoyancy will lead to comparable variations in the air exchange rate over time. Furthermore, depending on positions of the doors between habitable rooms and activity (wet) rooms, the exhaust air flow rate per room will vary.
All in all this means that these types of ventilation systems require an overall higher air exchange rate to achieve the related IAQ-class in all habitable rooms than others. Fully mechanical ventilation systems are less sensitive to these flow variations per habitable room.

The factors $f_{sys;dw}$ and $f_{sys;rm}$ correct for these air exchange variations See table 4.3.2.2-1 for the proposed values.

Table 4.3.2.2-1 Proposed values for *fsys;dw* and *fsys;rm*

Ventilation system			f_{sys} (= $f_{sys;dw} * f_{sys;rm}$)	
Type	*Driving force supply air*	*Driving force exhaust air*	$f_{sys;dw}$	$f_{sys;rm}$
A	natural	natural	1,25	1,15
B	mechanical	natural	1,15	1,05
C	natural	mechanical	1,10	1,10
D	mechanical	mechanical	1,00	1,00

4.3.2.3
Correction factor for the effectiveness of the ventilation f_{eff}

Ventilation systems differ in the effectiveness with which they remove/dilute the pollutants in a room. In EN-standards the following expression is used to indicate the ventilation effectiveness:

$$f_{eff} = 1 / \varepsilon_v \quad \text{with} \quad \varepsilon_v = \frac{C_{ETA} - C_{SUP}}{C_{IDA} - C_{SUP}}$$

Where : ε_v is the ventilation effectiveness

C_{ETA} is the pollution concentration in the extract air in mg/m^3

C_{IDA} the pollution concentration in the indoor air (breathing zone) in mg/m^3

C_{SUP} is the pollution concentration in the supply air in mg/m^3

Air flow direction and supply air distribution in a room have an important influence on the ventilation effectiveness. Systems that use air inlet and air exhaust openings that are situated in opposite or somewhat distant locations with a pressure difference guiding the airflow and systems that use the thermal convection cycle for distribution of supply air, will in general have a higher ventilation effectiveness than systems that do not use these principles. Rooms that use ventilation systems with an inlet and outlet on the same side of the room, without any additional forces guiding the air throughout the room, have to rely on partial pressure differences between the pollutant concentrations in fresh supplied air and the internal air. As a result, ventilation effectiveness will in general be lower. For energy calculation purposes the following figures for the f_{eff} are proposed (measurements in the field could be used to further substantiate these figures).

Table 4.3.2.3-1 Proposed values for f_{eff}

Ventilation system	f_{eff}
Systems with naturally driven air overflow from habitable to wet rooms	1,10
Systems with mechanically driven air overflow from habitable to wet rooms	1,00
Systems with room based nat. supply and mech. exhaust provisions on opposite or adjacent façades	1,00
Systems with room based mech. supply and exhaust on the same façade, using thermal convective air flow	1,00
Systems with room based mech. supply and exhaust on the same façade, without the use of thermal convection	1,20

* preliminary figures, to be discussed with industry on the basis of test results (measurements)

4.3.2.4
Correction factor for type of air flow control system f_{ctrl}

Ventilation systems that use some kind of control to minimize "over-ventilation" or - even better – to optimize the ventilation air flow rate to the actual need, will achieve a lower average air exchange rate than systems without such controls. This aspect is covered by the correction factor f_{ctrl}.
Various components of the ventilation system can be controlled in different manners. Controls can be applied on the air supply components or on the air extract component of the ventilation system. For systems that are based on mechanical supply and mechanical exhaust, the controls can be used for both air flows.

Two EN-standards make mention of control types and propose a classification:

<u>EN 13779</u>
This standard mentions in table 6 (page 21 of the standard) the following types of control of the IAQ

Table 4.3.2.4-1 Classification of control options

Category	Description
IDA-C1	System runs constantly
IDA-C2	Manual control (systems runs according to a manual controlled switch)
IDA-C3	Time control (system runs according to a given time schedule)
IDA-C4	Occupancy control (system runs dependent on the presence (infra red, light switch, etc.)
IDA-C5	Demand control (system runs dependent on number of people in a room/space/dwelling)
IDA-C5	Demand control (system is controlled by sensors measuring IAQ parameters (e.g. CO2-sensors)

<u>EN 13142</u>
En 13142 uses a similar classification for the aspect "Flow Rate Control" in table 8.17 (page 24 of the standard). See also paragraph 1.1.5 Classification of this report, table 1.1.5-14.

Unfortunately these classifications cover only a part of the control options available on the market and - in addition - do this on a rather abstract level. A more detailed description would be necessary to be able to value the influence of these control options on the overall air exchange.

The following tables try to give a more detailed description of the control options that are already on the market and combine this with a first proposal for the related f_{ctrl} –figures.

The first table (Table 4.3.2.4-2) gives an overview off existing control options for the ventilation systems that are based on the air-overflow principle (air supply provisions in the habitable rooms combined with the air exhaust provisions in the wet or utility rooms). In these systems, the exhaust provision in the wet rooms is not only necessary to compensate for humidity production, but also to power the requested air exchange in the habitable rooms. The first three columns describe the type of system (A, B, C or D) and type of supply and exhaust components that are used. The next four columns give a more detailed description of the type of control systems that can be applied. Finally the last two columns proposes values for the f_{ctrl} –factor. If the supply and exhaust provisions function independent from each other, two figures are given: one for the supply provision $f_{ctrl;sup}$, and one for the exhaust provision $f_{ctrl;exh}$. Multiplying these two factors gives the overall figure for f_{ctrl}. If the control of the air supply provision is somehow connected to the control of the air exhaust provision, only one overall figure for f_{ctrl} is mentioned.

The second table (Table 4.3.2.4-3) deals with room based ventilation systems. These are ventilation systems where the extract air from the habitable rooms is not expelled through the wet rooms, but directly outside. The supply air for the wet rooms is coming either from an air inlet in the wet room itself, or from air inlet openings in the common space (corridor, stairway, etc.). In these systems, the exhaust air from wet rooms is not a driving force behind the ventilation of the habitable rooms, in which case ventilation of the wet rooms is only necessary to reduce the humidity levels to acceptable ranges. The f_{ctrl} mentioned in this second table relates to the surface '*A'* of the room or rooms for which the ventilation system is designed and installed.

f_{ctrl} for ventilation systems *with* air overflow from habitable to wet rooms (i.e.: the air supplied in habitable rooms is extracted through the wet rooms; extraction in the wet rooms is therefore not only necessary for reducing humidity levels in the wet rooms, but it is also a driving force behind the air exchange in habitable rooms).

Table 4.3.2.4-2 Proposed values f_{ctrl} for ventilation systems with overflow from habitable to wet rooms

Type	Supply component	Exhaust component	Driving force	Adjustable parameter	Nr.	Control parameter / Operation	Air Flow range	$f_{ctrl;exh}$	$f_{ctrl;sup}$
A	Natural supply and natural exhaust								
	Room based air inlet openings (in all habitable rooms)		ΔP over facade	Size of inlet opening A_S	A-S1	Manual	*0* to *max* (depending instant. ΔP & A_S)	-	1,00
					A-S2	internal humidity	*min* to *max* (depending instant. ΔP & A_S)	-	0,95
					A-S3	ΔP over façade / manual override	*0* to *max* (depending instant. ΔP & A_S)	-	0,90
					A-S4	clock program / operated by actuator	*0* to *max* (depending instant. ΔP & A_S)	-	0,80
					A_S5	CO2 sensor per room / oper. by actuator	*0* to *max* (depending instant. ΔP & A_S)	-	0,75
		Passive Stack (PS = vert. duct) in all wet rooms	*ΔP over inlet & outlet of Pas. St.*	*None*	A-E1	*none*	*Depends on instantaneous ΔP*	1,00	-
				Fan assisted PS	A-E2	*humidity in wet rooms*	*Depends on instantaneous ΔP*	0,95	-
B	Mechanical supply and natural exhaust								
	Room based mechanical air supply unit (in all habitable rooms)		Fan motor	Power, on/off	B-S1	Manual switch *per room*	0 or rated flow		1,00
				Rpm, 3-4 steps	B-S2	Manual switch *per room*	0 to max rpm-related flow rate		0,95
					B-S3	Clock program *per room*	0 to max rpm-related flow rate		0,80
					B-S4	Presence sensor *per room*	0 to max rpm-related flow rate		0,75
					B-S5	CO2 (gas) sensor *per room*	0 to max rpm-related flow rate		0,70
	Centralized mechanical air supply unit, ducted to serve all habitable rooms		Fan motor	Rpm, 3-4 steps	B-S6	Manual switch *per dwelling*	min to max rpm-related flow rate		1,00
					S-B7	Clock program *per dwelling*	min to max rpm-related flow rate		0,85
					B-S8	Presence sensor *per dwelling*	min to max rpm-related flow rate		0,80
					B-S9	CO2 (gas) sensor *per dwelling*	min to max rpm-related flow rate		0,75
		Passive Stack (PS = vert. duct) in all wet rooms	ΔP over inlet & outlet of PS	None	B-E1	none	Depends on instantaneous ΔP	1,00	
				Fan assisted PS	B-E2	humidity in wet rooms	Depends on instantaneous ΔP	0,95	
C	Natural supply and m exhaust								
	Room based air inlet openings (in all habitable rooms)		ΔP over facade	Size of inlet opening A_S	C-S1	Manual	*0* to *max* (depending instant. ΔP & A_S)	-	1,00
					C-S2	internal humidity	*min* to *max* (depending instant. ΔP & A_S	-	0,95
					C-S3	ΔP over façade / manual override	*0* to *max* (depending instant. ΔP & A_S)	-	0,90
					C-S4	clock program / operated by actuator	*0* to *max* (depending instant. ΔP & A_S)	-	0,85
					C-S5	CO2 sensor per room / oper. by actuator	*0* to *max* (depending instant. ΔP & A_S)	-	0,75
		Room based mechanical air extract unit in all wet rooms; (continuous operation is assumed to also facilitate air exchange in habitable rooms)	Fan motor	Rpm, 3-4 steps	C-E1	manual switch *per wet room*	min to max rpm-related flow rate	0,95	
					C-E2	clock program *per wet room*	min to max rpm-related flow rate	0,95	
					C-E3	presence sensors *per wet room*	min to max rpm-related flow rate	0,90	
					C-E4	humidity sensor *per wet room*	min to max rpm-related flow rate	0,90	
		Centralized mechanical air exhaust unit, ducted to extract all wet rooms (continuous operation is assumed to also facilitate air exchange in habitable rooms)	Fan motor	Rpm, 3-4 steps	C-E5	manual switch *per dwelling*	min to max rpm-related flow rate	1,00	
					C-E6	clock program *per dwelling*	min to max rpm-related flow rate	0,95	
					C-E7	presence sensors *per dwelling*	min to max rpm-related flow rate	0,90	
					C-E8	humidity sensor *in exhaust*	min to max rpm-related flow rate	0,90	
				Rpm & size *exh.* opening A_E	C-E9	humidity and constant ΔP *in exhaust*	rpm and A_E related flow rate	0,90	
								Combined f_{ctrl}	
				Rpm	C-E10	Coupled to C-S4	min to max rpm-related flow rate	0,75	
					C-E11	Coupled to C-S5	min to max rpm-related flow rate	0,60	

Type	Supply component	Exhaust component	Driving force	Adjustable parameter		Control parameter / Operation	Air Flow range	Combined f_{ctrl}
D	Mechanical supply and mechanical exhaust / Exhaust is leading							
	Room based mechanical air supply unit (in all habitable rooms)		Fan motor	Rpm, 3-4 steps	D-S1	Coupled to D-E1	Coupled to D-E1	-
					D-S2	Coupled to D-E2	Coupled to D-E2	-
					D-S3	Coupled to D-E3	Coupled to D-E3	-
					D-S4	Coupled to D-E4	Coupled to D-E4	-
	Centralized mechanical air supply unit, ducted to serve all habitable rooms,		Fan motor	Rpm, 3-4 steps	D-S5	Coupled to D-E1	Coupled to D-E1	-
					D-S6	Coupled to D-E2	Coupled to D-E2	-
					D-S7	Coupled to D-E3	Coupled to D-E3	-
					D-S8	Coupled to D-E4	Coupled to D-E4	-
		Centralized mechanical air exhaust unit, ducted to extract all wet rooms (continuous operation is assumed to also facilitate air exchange in habitable rooms)	Fan motor	Rpm, 3-4 steps	D-E1	Manual switch *per dwelling*	min to max rpm-related flow rate	1,00
					D-E2	Clock program *per dwelling*	min to max rpm-related flow rate	0,80
					D-E3	Presence sensor *per dwelling*	min to max rpm-related flow rate	0,75
					D-E4	Humidity sensor in exhaust	min to max rpm-related flow rate	0,85
	/ Supply is leading							
	Room based mechanical air supply unit (in all habitable rooms)		Fan motor	Rpm, 3-4 steps	D-S9	Manual switch *per room*	0 to max rpm-related flow rate	0,95
					D-S10	Clock program *per room*	0 to max rpm-related flow rate	0,70
					D-S11	Presence sensor *per room*	0 to max rpm-related flow rate	0,65
					D-S12	CO2 (gas) sensor *per room*	0 to max rpm-related flow rate	0,55
	Centralized mechanical air supply unit, ducted to serve all habitable rooms		Fan motor	Rpm, 3-4 steps	D-S13	Manual switch *per dwelling*	min to max rpm-related flow rate	1,00
					D-S14	Clock program *per dwelling*	min to max rpm-related flow rate	0,80
					D-S15	Presence sensor *per dwelling*	min to max rpm-related flow rate	0,75
					D-S16	CO2 (gas) sensor *per dwelling (1 or 2 zones)*	min to max rpm-related flow rate	0,70
		Centralized mechanical air exhaust unit, ducted to extract all wet rooms (continuous operation is assumed to also facilitate air exchange in habitable rooms)	Fan motor	Rpm, 3-4 steps	D-E5	Coupled to D-S9 or D-S13	Coupled to D-S9 or D-S13	-
					D-E6	Coupled to D-S10 or D-S14	Coupled to D-S10 or D-S14	-
					D-E7	Coupled to D-S11 or D-S15	Coupled to D-S11 or D-S15	-
					D-E8	Coupled to D-S12 or D-S16	Coupled to D-S12 or D-S16	-

f_{ctrl} for ventilation systems *without* air overflow from habitable to wet rooms

These are ventilation systems where the extract air from the habitable rooms is not expelled through the wet rooms, but directly outside. The supply air for the wet rooms is coming either from an air inlet in the wet room itself, or from air inlet openings in the common space (corridor, stairway, etc.). In these systems, the exhaust air from wet rooms is not a driving force behind the ventilation of the habitable rooms, in which case ventilation of the wet rooms is only necessary to reduce the humidity levels to acceptable ranges.

The f_{ctrl} mentioned in the table relates to the surface '*A*' of the room or rooms for which the ventilation system is installed.

Table 4.3.2.4-3 Proposed values f_{ctrl} for Room Based Ventilation Systems (ventilation without overflow ; i.e. exhaust air is not re-used for wet (activity) rooms)

Type	Supply component	Exhaust component	Driving force	Adjustable parameter		Control parameter / Operation	Air Flow range	f_{ctrl}	
C	Natural supply and mechanical exhaust							$f_{ctrl;exh}$	$f_{ctrl;sup}$
	Room based air inlet openings (in all habitable rooms)		ΔP over facade	Size of inlet opening A_s	C-S1	Manual			1,00
					C-S2	ΔP over façade / manual override			0,85
		Centralized mechanical air extract units, ducted to extract air from all habitable and wet rooms	Fan motor	Rpm combined with valves per duct	C-E1	Centralized CO_2 meas. for habitable rooms Humidity in wet rooms		0,65	
D	Mechanical supply and mechanical exhaust								
	Combined dual fan mechanical supply and exhaust unit for all rooms		Fan motor	Rpm (incl basic ventilation rate)	D-SE1	Manual switch (*per room)*		0,90	
					D-SE2	Clock program (*per room)*		0,65	
					D-SE3	Presence sensor (*per room)*		0,55	
					D-SE4	CO_2 (gas) sensor (*per room)*		0,45	
	Mechanical single fan intermittent operating supply and exhaust unit for all rooms		Fan motor	Rpm, (incl basic ventilation rate)	D-SE5	Manual (*per room)*	min to max rpm-related flow rate	0,90	
					D-SE6	Clock program (*per room)*	min to max rpm-related flow rate	0,65	
					D-SE7	Presence sensor (*per room)*	min to max rpm-related flow rate	0,55	
					D-SE8	CO_2 (gas) sensor (*per room)*	min to max rpm-related flow rate	0,45	

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4.3.2.5
Correction factor for leakage of the ductwork f_{duct}

Ventilation systems that use ducts for the supply of air, for the exhaust of air or both, will have to take into account the possible leakage of air through the duct work. If not corrected, leakage in the duct work will lead to a reduction of the air flow rate in the actual rooms where the air exchanges are intended.
According EN 1507, EN 12237 and/or EN 125727 leakage classes for ductwork can be determined, leading to four different classes (Luka A to Luka D) for the air tightness of the ductwork. The following correction factors for the different leakage classes of ductwork are proposed:

Table 4.3.2.5-1 Classification and correction factor f_{duct} for leakage classes of ductwork

Leakage classes	f_{duct}
A	1,17
B	1,10
C	1,05
D	1,00

4.3.2.6
Determining the share of the thermal energy that is recovered $\eta_{HR;sys;i}$

$\eta_{HR;sys;I}$ is the share of the thermal energy that is recovered, related to the average reference air exchange rate of the pertaining ventilation system *i*.

$$\eta_{HR;sys;i} = f_{\eta;adj;i} * \eta_{\theta;sup;i}$$

with

$f_{\eta;adj;i}$ = Correction factor for the real life adjustments to the heat exchanger efficiency due to fouling of the *he*- surface between service intervals or during product lifetime, and due to flow balance variations of the pertaining mechanical ventilation unit *i*, For the time being this value is set at 1,00 (= no correction). It is to be determined together with the industry whether this correction factor will be maintained and if so, what its value should be.

$\eta_{\theta;sup;i}$ = Temperature ratio on supply air side at *reference air volume flow* of the pertaining mechanical ventilation system *i*, measured according to EN 13141-7 or EN 13141-8

4.3.3 Determining power consumption of mechanical ventilation unit and any auxiliary equipment: $P_{fan;sys;i}$ and $P_{aux;sys;i}$

$P_{fan;sys;i}$ is the power consumption of the mechanical ventilation unit *i* at the system specific air flow rate ($q_{ref;sys}$) at the reference system pressure drop of the mechanical ventilation system *i*, in watt [W], and can be determined with the following formula:

$$P_{fan;sys;i} = \sum_i \mathbf{SPI}\ i * q_{ref;sys} \quad \text{in watt [W]}$$

with

SPI*i* = The power input of mechanical ventilation unit *i* when the fans are operating at reference air volume flow and reference pressure difference (including electrical demands for fan(s), power supplies, controls, heat pumps etc.)

in formula : $SPI_i = P_{E;i} / q_{v;ref;I}$ in [W/m^3/h] (according to EN 13141-7 and -8)

$P_{aux;sys;i}$ is the average power consumption for auxiliary electric equipment (controls, sensors, actuators, etc.) of the mechanical ventilation unit *i* when the fans are not operating, including any auxiliary power used in other related components (e.g. electrical power air supply grid, remote sensors, communication devices, etc. in watt [W] . In formula:

$$P_{aux;sys;i} = \sum_i \mathbf{POM}i + P_{standby;aux} \quad \text{in watt [W]}$$

With

POM*i* = Standby power consumption of the mechanical ventilation unit *i* in fan-off mode, according EN 13142 in watts

$P_{standby;aux}$ = Standby power consumption of all other system components related to mechanical ventilation unit/system *i* in watts

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5. ASSESSMENT OF BASE-CASES

The aim of Task 5 is the assessment of the “Base Cases”, which represent the average new Ventilation Systems currently sold in the EU. The definition of the Base Case entails

- Performance Characteristics
- Environmental Impacts and
- Life Cycle Costs

It will be the basis for establishing the saving potential, both environmentally and economically, of the Design Options in Chapter 6 report and it will be one of the major inputs for the future Scenario Analyses in the Impact Assessment Phase.

This chapter comprises the following subtasks:

- Definition of Performance and Load Profile
- Retrieval of product-specific inputs
- BaseCase Environmental Impact Assessment
- BaseCase Life Cycle Costs assessment
- Calculation of EU-Totals
- EU-27 Total System Impact discussion

5.1 Definitions

5.1.1
Definition of Performance

The most commonly used performance characteristic of a ventilation system with a mechanical ventilation unit is the maximum airflow rate at reference pressure drop with the related electrical power input (in W) of the mechanical ventilation unit.

Although *‘maximum airflow’* and *‘power input’* are important parameters, they do not adequately represent the function of a ventilation system. After all, the purpose of a ventilation system is not just to transport a certain amount of air, but to exchange the correct amount of air in the wet rooms and to exchange with the outside the correct amount of air in the habitable rooms for the purpose of achieving an acceptable indoor air quality (IAQ).
Instead, it is proposed to use the following definition for the performance of a ventilation system, which more accurately represents to goals as described in the relevant EN-standards (see paragraph 1.2):

“the capability of the system to reach and maintain the <u>air exchange rate</u> in the utility (wet) rooms and habitable rooms of an enclosed space (residential dwellings & buildings etc.) at a desired level under reference circumstances, in as much as is possible through fan assisted ventilation systems and their related system components ”.

This definition consists of the following components:

a.
A general description of the aim of the ventilation system*”: “achieving the desired air exchange rate”.*
Although the actual goal behind this air exchange is achieving *“an acceptable indoor air quality”*, the performance of the ventilation system is expressed in *air exchange rate*, simply because this is the key instrument with which the IAQ is to be achieved, and because all building codes and standards relate to this parameter “air exchange”. This does not mean however, that ventilation systems that use IAQ-sensors to optimize the air exchange rate will not be valued accordingly.

b.
A further specification stating that *“the desired air exchange rate must be achieved in all utility and habitable rooms”.*
As such, the term “*desired air exchange”* in the definition does not only relates to the capability of the ventilation system to achieve the desired overall air exchange of the dwelling, but also to the capability of the

system to actually and continuously achieve the desired air exchange rates in the individual rooms. The degree to which ventilation systems can achieve this, varies per type of ventilation system

c.
A restriction regarding the ventilation systems that are assessed: *“in as much as is possible through fan assisted ventilation systems and their related components”*
This excludes the fully natural ventilation systems. However, for reference purposes the fully natural ventilation system will be assessed here in a similar manner, primarily to be able to compare their IAQ-related overall energy performance of these systems with the fan assisted systems.

Filtering performance
A performance characteristic that is not covered by this definition is the filtering performance on the supplied air. Centralized mechanical ventilation units with supply fans generally are also equipped with air filters that need to be replaced at least once or twice a year. This increases the annual costs of the ventilation unit but in return it provides cleaner air. Wall and window supply fans may occasionally also be provided with some form of supply filter (G3), but usually they don’t. The mechanical exhaust units (in combination with their natural supply provisions) normally also don’t use filters. Because of this, a strict and fair comparison between systems is not quite possible.
Because filtering of ventilation air still is a low interest topic in the residential sector and because Heat Recovery units have a secondary reason for applying filters (keeping the heat exchanger clean), the following is suggested regarding the use of filters for the BaseCases :

- use standard filters (e.g. G3) in both centralized and room based HR-units
- only use standard (G3) filters in the centralized mechanical supply unit,

both to be replaced once a year. This leaves the room based supply units (and the systems with natural supply provisions) without filters for the supply air. In that sense it is not a complete fair comparison, but for the time being an acceptable one.

Comfort performance
Another performance characteristic that is not covered by this definition is the comfort performance, in casu the combination of temperature and speed of the supplied air and the degree in which these two parameters fall within the defined “comfort zone” values. These comfort performance issues are not taken into account in this study, since it is assumed that the requested air exchange rates are achieved anyhow, despite possible comfort issues.
In real life, inhabitants will reduce the air supply flow rate to prevent cold draughts. As a result IAQ levels will drop. This phenomenon will not (or to a lesser extent) occur with ventilation systems that use heat recovery or some form of pre heating. But to be able to compare ventilation systems on the basis of a comparable IAQ, it is decided to leave this comfort-performance issue for what is it.

As a consequence of this approach a rebound effect occurs, in the sense that this study calculates the energy consumption of the ventilation function on the basis of the required ventilation flow rates, while in real life they may not always occur due to comfort issues.

5.1.2
Definition of load profile

A definition of performance also requires a description of the circumstances under which the performance requirements must be achieved. Furthermore, the indication *“desired level”* for the air exchange rate must be further quantified and substantiated, making the relation between desired air exchange rate and the IAQ more apparent.

IAQ-specific continuous reference air exchange rate
Averaging the buildings codes of the different member states on ventilation rate per m^2 of habitable rooms, looking at EU-standards for residential ventilation, and the average air exchange values that are used for making the EPBD-calculation, it may be concluded that the IAQ-specific average continuous reference air volume flow rate

q_{ref} = 1,3 m^3/h per m^2 of dwelling surface (see also paragraph 4.4.2.1)

This corresponds with an air change per hour (ACH) of 0,5 and an indoor air quality category of IDA III (up to 800 ppm CO_2 above outdoors) under reference circumstances.

Reference circumstances
The reference circumstances relate to an average occupancy of the dwelling and an average pollutant emission load, as defined in table 3 of EN 15665 (see also § 1.2.5)

Table 5.1.2-1 Average pollutant emission load

Pollutant emission[2] (water)			
Water vapour awake		55	g/h/pp
Water vapour sleeping		40	g/h/pp
Breakfast		50	g/pp
Lunch		75	g/pp
Dinner		300	g/pp
Natural gas cooking		350	g/day
Shower[4]		300	g/shower
Washing drying inside		1200	g/washing
Frequency of showers/person		1	shower/pp/day
Frequency of washing/person		1	washing/pp/day
Pollutant emission[2] (metabolic CO2)			
CO2 awake		16	l/h/pp
CO2 sleeping		10	l/h/pp

The average occupancy pattern is generally derived from a four person family (two adults two children) in an average 100 m^2 house, displaying a traditional average activity- and occupancy pattern.

System specific reference air exchange rate
The system specific reference air exchange rate can be determined by correcting the IAQ specific reference air exchange rate q_{ref} of 1,3 m^3/h per m^2 of dwelling surface, for the system- and product specific parameters as described in paragraph 4.4.2. of chapter 4.4 "System Modeling for Energy Consumption during Use Phase. These correctional parameters represent issues that relate to :

- the likelihood that the overall air exchange rate over the dwelling is continuously achieved ($f_{sys;dw}$)
- the likelihood that the air exchange rate in individual rooms is continuously achieved ($f_{sys;rm}$)
- the effectiveness of the ventilation system (f_{eff})
- the type of controls that are used (f_{ctrl})
- possible air leakage in duct systems (f_{duct})

The overall air exchange that is thus calculated for each ventilation product/system (see § 4.4.2), represents the air exchange rate per square meter of dwelling necessary to obtain similar IAQ-levels .
Such an approach makes it possible to calculate the EU-wide overall energy consumption for ventilation on the basis of m^2 of dwelling. Dwelling characteristics only play a role in case they exclude certain types of ventilation systems.

For ventilation products/systems that apply heat recovery, this overall air exchange rate is corrected for the amount of thermal energy that is recovered ($\eta_{HR;sys}$)

Climates:
Having determined the air exchange rate per m^2 that is typical for a certain type of ventilation product/system for the desired IDA III categorie (corrected for possible heat recovery), the thermal energy content can than be calculated on the basis of the average temperature difference between inside and outside.

By analogy with the Ecodesign Preparatory Study for LOT1, three different climate zones are discriminated here, each with its own average outdoor temperature during heating season.

Table 5.1.2-2 Average outdoor temperature per climate zone

bin nr.	Tj	Number of hours			Fraction of heating season		
#	oC	Warm	Average	Cold	Warm	Average	Cold
9	-22			1			0,02%
10	-21			6			0,09%
11	-20			13			0,20%
12	-19			17			0,26%
13	-18			19			0,29%
14	-17			26			0,40%
15	-16			39			0,60%
16	-15			41			0,63%
17	-14			35			0,53%
18	-13			52			0,79%
19	-12			37			0,56%
20	-11			41			0,63%
21	-10		1	43		0,02%	0,66%
22	-9		25	54		0,49%	0,82%
23	-8		23	90		0,45%	1,37%
24	-7		24	125		0,47%	1,91%
25	-6		27	169		0,53%	2,58%
26	-5		68	195		1,33%	2,98%
27	-4		91	278		1,78%	4,24%
28	-3		89	306		1,74%	4,67%
29	-2		165	454		3,22%	6,93%
30	-1		173	385		3,38%	5,88%
31	0		240	490		4,68%	7,48%
32	1		280	533		5,46%	8,13%
33	2	3	320	380	0,07%	6,25%	5,80%
34	3	22	357	228	0,50%	6,97%	3,48%
35	4	63	356	261	1,43%	6,95%	3,98%
36	5	63	303	279	1,43%	5,91%	4,26%
37	6	175	330	229	3,98%	6,44%	3,50%
38	7	162	326	269	3,69%	6,36%	4,11%
39	8	259	348	233	5,90%	6,79%	3,56%
40	9	360	335	230	8,20%	6,54%	3,51%
41	10	428	315	243	9,74%	6,15%	3,71%
42	11	430	215	191	9,79%	4,20%	2,92%
43	12	503	169	146	11,45%	3,30%	2,23%
44	13	444	151	150	10,11%	2,95%	2,29%
45	14	384	105	97	8,74%	2,05%	1,48%
46	15	294	74	61	6,69%	1,44%	0,93%
47	16	802	214	106	18,26%	4,18%	1,62%
	Total	4392	5124	6552	100,00%	100,00%	100,00%
Average Outdoor Temp Tj					**12**	**6**	**2**

With these average outdoor temperatures per climate zone, the thermal energy losses related to the air exchanges that are induced by the fan assisted ventilation system, will be calculated.

System specific electrical power loads

The electric power loads will be related to the Specific Power Input (SPI; see EN 13142) of the mechanical ventilation unit(s) in question at System Specific Reference Air Volume flow *($q_{sys;ref}$)* and reference pressure difference. By using the $q_{sys;ref}$ that includes f_{cntrl}, possible savings on fan power consumption because of use of controls, are incorporated.

In case heat recovery is involved, additional electricity consumption is assumed to preheat the incoming are to a temperature level of -4 ºC, to prevent freezing of the heat exchanger.

Any additional auxiliary power consumption caused by other system related components (controls, sensors, actuators, etc.) will be calculated separately on the basis of default values.

5.1.3
Definition Environmental Impact

The assessment of the environmental impact should follow the MEEUP methodology and more specifically the EcoReport tool. The latter is a spreadsheet calculation tool that helps the user in performing the proper calculations with the Unit Indicators in Table 29 of the MEEUP Methodology Report (VHK, Nov. 2005)

The Environmental Impact of the thermal energy content of the exchanged air will be based on the mix of the fuel use by the boiler stock (solid fuels excluded, see Preparatory Study Lot 1, chapter 5):
Gas : 76%
Oil : 21%
Electricity (grid) : 3 %

5.1.4
Definition and fixed inputs Life Cycle Costs

Annex II of the EuP-Directive provides guidance regarding the definition of Life Cycle Costs (LCC). The LCC analysis method 'uses a real discount rate on the basis of data provided from the European Central Bank and a realistic lifetime for the EuP; it is based on the sum of the variation in purchase price (resulting from variations in industrial costs) and in operating expenses, which result from the different levels of technical improvement options, discounted over the lifetime of the representative EuP. The operating expenses cover primarily energy consumption an additional expenses in other resources (such as service and maintenance, costs for filters, etc).'

The relevant equation is

LCC = PP + PWF * OE,

where LCC is Life Cycle Costs, PP is the purchase price (incl. installation costs) and OE is the operating expense.

The PWF (Present Worth Factor) is defined as

PWF= N * 1/(1+ r)^{N} ,

in which N is the product life and r is the discount (interest-inflation) rate.

The table below gives a summary of the running cost parameters that will be used for the Base Case (average EU-27):

Table 5.1.4-1. Running costs fixed parameters for LCC (EU avg)

Product Life (years) Rlife	17	years
Discount rate Rdis	4%	
Electricity rate per kWhe Rel	0,16	€/ kWhe
Avg. Fuel per GJ Rfuel	28,50	€/ GJ

The prices of the products and installation costs will be based on the data in Chapters 2, but they are direct <u>variables</u> for the design options and will therefore be discussed in the next chapter.

5.2 Product Specific Inputs BaseCases

Six BaseCases will be assessed in this chapter. BaseCases number 1 and 2 represent the mechanical ventilation units with the highest sales and the largest degree of penetration (systems with natural supply and mechanical exhaust). Number 3 and 4 represent the two products with a high growth rate and large saving potential (units with mechanical supply & exhaust with HR). The last two BaseCases (5 and 6) are only in for reasons of completeness (systems with mechanical supply and natural exhaust). They have a limited market penetration and are expected to have comparable environmental impacts to the exhaust type units (1 and 2).

Note: Only the materials of the mechanical ventilation unit will be involved in the calculations for the Environmental Impact (so no materials for natural supply provisions, ducts, etc.).

Table 5.2-1 Description BaseCases

	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR- unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + natural exhaust provisions (p.s)	6. Centralized mech. supply unit + natural exhaust provisions (p.s)
AC/DC	AC	AC	DC	DC	AC	AC
Max. flow rate [m3/h]	80	250	250	115	80	250
- Related max. power [W]	17	65	100	40	17	70
- Related pressure drop [Pa]	15	80	120	40	15	120
Reference flow rate (EN 13142) [m3/h]	56	175	175	80	56	175
- Related power [W]	12	40	45	23	12	45
- Related pressure drop [Pa]	10	40	65	25	10	65
- Related SPI (EN 13142)	0,21	0,23	0,26	0,28	0,21	0,26
Temperature ratio (EN 13142) [%]	-	-	80%	65%		
Controlled by manual operation: on-off and/or number of positions	On/off 2	- 3	- 3	- 3	On/off 2	- 3

5.2.1 Materials (BOMs)

The bills of materials are constructed on the basis of the data supplied by the European Ventilation Industry Association (EVIA), and were cross checked with the data from the original LOT10 Preparatory Study on Residential Ventilation. Unfortunately the provided data is not detailed enough to make a break down to more detailed material specifications
Because for centralized or room based heat recovery units, the differences between products of different manufacturers can be quite big, an average-BOM is composed for these units.

Table 5.2.1-1 BOMs of BaseCases

	unit	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR-unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
Steel	gr.	560	2130	23700	3600	560	2130
Iron	gr.		275	800	550		275
Aluminum	gr.	30	200	2100	250	30	200
Copper	gr.	40	500	900	650	40	500
Brass	gr.	0	0	0	0	0	0
Techn. plastics	gr.	110	400	1200	1200	110	400
Bulk plastics	gr.	235	2250	5650	4700	235	2250
Electronics	gr.	25	300	800	800	25	300
Other	gr.	0	0	0		0	0
Total	gr	1000	6055	35150	11750	1000	6055

5.2.2
Manufacturing phase

The inputs required to assess the environmental impacts for the manufacturing phase are generated automatically by the EcoReport. As metal scrap percentage we use the default 25%. Please note that for plastics the manufacturing impacts are included in the materials.

Table 5.2.2-1 Manufacturing inputs for BaseCases

Row nr	**Mat/process**		1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR-unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
20	OEM Plastics Manufacturing		345	2650	6850	5900	345	2650
34	Foundries Fe/Cu/Zn		0	275	800	550	0	275
35	Foundries Al/Mg		0	0	0	0	0	0
36	Sheet metal Manufacturing		590	2330	25800	3850	590	2330
53	PWB Manufacturing		0	0		0	0	0
	Other materials		65	800	1700	1450	65	800
37	Sheet metal scrap		148	583	6450	963	148	583

5.2.3 Distribution phase

The EcoReport requires the product volume as an input for transportation and warehouse.
See Table 5.2.3-1

Table 5.2.3-1 Distribution inputs for BaseCases

Row nr	Mat/process	unit	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR-unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
59	Is it an ICT or Cons. Electr. Product< 15kg ?		no	no	no	no	no	no
60	Is it an installed appliance ?		yes	yes	yes	yes	yes	yes
63	Volume of packaged final product	m3	0,002	0,125	0,300	0,080	0,002	0,125

5.2.4 Use phase

The use phase consists of the energy consumption and the maintenance/repairs. For the latter we assume for centralized mechanical HR units a total service travel distance of 500 km for 17 years of maintenance. For room based HR and centralized exhaust (or supply) units a total travel distance of 100 km during lifetime.

But the most important is of course the energy consumption of the Mechancial Ventilation Units during its use phase, based on their technical design features. The basis for the design features of these BaseCases is table 5.2-1 containing a first description of the BaseCases and the parameters from the CALCULATION MODEL for Residential Ventilation as described in § 4.4 System Modeling for Energy Consumption of Ventilation during Use Phase.

The operating time of the fans, and the related air exchange that is caused by it, are the key parameters for calculating the energy consumption during use phase. Centralized ventilation units and heat recovery ventilation units are considered to be operating continuously to achieved the required air exchange rates and the related IAQ-levels; the dwellings in which they are installed are built airtight enough, to consider the naturally induced air exchanges as inapt for ventilation purposes (too small and too variable)

But the room based exhaust (and supply) fans (BaseCase 1 and 5) are considered to operate only during use of the wet rooms (bath, toilet, kitchen). Because these products are mainly installed as retrofit ventilation products in older dwellings (e.g. after renovation or cavity-wall-insulation) to solve humidity problems, it is realistic to assume that air exchanges also occur when the wall- or window fans are switched off, through natural ventilation. These BaseCases 1 and 5 are therefore considered to be a combination of system A (natural supply and natural exhaust) with system B of C, meaning that if the wall fans are switched off, the required air exchange is expected to be induced by the natural ventilation system. For these two BaseCases the system reference airflow rate will be calculated on the basis of a mix of 4 hours per day system B/C and 20 hours per day system A . By doing this the momentary use of the room based fans is valued in the right perspective, and the combined systems described in BaseCase 1 and 5 can energy-wise still be compared with the four other BaseCases: namely on the basis of a comparable IAQ.

An overview of the applicable parameters and correction factors for all BaseCases is given in table 5.2.4-1. Just for reference purposes, the fully natural ventilation system A (no fan-units) is also inserted in the table.
Table 5.2.4-2 Calculates the annual energy consumption for the BaseCases.
Table 5.2.4-3 is the Summary of the Use Phase Inputs.

Table 5.2.4-1 Design Inputs BaseCases

Parameter	Description	unit	0. Refernce System A	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR-unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
Airflow related parameters									
q_{ref}	IAQ-specific reference air flow rate	$m^3/m^2/h$	1,30	1,30	1,30	1,30	1,30	*1,30*	*1,30*
$f_{sys;dw}$	System related corr. factor for air exchange variations over the dwelling	[-]	1,25	1,10	1,10	1,00	1,00	*1,15*	*1,15*
$f_{sys;rm}$	System related corr. factor for air exchange variations over the indiv. rooms	[-]	1,15	1,10	1,10	1,00	1,00	*1,05*	*1,05*
$f_{ctrl;sup}$	Corr. factor controls on supply provisions	[-]	1,00	1,00	1,00	-	-	*1,00*	*1,00*
$f_{ctrl;exh}$	Corr. factor controls on exhaust provisions	[-]	1,00	1,00	1,00	-	-	*1,00*	*1,00*
f_{ctrl}	Resulting corr. factor for comb. controls	[-]	1,00	1,00	1,00	1,00	0,95	*1,00*	*1,00*
f_{eff}	Corr. factor for effectiveness of ventilation	[-]	1,10	1,00	1,00	1,00	1,20	*1,00*	*1,00*
f_{duct}	Corr. factor for leakage of the ductwork	[-]	1,00	1,00	1,10	1,10	1,00	*1,00*	*1,10*
$\eta_{\theta;sup}$	Temp. ratio on supply air at ref. air flow	[%]	0,00	0,00	0,00	0,80	0,64	*0,00*	*0,00*
f_{deg}	Corr. factor for degradation of heat exchanger efficiency due to fouling	[-]	-	-	-	1,00	1,00	-	-
$q_{sys;ref}$	System-specific reference air flow rate (calculated as single ventilation system)	$m^3/m^2/h$	2,05	1,57	1,73	0,29	0,51	*1,57*	*1,73*
$q_{sys;ref}$	System-specific reference air flow rate (Rm based units calculated in comb. with syst. A)	$m^3/m^2/h$	2,05	1,96	1,73	0,29	0,51	*1,96*	*1,73*
$\Delta T_{av.}$	Weighted ann. temp difference: *Cold*	[°C]	17	17	17	17	17	17	17
	Weighted ann. temp difference: *Average*	[°C]	13	13	13	13	13	13	13
	Weighted ann. temp difference: *Warm*	[°C]	7	7	7	7	7	7	7
$T_{h;hs}$	Duration of heating season: *Cold*	[h]	6552	6552	6552	6552	6552	6552	6552
	Duration of heating season: *Average*	[h]	5112	5112	5112	5112	5112	5112	5112
	Duration of heating season: *Warm*	[h]	4392	4392	4392	4392	4392	4392	4392
Power consumption related parameters									
SPI	Specific power input at ref. air flow rate	$W/m^3/h$	0,00	0,21	0,23	0,26	0,28	*0,21*	*0,26*
POM	Standby power cons. in fan off mode	W	0,00	0,00	0,00	0,00	0,00	0,00	0,00
$P_{aux;sys}$	Standby cons. other system components	W	0,00	0,00	0,00	0,00	0,00	0,00	0,00
$T_{h;an}$	Annual operating hours for SPI / POM and $P_{aux;sys}$	[-]	0,00	1460	8760	8760	8760	1460	8760
$\Delta T_{pr;h}$	Weighted ΔT for preheating: *Cold*	[°C]	5,2	5,2	5,2	5,2	5,2	5,2	5,2
	Weighted ΔT for preheating: *Average*	[°C]	2,4	2,4	2,4	2,4	2,4	2,4	2,4
	Weighted ΔT for preheating: *Warm*	[°C]	-	-	-	-	-	-	-
$T_{h;pr;h}$	Duration of pre-heating period *Cold*	[h]	1003	1003	1003	1003	1003	1003	1003
	Duration of pre-heating period *Average*	[h]	168	168	168	168	168	168	168
	Duration of pre-heating period *Warm*	[h]	-	-	-	-	-	-	-

Table 5.2.4-2 Calculation Annual Energy consumption BaseCases

BaseCases and Primary Energy Consumptiom for Residential Ventilation per m2 of dwelling surface per year

INPUTS		Description BaseCases: No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit	
Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D	
	unit	description	value	description	value	description	value	description	value	description	value	description	value
qref/m²	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
fsys;dw	-	no system	1,25	system A	1,25	system c	1,10	system C	1,10	system D	1,00	system D	1,00
fsys;rm		no system	1,20	system A	1,15	system c	1,10	system C	1,10	system D	1,00	system D	1,00
feff	-	nat.driv.overfl	1,10	nat.driv.overfl	1,10	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	same fac.no conv	1,20
fctrl;sup	-	infiltr+airing	1,10	man.sup.grid	1,00	man.sup.grid	1,00	man.sup.grid	1,00	manual switch	-	manual switch	-
fctrl;exh	-	passive stack	1,00	passive stack	1,00	loc.exh.man	1,00	man.switch	1,00	manual switch	-	manual switch	-
fctrl	-	overall *f* cntr	1,10	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	0,90
fduct	-	no duct	1,00	no duct	1,00	sup.duct class B	1,00	exh.duct class B	1,10	exh.duct class B	1,10	no duct	1,00
ηHR;sys	-	no HR	0,00	no HR	0,00	no HR	0,00	no HR	0,00	HR	0,80	HR	0,64
fη;adj;		no heat exch.	1,00	no heat exch.	1,00	no heat exch.	1,00	no heat exch.	1,00	no adjustment	1,00	no adjustment	1,00
Ref.flowrate vent.unit	m^3/h		-		-		56		175		175		80
SPI	$W/m^3/h$	no fan(s)	0,00	no fan(s)	0,00	loc.exh.unit	0,21	centr.exh. unit	0,23	mech HR unit	0,26	mech HR unit	0,28
POM	W	no standby	0,00	no standby	0,00	no standby	0	no standby	0	no standby	0	no standby	0
Paux;sys	W	no aux.	0,00	no aux.	0,00	no aux.	0	no aux.	0	no aux.	0	no aux.	0

Share of operating time in case multiple vent. systems are combined

Type / share	%		n.a.		n.a.	C	17%		n.a.		n.a.		n.a.
Type / share	%		n.a.		n.a.	A	83%		n.a.		n.a.		n.a.

MAIN OUTPUTS

		No ventilation		0.		1.		2.		3.		4.	
System reference air exchange rates		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
qsys;ref	$m^3/m^2/h$	**2,36**	-	**2,06**	-	1,57	**1,97**	**1,73**	-	**1,43**	-	**1,40**	-
qsys;ref (incl.HR)	$m^3/m^2/h$	**2,36**	-	**2,06**	-	1,57	**1,97**	**1,73**	-	**0,29**	-	**0,51**	-
Ref. for calc.purps	*m^2*	-		-		*36*	*28*	*101*		*122*		*57*	
Thermal energy content exchanged air		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth **cold**	$MJ/m^2/a$	326	-	284	-	217	272	239	-	39	-	70	-
Qth **average**	$MJ/m^2/a$	194	-	169	-	129	162	142	-	24	-	42	-
Qth **warm**	$MJ/m^2/a$	90	-	78	-	60	75	66	-	11	-	19	-
Qgain	$MJ/m^2/a$	57	-	57	-	57	57	57	-	11	-	20	-
Primary energy consumption for heating of exchanged air		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth;prim GCV **cold**	$MJ/m^2/a$	**448**	-	**378**	-	267	**359**	**304**	-	**47**	-	**82**	-
Qth;prim GCV **avera.**	$MJ/m^2/a$	**229**	-	**188**	-	121	**176**	**143**	-	**20**	-	**35**	-
Qth;prim GCV **warm**	$MJ/m^2/a$	**55**	-	**36**	-	5	**31**	**15**	-	**0**	-	**0**	-
Electric energy consumption		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qel (SPI, POM, AUX)	$kWhe/m^2/a$	**0,00**	-	**0,00**	-	**2,89**	**0,62**	**3,49**	-	**3,26**	-	**3,44**	-
Qel;pr-h **cold**	$kWhe/m^2/a$	**0,00**		**0,00**		0,00	**0,00**	**0,00**		**2,57**	-	**2,52**	-
Qel;pr-h **average**	$kWhe/m^2/a$	**0,00**		**0,00**		0,00	**0,00**	**0,00**		**0,20**	-	**0,19**	-
Qel TOTAL **cold**	$kWhe/m^2/a$	**0,00**		**0,00**		**2,89**	**0,62**	**3,49**		**5,82**	-	**5,96**	
Qel TOTAL **average**	$kWhe/m^2/a$	**0,00**		**0,00**		**2,89**	**0,62**	**3,49**		**3,46**		**3,64**	-
Qel TOTAL **warm**	$kWhe/m^2/a$	**0,00**		**0,00**		**2,89**	**0,62**	**3,49**		**3,26**		**3,44**	

DEFAULT CALCULATING PARAMETERS

Cp	=	1,007	kJ/kg/K	*P int*	=	5,00	W/m^2	th;an	=	8760	h	*ΔTav* cold	=	17,0	°C
ρ	=	1,230	kg/m3	*P sol*	=	3,00	W/m^2	th;hs cold	=	6552	h	*ΔTav* aver.	=	13,0	°C
η_H	=	0,6	-	*f gain*	=	0,30	-	th;hs aver	=	5112	h	*ΔTav* warm	=	7,0	°C
η_e	=	0,4	-					th;hs warm	=	4392	h	*ΔTpr;h* cold	=	5,2	°C
								th;pr;h cold	=	1003	h	*ΔTpr;h* aver.	=	2,4	°C
								th;pr;h aver.	=	168	h				

Table 5.2.4-3 Summary Use Phase Inputs

Row	Mat/process	unit	No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit	
	Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D	
	Calc.capacity vent.unit	m2	-		-		36	28	101		122		57	
			monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
65	Electricity cold cl.	kWhe/m^2/a	0,00	-	0,00	-	2,89	0,62	3,49	-	5,82	-	5,25	-
	Electricity average cl.	kWhe/m^2/a	0,00		0,00		2,89	0,62	3,49		3,46		3,20	
	Electricity warm cl.	kWhe/m^2/a	0,00		0,00		2,89	0,62	3,49		3,26		3,03	
	Fuel cold cl.	MJ/m^2/a	448	-	378	-	267	359	304	-	45	-	79	-
	Fuel average cl.	MJ/m^2/a	229		188		121	176	143		19		31	
	Fuel warm cl.	MJ/m^2/a	55	-	36	-	5	31	15		0		0	-
86	Mini-van diesel	km	-		-		-		100		500		100	

To convert the figures on energy use per m2 of dwelling to the energy use of the mechanical ventilation unit, just multiply these figures with the calculated airflow capacity of the pertaining unit.

5.2.5 End-of-Life phase

For the End-of-Life we assume the EcoReport default scenario:

Table 5.2.5-1. Default EOL scenario

Landfill (not recovered)	5% of total weight * [row 89]
Incinerated	(plastics & PWB fraction -(re-used + recycled)) * [row 91]
Cost of plastics recycling	(re-used + recycled fraction) * [row 92]
Plastics: Re-used (closed loop)	1% of plastics fraction
Plastics: Materials recycling	9 % of plastics fraction
Plastics: Thermal recycling	90 % of plastics fraction
Electronics easy to assembly	YES: electronics fraction & manuf. [=row 98] * 20%
Metals & Misc.	95% recycled (value already incorporated)

As a consequence, the following inputs will be used for the EOL:

Table 5.2.5-2 EOL Inputs BaseCases

Row nr	**Mat/process**	unit	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR- unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
Disposal								
88	Landfill	g	50	303	1758	588	50	303
91	Incineration	g	311	2385	6165	5310	311	2385
92	Plastic: Re-use & Recycling (cost-side)	g	35	265	685	590	35	265
Re-use, Recycling Benefit								
4	Plastics: Re-use, Closed Loop Recycling	g	3	27	69	59	3	27
4	Plastics: Materials Recycling	g	31	239	617	531	31	239
72	Plastics: Thermal Recycling	g	311	2385	6165	5310	311	2385
98	Electronics: PWB Easy to Disassemble?		Yes	Yes	Yes	Yes	Yes	Yes
	Metals & TV glass + Misc.	g	622	3235	26885	5558	622	3235

5.2.6
LCC Inputs: Prices and installation costs

The prices of the BaseCases are derived from chapter 2, paragraph 2.3 “Prices and Rates” and 2.4 “Industry, Distribution and Costs”. The results are given in the table below.

Table 5.2.6-1 Prices and installation costs BaseCases per unit

	unit	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR- unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
Product price							
Manufacturing selling Price, VAT excl.	€	50,-	165,-	1269,-	609,-	50,-	165,-
Ex. Wholesale price, VAT excl. (msp + 20%)	€	60,-	198,-	1522,-	731,-	60,-	198,-
Ex. Installer, VAT excl. (wholesaleprice + 20%)	€	73,-	237,-	1827,-	877,-	73,-	237,-
Consumer street price, VAT included	€	**87,-**	**283,-**	**2174,-**	**1043,-**	**87,-**	**283,-**
Installation materials							
Installation Kit, VAT included	€	-	300,-	600,-	100,-	-	300,-
Supply / overflow provisions, VAT included	€	-	300,-	150,-	-	-	300,-
Total	€	87,-	883,-	2924,-	1143,-	87,-	883,-
Installation costs per unit							
Installation costs New built, VAT included	€	55,-	330,-	1320,-	110,-	55,-	330,-
Installation costs Renovation, VAT included	€	55,-	825,-	2200,-	110,-	55,-	825,-
Total costs per unit for New Built	€	142,-	1213,-	4244,-	1253,-	142,-	1213,-
Total costs per unit for Renovation	€	142,-	1708,-	5124,-	1253,-	142,-	1708,-

5.2.7
LCC Inputs: Maintenance

As explained in paragraph 5.1.1 “Definition of Performance”, filtering performance is an important topic but not applicable for all ventilation units/systems. In an attempt to harmonize the quality of the supplied air for ventilation systems that don’t apply filtering with he ones that do, it is proposed for the centralized mechanical supply unit and for he HR-units only to use standard G3 filters and to change them once a year. Costs for filter replacement are based on this assumption (see also table 2.3.3-1).

Table 5.2.7-1 Maintenance costs per unit over lifetime

	unit	1. Room based mech. exhaust unit + natural supply provisions	2. Centralized mech. exhaust unit + natural supply provisions	3. Centralized mech. Mech. HR-unit	4. Room based mech. HR- unit	5. Room based mech. Supply unit + nat. exhaust provisions (p.s)	6. Centralized mech. supply unit + nat. exhaust provisions (p.s)
Cleaning of centralized ductwork	€	-	255,-	340,-	-	-	255,-
Replacement supply filter once per year	€	-	-	595,-	255,-	-	595,-
Replacement exhaust filter once a year	€	-	-	425,-	170,-	-	-
Total	€	**-**	**255,-**	**1360,-**	**425,-**	**-**	**850,-**

5.2.8
EU-totals: Markets by Category

Based on the market data from paragraph 2.2 “Market and Stock Data”, the following tables are put together:

Table 5.2.8-1 Stock and segmentation mechanical ventilation *units*

BaseCases		Estimated segmentation ventilation units	
		Stock 2003	**Stock 2005**
1.	Average Room based mechanical exhaust /(supply) unit	59.520.000	60.546.000
2.	Average Centralized mechanical exhaust /(supply) unit	17.700.000	20.546.000
3.	Average Centralized mechanical HR unit	428.000	650.000
4.	Average Room based mechanical HR unit	28.000	96.000
Total stock mech. ventilation units		**77.676.000**	**81.838.000**

Table 5.2.8-2 Sales 2005 and segmentation mechanical ventilation *units*

BaseCases		Estimated sales ventilation units 2005
1.	Average Room based mechanical exhaust /(supply) unit	4.100.000
2.	Average Centralized mechanical exhaust /(supply) unit	2.665.000
3.	Average Centralized mechanical HR unit	135.000
4.	Average Room based mechanical HR unit	34.000
Total sales		**6.933.000**

Table 5.2.8-3 Stock and segmentation mechanical ventilation *systems* in dwellings

BaseCases	Estimated segmentation Dwellings & ventilation systems	
	Stock 2003 *k#*	Share %
Dwellings without dedicated ventilation provisions (air exchange based on infiltration & airing)	67.654	41%
Dwellings, originally without ventilation provisions, afterwards supplied with one or more retrofit room based mech. ventilation units	28.994	18%
Dwelling with natural supply & exhaust (system A)	37.357	24%
Dwelling with mechanical supply and natural exhaust (system B)	716	0,5%
Dwellings with natural supply and mechanical exhaust (system C)	26.389	16%
Dwellings with mechanical supply and exhaust	451	0,3%

5.3 Environmental Impact BaseCases

Annex 4 gives the EcoReports for all four Bases

The table below (5.3-1) summarizes the outcome for all the BaseCase ventilation units for Climate zone "Average". The environmental impact is related to the calculated ventilation capacity (in m^2 of dwelling surface) that can be served by the ventilation unit, based on the system specific reference airflow $q_{sys;ref}$, when running at reference (= 70% of the maximum) airflow.

Main findings are:

- 97 to 100,0% of all CO2 emissions relate to the use phase
- 94 to 99% of all Sox emissions relate to the use phase
- Practically all VOC emissions relate to the use phase
- 50 – 70% of all PM emissions relate to the use phase.

Table 5.3-1 Environmental Impact *BaseCase Units* over lifetime for climate zone "Average"

ENVIRONMENTAL IMPACT BASECASE UNITS OVER LIFE FOR CLIMATE ZONE "AVERAGE"

	unit	No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit	
Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D	
Calc. ventilation cap. unit	**m2**					**36**	**28**	**101**		**122**		**57**	
MATERIALS		total	use	total	use	total	use	total	use	total	use	total	use
TOTAL	kg					1,00		6,06		35,15		11,75	
of which													
Disposal	kg					0,37		2,84		8,34		6,36	
Recycled	kg					0,63		3,22		26,81		5,39	
OTHER RESOURCES													
Total Energy (GER)	GJ					93,96	93,79	326,27	325,26	123,06	119,23	66,73	64,82
of which electric (in primary)	GJ					3,16	3,12	63,30	63,01	76,35	75,34	33,27	32,57
Water (process)	m3					0,22	0,21	4,38	4,20	5,50	5,03	2,64	2,18
Water (cooling)	m3					8,36	8,33	168,23	168,03	201,51	200,88	87,31	86,83
Waste, non-haz /landfill	kg					5,80	3,64	89,43	73,21	162,67	88,06	61,94	37,98
Waste, hazardous/incinerate	kg					0,40	0,07	4,05	1,45	8,47	1,74	6,62	0,75
EMISSIONS TO AIR													
GHG in GWP100	tCO2					5,16	5,15	17,31	17,25	5,98	5,74	3,32	3,21
AP Acidification	kgSOx					2,32	2,27	20,89	20,47	21,49	20,19	9,70	8,93
VOC	kg					0,07	0,07	0,22	0,22	0,10	0,08	0,05	0,04
POP Perst.Organic.Poll.	mg i-Teq					0,04	0,02	0,49	0,41	1,23	0,50	0,34	0,22
Hma Heavy Metals	g Ni					0,07	0,05	1,27	1,13	2,08	1,56	0,86	0,61
PAHs	g Ni					0,02	0,01	0,23	0,18	0,69	0,41	0,20	0,12
PM Particulate Mater	kg					0,09	0,04	2,00	1,30	6,73	4,84	1,93	1,07
EMISSIONS TO WATER													
HMw Heavy Metals	g Hg/20					0,04	0,02	0,59	0,41	1,05	0,49	0,60	0,21
EP Eutrophication	g PO4					0,00	0,00	5,00	2,00	12,00	2,00	9,00	1,00

To compare the Environmental Impact for ventilation between dwellings that use these BaseCase mechanical ventilation units, and dwellings that use a fully natural ventilation system (system A) or no dedicated ventilation system at all, the following table gives the Environmental Impact data for an average 100 m2 dwelling.

Table 5.3-1 Environmental Impact *BaseCase Ventilation Systems in 100 m2 dwelling* over lifetime for climate zone “Average”

ENVIRONMENTAL IMPACT BASECASE VENTILATION SYSTEMS PER 100 m2 DWELLING OVER LIFE FOR CLIMATE ZONE "AVERAGE"

	unit	No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit	
Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D	
MATERIALS		total	use	total	use	total	use	total	use	total	use	total	use
TOTAL	kg					2,81		5,99		28,72		20,73	
of which													
Disposal	kg					1,03		2,81		6,81		11,23	
Recycled	kg					1,78		3,18		21,91		9,51	
OTHER RESOURCES													
Total Energy (GER)	GJ	414,67	414,67	340,67	340,67	331,13	330,55	322,59	321,60	100,55	97,43	117,73	114,35
of which electric (in primary)	GJ					11,13	11,01	62,59	62,30	62,39	61,56	58,70	57,45
Water (process)	m3					0,79	0,73	4,33	4,15	4,49	4,11	4,65	3,84
Water (cooling)	m3					29,47	29,36	166,34	166,14	164,66	164,15	154,04	153,19
Waste, non-haz /landfill	kg					20,45	12,84	88,42	72,39	132,93	71,96	109,29	67,01
Waste, hazardous/incinerate	kg					1,42	0,25	4,00	1,44	6,92	1,42	11,68	1,32
EMISSIONS TO AIR													
GHG in GWP100	tCO2	22,93	22,93	18,835	18,835	18,19	18,15	17,12	17,06	4,88	4,69	5,86	5,66
AP Acidification	kgSOx	6,68	6,68	5,49	5,49	8,17	7,98	20,65	20,24	17,56	16,50	17,12	15,75
VOC	kg	0,30	0,30	0,25	0,25	0,24	0,24	0,22	0,22	0,08	0,06	0,08	0,07
POP Perst.Organic.Poll.	mg i-Teq	0,00	0,00	0,00	0,00	0,13	0,07	0,48	0,41	1,00	0,41	0,59	0,38
Hma Heavy Metals	g Ni	0,00	0,00	0,00	0,00	0,26	0,19	1,25	1,12	1,70	1,27	1,51	1,07
PAHs	g Ni	0,01	0,01	0,01	0,01	0,06	0,03	0,23	0,18	0,56	0,34	0,36	0,21
PM Particulate Mater	kg	0,12	0,12	0,10	0,10	0,30	0,15	1,98	1,29	5,50	3,95	3,40	1,88
EMISSIONS TO WATER													
HMw Heavy Metals	g Hg/20	0,00	0,00	0,00	0,00	0,13	0,07	0,58	0,40	0,85	0,40	1,05	0,37
EP Eutrophication	g PO4	0,00	0,00	0,00	0,00	0,00	0,00	4,94	1,98	9,81	1,63	15,88	1,76

<u>Main findings</u>

Dwellings that are constructed airtight enough, making it necessary to use dedicated ventilation systems, have a lower impact on the environment due to ventilation, than dwellings with fully natural systems.
With main stream centralized mechanical exhaust units, emissions can be reduced up to 25%.
With mechanical heat recovery units, emissions can be reduced with more than 75%.

5.4 Life Cycle Costs BaseCases

Life Cycle costs per ventilation unit
An overview of the lifecycle costs *per BaseCase unit* for climate zone "*average*" and "*cold*" is given in table 5.4-1 on the next page.

Comparing the Life Cycle Costs of the BaseCase Units per m2 with each other (on the basis of their calculated ventilation capacity (in m^2 of dwelling surface)), the two heat recovery units clearly have the least lifecycle costs. This is true for both the average climate zone and the cold climate zone.
For BaseCase units without heat recovery, the energy costs represent the biggest share (80 – 90%) in the annual expenditure. For the units that apply heat recovery, the biggest share in the annual expenditure is the depreciation of the product and installation costs (50 - 60%).

Life Cycle costs per ventilation system
An overview of the lifecycle costs *per BaseCase ventilation system* for an average 100 m^2 dwelling for climate zone "*average*" and "*cold*" is given in table 5.4-2.

When comparing BaseCase ventilation systems on the basis of an average 100 m2 dwelling, the number of room based units need to be selected.
For the ventilation system based on BaseCase decentralized exhaust units, 3 products will be installed (kitchen, bathroom and toilet).
For the ventilation system based on BaseCase decentralized HR-units, 4 of these will be installed (living room and 3 bedrooms) together with 3 exhaust fans in the wet rooms. This increase in number of room based HR units, also increases the total investment costs. As a results, least life cycle costs for the room based – systems will shift.

Table 5.4-2 illustrates that with the parameters of the BaseCase units presented in this study, the centralized HR-system still is the system with the least life cycle costs for both the the "Average" and "Cold" climate zone. The room based HR-system holds the second place on least life cycle costs in the Cold climate zone, but for the Average climate zone this system does no longer ranks amongst the cheapest solutions.
For the system with room based mechanical exhaust units, the product price increase is limited and the energy costs remain the biggest part. Concerning annual expenditure, this system holds the fourth place in cold climates and the second place in an average climate..

Given the fact that the BaseCase mechanical ventilation units described in this chapter do not represent "market best units", and given the fact that more intelligent selections and combinations of room based units can be made, further improvements on life cycle costs and energy savings can be achieved.
This will be further investigated in Chapter 6. Design Options.

Table 5.4-1

LIFE CYCLE COSTS AND ANNUAL EXPENDITURE PER BASECASE UNIT FOR CLIMATE ZONE "AVERAGE"

	unit	No ventilation system (infiltration and airing in leaky dwelling)	0. Reference system A (dedicated natural ventilation system)	1. Room based mechanical exhaust unit + natural supply	2. Centralized mechanical exhaust unit+ natural supply	3. Centralized mechanical heat recovery unit	4. Room based mechanical heat recovery unit
Type of ventilation system		infiltration + airing	A .	Local mech.exh. + A	C	D	D
Calc. ventilation cap. unit	m2			36 28	101	122	57
LCC break down							
Product Price				€ 87	€ 883	€ 2.924	€ 1.143
Installation				€ 55	€ 330	€ 1.320	€ 110
Fuel energy (gas, oil)				€ 1.714	€ 4.954	€ 807	€ 605
Electricity				€ 34	€ 687	€ 821	€ 355
Repair & Maintenance				€ 0	€ 182	€ 973	€ 304
TOTAL LCC				€ 1.890	€ 7.036	€ 6.845	€ 2.517
TOTAL LCC / m2 dwelling				€ 66,61	€ 69,57	€ 55,93	€ 44,17
Annual expenditure							
Product Price				€ 5,12	€ 51,94	€ 172,00	€ 67,24
Installation				€ 3,24	€ 19,41	€ 77,65	€ 6,47
Fuel energy (gas, oil)				€ 100,82	€ 291,41	€ 47,47	€ 35,59
Electricity				€ 2,00	€ 40,41	€ 48,29	€ 20,88
Repair & Maintenance				€ 0,00	€ 10,71	€ 57,24	€ 17,88
TOTAL expenditure / annum				€ 111,18	€ 413,88	€ 402,65	€ 148,06
Annual exp./ m2 dwelling				€ 3,92	€ 4,09	€ 3,29	€ 2,60

LIFE CYCLE COSTS AND ANNUAL EXPENDITURE PER BASECASE UNIT FOR CLIMATE ZONE "COLD"

	unit	No ventilation system (infiltration and airing in leaky dwelling)	0. Reference system A (dedicated natural ventilation system)	1. Room based mechanical exhaust unit + natural supply	2. Centralized mechanical exhaust unit+ natural supply	3. Centralized mechanical heat recovery unit	4. Room based mechanical heat recovery unit
Type of ventilation system		infiltration + airing	A .	Local mech.exh. + A	C	D	D
Calc. ventilation cap. unit	m2			36 28	101	122	57
LCC break down							
Product Price				€ 87	€ 883	€ 2.924	€ 1.143
Installation				€ 55	€ 330	€ 1.320	€ 110
Fuel energy (gas, oil)				€ 3.441	€ 10.514	€ 1.882	€ 1.542
Electricity				€ 34	€ 687	€ 1.382	€ 582
Repair & Maintenance				€ 0	€ 182	€ 973	€ 304
TOTAL LCC				€ 3.617	€ 12.596	€ 8.481	€ 3.681
TOTAL LCC / m2 dwelling				€ 127,47	€ 124,54	€ 69,30	€ 64,60
Annual expenditure							
Product Price				€ 5,12	€ 51,94	€ 172,00	€ 67,24
Installation				€ 3,24	€ 19,41	€ 77,65	€ 6,47
Fuel energy (gas, oil)				€ 202,41	€ 618,47	€ 110,71	€ 90,71
Electricity				€ 2,00	€ 40,41	€ 81,29	€ 34,24
Repair & Maintenance				€ 0,00	€ 10,71	€ 57,24	€ 17,88
TOTAL expenditure / annum				€ 212,76	€ 740,94	€ 498,88	€ 216,53
Annual exp./ m2 dwelling				€ 7,50	€ 7,33	€ 4,08	€ 3,80

To compare the Life Cycle Costs for ventilation between dwellings that use these BaseCase mechanical ventilation units, and dwellings that use a fully natural ventilation system (system A) or no dedicated ventilation system at all, the following table gives the LCC costs for an average 100 m2 dwelling.

Table 5.4-2

LIFE CYCLE COSTS & ANNUAL EXPENDITURE PER VENTILATION SYSTEM PER 100 m2 DWELLING FOR CLIMATE ZONE "AVERAGE"

unit	No ventilation system (infiltration and airing in leaky dwelling)	0. Reference system A (dedicated natural ventilation system)	1. 3x Room based mechanical exhaust unit + natural supply	2. Centralized mechanical exhaust unit+ natural supply	3. Centralized mechanical heat recovery unit	4. 4x Room based mechanical heat recovery unit
Type of ventilation system	infiltration + airing	A .	Local mech.exh. + A	C	D	D
Calc. ventilation cap. unit			36 28	101	122	57
LCC break down						
Product Price		€ 600	€ 261	€ 883	€ 2.924	€ 4.833
Installation			€ 165	€ 330	€ 1.320	€ 440
Fuel energy (gas, oil)	€ 7.840	€ 6.441	€ 6.041	€ 4.898	€ 659	€ 1.062
Electricity			€ 120	€ 679	€ 671	€ 623
Repair & Maintenance			€ 0	€ 182	€ 973	€ 1.216
TOTAL LCC	€ 7.840	€ 7.041	€ 6.586	€ 6.972	€ 6.547	€ 8.174
TOTAL LCC / m2 dwelling	€ 78,40	€ 70,41	€ 65,86	€ 69,72	€ 65,47	€ 81,74
Annual expenditure						
Product Price		€ 35,29	€ 15,35	€ 51,94	€ 172,00	€ 284,29
Installation			€ 9,71	€ 19,41	€ 77,65	€ 25,88
Fuel energy (gas, oil)	€ 461,18	€ 378,88	€ 355,33	€ 288,13	€ 38,79	€ 62,46
Electricity			€ 7,05	€ 39,96	€ 39,46	€ 36,65
Repair & Maintenance			€ 0,00	€ 10,71	€ 57,24	€ 71,53
TOTAL expenditure / annum	€ 461,18	€ 414,18	€ 387,43	€ 410,15	€ 385,14	€ 480,81
Annual exp./ m2 dwelling	€ 4,61	€ 4,14	€ 3,87	€ 4,10	€ 3,85	€ 4,81

LIFE CYCLE COSTS & ANNUAL EXPENDITURE PER VENTILATION SYSTEM PER 100 m2 DWELLING FOR CLIMATE ZONE "COLD"

unit	No ventilation system (infiltration and airing in leaky dwelling)	0. Reference system A (dedicated natural ventilation system)	1. 3x Room based mechanical exhaust unit + natural supply	2. Centralized mechanical exhaust unit+ natural supply	3. Centralized mechanical heat recovery unit	4. 4x Room based mechanical heat recovery unit
Type of ventilation system	infiltration + airing	A .	Local mech.exh. + A	C	D	D
Calc. ventilation cap. unit			36 28	101	122	57
LCC break down						
Product Price		€ 600	€ 261	€ 883	€ 2.924	€ 4.833
Installation			€ 165	€ 330	€ 1.320	€ 440
Fuel energy (gas, oil)	€ 15.345	€ 12.948	€ 12.127	€ 10.396	€ 1.538	€ 2.706
Electricity			€ 120	€ 679	€ 1.129	€ 1.021
Repair & Maintenance			€ 0	€ 182	€ 973	€ 1.216
TOTAL LCC	€ 15.345	€ 13.548	€ 12.673	€ 12.470	€ 7.884	€ 10.217
TOTAL LCC / m2 dwelling	€ 153,45	€ 135,48	€ 126,73	€ 124,70	€ 78,84	€ 102,17
Annual expenditure						
Product Price		€ 35,29	€ 15,35	€ 51,94	€ 172,00	€ 284,29
Installation			€ 9,71	€ 19,41	€ 77,65	€ 25,88
Fuel energy (gas, oil)	€ 902,65	€ 761,65	€ 713,35	€ 611,51	€ 90,46	€ 159,19
Electricity			€ 7,05	€ 39,96	€ 66,43	€ 60,08
Repair & Maintenance			€ 0,00	€ 10,71	€ 57,24	€ 71,53
TOTAL expenditure / annum	€ 902,65	€ 796,94	€ 745,46	€ 733,52	€ 463,77	€ 600,98
Annual exp./ m2 dwelling	€ 9,03	€ 7,97	€ 7,45	€ 7,34	€ 4,64	€ 6,01

5.5 EU-27 Total Impact

Table 5.5-1 shows the total environmental impact of the BaseCase units sold in 2005 over their lifetime, i.e. the period between 2005 and 2022.

Table 5.5-1 EU Total Environmental Impact BaseCase units sold in 2005

ENVIRONMENTAL IMPACT BASECASE UNITS SOLD IN 2005 OVER THEIR PRODUCT LIFE FOR CLIMATE ZONE "AVERAGE"

	unit	No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit		**EU TOTAL** Environmental Impact of units sold in 2005
Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D		
Calc. ventilation cap. unit	m2					36	28	101		122		57		
MATERIALS		total	use	total	use	total	use	total	use	total	use	total	use	
TOTAL	kt					4		16		5		0		**25**
of which														
Disposal	kt					3		9		4		0		**16**
Recycled	kt					2		8		1		0		**11**
OTHER RESOURCES														
Total Energy (GER)	pJ					385	385	869	867	17	16	2	2	**1273**
of which electric (in primary)	Pj					13	13	169	168	10	10	1	1	**193**
Water (process)	mln.m3					1	1	12	11	1	1	0	0	**14**
Water (cooling)	mln.m3					34	34	448	448	27	27	3	3	**512**
Waste, non-haz /landfill	kt					24	15	238	195	22	12	2	1	**286**
Waste, hazardous/incinerate	kt					2	0	11	4	1	0	0	0	**14**
EMISSIONS TO AIR														
GHG in GWP100	mtCO2					21	21	46	46	1	1	0	0	**68**
AP Acidification	ktSOx					10	9	56	55	3	3	0	0	**69**
VOC	kt					0	0	1	1	0	0	0	0	**1**
POP Perst.Organic.Poll.	g i-Teq					0	0	1	1	0	0	0	0	**1**
Hma Heavy Metals	ton Ni eq					0	0	3	3	0	0	0	0	**3**
PAHs	ton Ni eq					0	0	1	0	0	0	0	0	**1**
PM Particulate Mater	kt					0	0	5	3	1	1	0	0	**6**
EMISSIONS TO WATER														
HMw Heavy Metals	ton Hg/20					0	0	2	1	0	0	0	0	**2**
EP Eutrophication	kt PO4					0	0	0	0	0	0	0	0	**0**

Table 5.5-2 on the next page gives the EU total environmental impact of the complete 2005 stock of mechanical ventilation units. Because these mechanical units only cover 35% of all EU27 primary dwellings, this table also gives an estimate of the environmental impact of ventilation for the remaining 65% of the primary dwellings. 41% relates to primary dwellings without dedicated ventilation systems (leaky dwellings relying on infiltration and airing). The remaining 24% relates to dwellings with dedicated natural ventilation systems (system A).

The calculations are made on the basis of the average floor area of the EU-dwelling (87m2), the calculated impact for natural ventilation according to table 5.3-1, and the number of dwellings according to table 5.2.8.-3.

Table 5.5-2 Total Environmental Impact of EU-Stock BaseCase ventilation systems in 2005

ENVIRONMENTAL IMPACT OF EU STOCK IN 2005 FOR CLIMATE ZONE "AVERAGE"

	unit	No ventilation system (infiltration and airing in leaky dwelling)		0. Reference system A (dedicated natural ventilation system)		1. Room based mechanical exhaust unit + natural supply		2. Centralized mechanical exhaust unit+ natural supply		3. Centralized mechanical heat recovery unit		4. Room based mechanical heat recovery unit		**EU TOTAL** Environmental Impact of units sold in 2005
Type of ventilation system		infiltration + airing		A .		Local mech.exh. + A		C		D		D		
MATERIALS		total	use	total	use	total	use	total	use	total	use	total	use	
TOTAL	kt					4		16		5		0		**25**
of which														
Disposal	kt					3		9		4		0		**16**
Recycled	kt					2		8		1		0		**11**
OTHER RESOURCES														
Total Energy (GER)	pJ		1436		651	334	334	395	392	5	5	0	0	**2821**
of which electric (in primary)	Pj					11	11	77	76	3	3	0	0	**91**
Water (process)	mln.m3					1	1	6	5	0	0	0	0	**7**
Water (cooling)	mln.m3					30	30	203	203	8	8	1	0	**242**
Waste, non-haz /landfill	kt					22	13	131	88	13	3	1	0	**167**
Waste, hazardous/incinerate	kt					2	0	9	2	1	0	0	0	**12**
EMISSIONS TO AIR														
GHG in GWP100	mtCO2		79		36	18	18	21	21	0	0	0	0	**154**
AP Acidification	ktSOx		23		10	8	8	26	25	1	1	0	0	**69**
VOC	kt		1		0	0	0	0	0	0	0	0	0	**2**
POP Perst.Organic.Poll.	g i-Teq		0		0	0	0	1	0	0	0	0	0	**1**
Hma Heavy Metals	ton Ni eq		0		0	0	0	2	1	0	0	0	0	**2**
PAHs	ton Ni eq		0		0	0	0	0	0	0	0	0	0	**0**
PM Particulate Mater	kt		0		0	0	0	3	2	0	1	0	0	**4**
EMISSIONS TO WATER														
HMw Heavy Metals	ton Hg/20		0		0	0	0	1	0	0	0	0	0	**1**
EP Eutrophication	kt PO4		0		0	0	0	0	0	0	0	0	0	**0**

The total EU energy consumption for residential ventilation is estimated at 2.821 PJ of primary energy per year, with a related emission of 154 Mt CO2 equivalent per annum.
Clearly the penetration of the more energy friendly mechanical ventilation units (especially the units with heat recovery) is just beginning. With combined measures (i.e. improving the air tightness of dwellings and installing efficient ventilation systems) it is theoretically possible to save the largest part of these annual EU-consumption and emission figures.

6. ECODESIGN IMPROVEMENT POTENTIAL

6.1 Introduction

The scope of this Task is the identification of the short-term target design options, their monetary consequences in terms of Life Cycle Costs for the consumer, their environmental costs and benefits and pinpointing the solution with the least Life Cycle Costs (LLCC) and the Best Available Technology (BAT). The assessment of monetary Life Cycle Costs is relevant to indicate whether design solutions might negatively or positively impact the total EU consumer's expenditure over the total product life (purchase, running costs, etc.). The distance between the LLCC and the BAT indicates – in a case a LLCC solution is set as a minimum target – the remaining space for product-differentiation (competition). The BAT indicates a medium-term target that would probably be more subject to promotion measures than restrictive actions. The BNAT (= Best Not yet Available Technologies indicates the long-term possibilities and helps to define the exact scope and nature of possible measures.

All calculations are based on the Excel version of the Calculation Model as described in paragraph 4.4 "System Analysis".

6.2 Design Options & Costs

The following additional costs for the various design options will be used the calculate the related life cycle costs.

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

6.3 Design Options

6.3.1
Design Options System B

INPUTS		0. Reference system A (dedicated natural ventilation system)		B.0 BaseCase Centralizid mech. supply + psv /nat.exh		B.1 Centralized mechanical supply unit + psv Options:SPI = 0,15; clock progr.		B.2 Centralized mechanical supply unit + psv Options:SPI = 0,15; CO2 sensor per room;		B.3 Centralized mechanical supply unit + psv Options:SPI = 0,15; CO2 sensor per room; RH contr. fan ass. Psv (total SPI = 0,22) ; duct.class C	
Type of ventilation system		A .		B BaseCase		B		B		B	
	unit	description	value	description	value	description	value	description	value	description	value
q_{ref/m^2}	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
$f_{sys;dw}$	-	system A	1,25	system b	1,15	system b	1,15	system b	1,15	system b	1,15
$f_{sys;rm}$	-	system A	1,15	system b	1,05	system b	1,05	system b	1,05	system b	1,05
f_{eff}	-	nat.driv.overfl	1,10	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00
$f_{ctrl;sup}$	-	man.sup.grid	1,00	man.switch	1,00	clock progr.	0,80	CO2 sens/ rm	0,75	CO2 sens/ rm	0,75
$f_{ctrl;exh}$	-	passive stack	1,00	psv	1,00	psv	1,00	psv	1,00	psv + RH-fan	0,90
f_{ctrl}	-	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	0,80	overall *f* cntr	0,75	overall *f* cntr	0,68
f_{duct}	-	no duct	1,00	sup.duct class B	1,10	sup.duct class B	1,10	sup.duct class B	1,10	sup.duct class C	1,05
$\eta_{HR;sys}$	-	no HR	0,00	no HR	0,00	no HR	0,00	no HR	0,00	no HR	0,00
$f_{\eta;adj;}$		no HR	1,00	no HR	1,00	no HR	1,00	no HR	1,00	no HR	1,00
Ref.flowrate vent.unit	m^3/h		-		175		175		175		175
SPI	$W/m^3/h$	no fan(s)	0,00	centr.sup.unit	0,23	centr.sup.unit	0,15	centr.sup.unit	0,15	sup.+ exh unit	0,22
POM	W	no standby	0,00	no standby	0	no standby	0	standby	3	standby	3
Paux;sys	W	no aux.	0,00	no aux.	0	no aux.	0	4 CO2 sens.	8	4 CO2 sens.	8
		Share of operating time in case multiple vent. systems are combined									
Type / share	%		n.a.	C	100%		n.a.		n.a.		n.a.
Type / share	%		n.a.		0%		n.a.		n.a.		n.a.
MAIN OUTPUTS		System reference air exchange rates									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$q_{sys;ref}$	$m^3/m^2/h$	**2,06**	-	1,73		**1,38**	-	**1,30**	-	**1,11**	-
$q_{sys;ref}$ (incl.HR)	$m^3/m^2/h$	**2,06**	-	1,73		**1,38**	-	**1,30**	-	**1,11**	-
Ref. for calc.purps	*m^2*	-		*101*		*127*		*135*		*157*	
		Thermal energy content exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{th} **cold**	$MJ/m^2/a$	284	-	238		191	-	179	-	153	-
Q_{th} **average**	$MJ/m^2/a$	169	-	142		114	-	107	-	92	-
Q_{th} **warm**	$MJ/m^2/a$	78	-	66		53	-	49	-	42	-
Q_{gain}	$MJ/m^2/a$	57	-	57		57	-	57	-	57	-
		Primary energy consumption for heating of exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$Q_{th;prim}$ GCV **cold**	$MJ/m^2/a$	**378**	-	303		**223**	-	**203**	-	**161**	-
$Q_{th;prim}$ GCV **avera.**	$MJ/m^2/a$	**188**	-	**143**		**95**	-	**83**	-	**58**	-
$Q_{th;prim}$ GCV **warm**	$MJ/m^2/a$	**36**	-	15		**0**	-	**0**	-	**0**	-
		Electric energy consumption									
		monovalent	comb.	monovalent		monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{el} (SPI, POM, AUX)	$kWhe/m^2/a$	**0,00**	-	**3,48**		**1,82**	-	**2,41**	-	**2,76**	-
$Q_{el;pr-h}$ **cold**	$kWhe/m^2/a$	**0,00**		0,00		**0,00**		**0,00**		**0,00**	
$Q_{el;pr-h}$ **average**	$kWhe/m^2/a$	**0,00**		0,00		**0,00**		**0,00**		**0,00**	
Q_{el} TOTAL **cold**	$kWhe/m^2/a$	**0,00**		**3,48**		**1,82**		**2,41**		**2,76**	
Q_{el} TOTAL **average**	$kWhe/m^2/a$	**0,00**		**3,48**		**1,82**		**2,41**		**2,76**	
Q_{el} TOTAL **warm**	$kWhe/m^2/a$	**0,00**		**3,48**		**1,82**		**2,41**		**2,76**	

6.3.2
Design Options System C

INPUTS		0. Reference system A (dedicated natural ventilation system)		C.0 BaseCase Centralized mech. exhaust + natural supply		C.1 Centralized mechanical exhaust unit+ natural supply Options:SPI = 0,10; RH sens.exh		C.2 Centralized mechanical exhaust unit+ natural supply Options:SPI = 0,10; RH sens.exh; ΔP corr. Supply grid		C.3 Centralized mechanical exhaust unit+ natural supply Options:SPI = 0,10; RH sens.exh; CO2 contr.supp.grid;duct class C	
Type of ventilation system		A .		C BaseCase		C		C		C	
	unit	description	value	description	value	description	value	description	value	description	value
q_{ref/m^2}	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
$f_{sys;dw}$	-	system A	1,25	system c	1,10	system C	1,10	system C	1,10	system C	1,10
$f_{sys;rm}$		system A	1,15	system c	1,10	system C	1,10	system C	1,10	system C	1,10
f_{eff}	-	nat.driv.overfl	1,10	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00
$f_{ctrl;sup}$	-	man.sup.grid	1,00	man.sup.grid	1,00	man.sup.grid	1,00	ΔP sup.grid	0,90	CO2 contr.grid	0,75
$f_{ctrl;exh}$	-	passive stack	1,00	man.switch	1,00	RH sens	0,90	RH sens	0,90	RH sens	0,90
f_{ctrl}	-	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	0,90	overall *f* cntr	0,81	overall *f* cntr	0,68
f_{duct}	-	no duct	1,00	sup.duct class B	1,10	exh.duct class B	1,10	exh.duct class B	1,10	exh.duct class C	1,05
$\eta_{HR;sys}$	-	no HR	0,00	no HR	0,00	no HR	0,00	no HR	0,00	no HR	0,00
$f_{\eta;adj;}$		no HR	1,00	no HR	1,00	no HR	1,00	no HR	1,00	no HR	1,00
Ref.flowrate vent.unit	m^3/h		-		175		175		175		175
SPI	$W/m^3/h$	no fan(s)	0,00	loc.exh.unit	0,23	centr.exh. unit	0,10	centr.exh. unit	0,10	centr.exh. unit	0,10
POM	W	no standby	0,00	no standby	0	no standby	0	no standby	0	no standby	0
$P_{aux;sys}$	W	no aux.	0,00	no aux.	0	no aux.	0	no aux.	0	4 CO2 sens	8
		Share of operating time in case multiple vent. systems are combined									
Type / share	%		n.a.	C	100%		n.a.		n.a.		n.a.
Type / share	%		n.a.		0%		n.a.		n.a.		n.a.
MAIN OUTPUTS		System reference air exchange rates									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$q_{sys;ref}$	$m^3/m^2/h$	**2,06**	-	1,73		**1,56**	-	**1,40**	-	**1,11**	-
$q_{sys;ref}$ (incl.HR)	$m^3/m^2/h$	**2,06**	-	1,73		**1,56**	-	**1,40**	-	**1,11**	-
Ref. for calc.purps	m^2	-		*101*		*112*		*125*		*157*	
		Thermal energy content exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{th} **cold**	$MJ/m^2/a$	284	-	239		215	-	193	-	154	-
Q_{th} **average**	$MJ/m^2/a$	169	-	142		128	-	115	-	92	-
Q_{th} **warm**	$MJ/m^2/a$	78	-	66		59	-	53	-	42	-
Q_{gain}	$MJ/m^2/a$	57	-	57		57	-	57	-	57	-
		Primary energy consumption for heating of exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$Q_{th;prim}$ GCV **cold**	$MJ/m^2/a$	**378**	-	304		**264**	-	**228**	-	**162**	-
$Q_{th;prim}$ GCV **avera.**	$MJ/m^2/a$	**188**	-	**143**		**119**	-	**98**	-	**59**	-
$Q_{th;prim}$ GCV **warm**	$MJ/m^2/a$	**36**	-	15		**4**	-	**0**	-	**0**	-
		Electric energy consumption									
		monovalent	comb.	monovalent		monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{el} (SPI, POM, AUX)	$kWhe/m^2/a$	**0,00**	-	**3,49**		**1,36**	-	**1,23**	-	**1,42**	-
$Q_{el;pr\text{-}h}$ **cold**	$kWhe/m^2/a$	**0,00**		0,00		**0,00**		**0,00**		**0,00**	
$Q_{el;pr\text{-}h}$ **average**	$kWhe/m^2/a$	**0,00**		0,00		**0,00**		**0,00**		**0,00**	
Q_{el} TOTAL **cold**	$kWhe/m^2/a$	**0,00**		**3,49**		**1,36**		**1,23**		**1,42**	
Q_{el} TOTAL **average**	$kWhe/m^2/a$	**0,00**		**3,49**		**1,36**		**1,23**		**1,42**	
Q_{el} TOTAL **warm**	$kWhe/m^2/a$	**0,00**		**3,49**		**1,36**		**1,23**		**1,42**	

6.3.3
Design Options System D / Centralized HR-unit

INPUTS		0. Reference system A (dedicated natural ventilation system)		D.0 BaseCase Centralized mechanical HR unit		D.1 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,35		D.2 BaseCase Centralized mechanical HR unit Options: η = 95%; SPI = 0,25; clock progr. Centr. HR-unit		D.3 BaseCase Centralized mechanical HR unit Options: η = 95%; SPI = 0,65; CO2-contr. VAV per hab. Room	
Type of ventilation system		A .		D BaseCase		D		D		D	
	unit	description	value	description	value	description	value	description	value	description	value
q_{ref}/m^2	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
fsys;dw	-	system A	1,25	system D	1,00	system D	1,00	system D	1,00	system D	1,00
fsys;rm		system A	1,15	system D	1,00	system D	1,00	system D	1,00	system D	1,00
feff	-	nat.driv.overfl	1,10	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00	mech.driv.overfl.	1,00
fctrl;sup	-	man.sup.grid	1,00	linked	-	linked	-	clock progr.dw.	-	CO2 cntr.VAV term	-
fctrl;exh	-	passive stack	1,00	man.switch	-	man.switch	-	man.switch	-	linked	-
fctrl	-	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	1,00	overall *f* cntr	0,80	overall *f* cntr	0,45
fduct	-	no duct	1,00	duct class B	1,10	duct class B	1,10	duct class B	1,10	duct class B	1,05
ηHR;sys	-	no HR	0,00	η HR	0,75	η HR	0,90	η HR	0,95	η HR	0,95
fη;adj;		no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00
Ref.flowrate vent.unit	m^3/h		-		175		175		175		175
SPI	$W/m^3/h$	no fan(s)	0,00	centr.HR unit	0,45	centr.HR unit	0,35	centr.HR unit	0,25	centr.HR unit	0,65
POM	W	no standby	0,00	no standby	0	no standby	0	no standby	2	standby	4
Paux;sys	W	no aux.	0,00	no aux.	0	no aux.	0	no aux.	0	4 CO2 sens	8
		Share of operating time in case multiple vent. systems are combined									
Type / share	%		n.a.		n.a		n.a.		n.a.		n.a.
Type / share	%		n.a.		n.a.		n.a.		n.a.		n.a.
MAIN OUTPUTS		System reference air exchange rates									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$q_{sys;ref}$	$m^3/m^2/h$	**2,06**	-	**1,43**		**1,43**	-	**1,14**	-	**0,61**	-
$q_{sys;ref}$ (incl.HR)	$m^3/m^2/h$	**2,06**	-	**0,36**		**0,14**	-	**0,06**	-	**0,03**	-
Ref. for calc.purps	m^2	-		*122*		*122*		*153*		*285*	
		Thermal energy content exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth **cold**	$MJ/m^2/a$	284	-	49		20	-	8	-	4	-
Qth **average**	$MJ/m^2/a$	169	-	29		12	-	5	-	3	-
Qth **warm**	$MJ/m^2/a$	78	-	14		5	-	2	-	1	-
Qgain	$MJ/m^2/a$	57	-	14		6	-	3	-	3	-
		Primary energy consumption for heating of exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth;prim GCV **cold**	$MJ/m^2/a$	**378**	-	**59**		**23**	-	**8**	-	**2**	-
Qth;prim GCV **avera.**	$MJ/m^2/a$	**188**	-	**25**		**10**	-	**3**	-	**0**	-
Qth;prim GCV **warm**	$MJ/m^2/a$	**36**	-	0		**0**	-	**0**	-	**0**	-
		Electric energy consumption									
		monovalent	comb.	monovalent		monovalent	comb.	monovalent	comb.	monovalent	comb.
Qel (SPI, POM, AUX)	$kWhe/m^2/a$	**0,00**	-	**5,64**		**4,38**	-	**2,62**	-	**3,87**	-
Qel;pr-h **cold**	$kWhe/m^2/a$	**0,00**		**2,57**		**2,57**		**2,05**		**1,10**	
Qel;pr-h **average**	$kWhe/m^2/a$	**0,00**		**0,20**		**0,20**		**0,16**		**0,09**	
Qel TOTAL **cold**	$kWhe/m^2/a$	**0,00**		**8,20**		**6,95**		**4,67**		**4,97**	
Qel TOTAL **average**	$kWhe/m^2/a$	**0,00**		**5,84**		**4,58**		**2,78**		**3,95**	
Qel TOTAL **warm**	$kWhe/m^2/a$	**0,00**		**5,64**		**4,38**		**2,62**		**3,87**	

6.3.4
Design Options System D / Room based HR-unit

INPUTS		0. Reference system A (dedicated natural ventilation system)		d.0 BaseCase Centralized mechanical HR unit		d.1 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25		d.2 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25; presence sensor per room unit		d.3 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25; CO2-sensor per room unit	
Type of ventilation system		A .		d BaseCase		d		d		d	
	unit	description	value	description	value	description	value	description	value	description	value
q_{ref}/m^2	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
fsys;dw	-	system A	1,25	system d	1,00	system d	1,00	system d	1,00	system d	1,00
fsys;rm		system A	1,15	system d	1,00	system d	1,00	system d	1,00	system d	1,00
feff	-	nat.driv.overfl	1,10	same fac.no conv	1,20	same fac.no conv	1,20	same fac.no conv	1,20	conv.airfl.	1,00
fctrl;sup	-	man.sup.grid	1,00	linked	-	linked	-	presence sens	-	CO2 sensor	-
fctrl;exh	-	passive stack	1,00	man.switch	-	man.switch	-	linked	-	linked	-
fctrl	-	overall *f* cntr	1,00	overall *f* cntr	0,90	overall *f* cntr	0,90	overall *f* cntr	0,55	overall *f* cntr	0,45
fduct	-	no duct	1,00	no duct	1,00	no duct	1,00	no duct	1,00	no duct	1,00
ηHR;sys	-	no HR	0,00	η HR	0,65	η HR	0,90	η HR	0,90	η HR	0,90
fη;adj;		no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00	no adjustment η	1,00
Ref.flowrate vent.unit	m^3/h		-		80		80		80		80
SPI	$W/m^3/h$	no fan(s)	0,00	loc.HR unit	0,35	loc.HR unit	0,25	loc.HR unit	0,25	loc.HR unit	0,25
POM	W	no standby	0,00	no standby	0	no standby	0	no standby	2	standby	2
Paux;sys	W	no aux.	0,00	no aux.	0	no aux.	0	no aux.	0	no.aux.	
		Share of operating time in case multiple vent. systems are combined									
Type / share	%		n.a.		n.a		n.a.		n.a.		n.a.
Type / share	%		n.a.		n.a.		n.a.		n.a.		n.a.
MAIN OUTPUTS		System reference air exchange rates									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
qsys;ref	$m^3/m^2/h$	**2,06**	-	**1,40**		**1,40**	-	**0,86**	-	**0,59**	-
qsys;ref (incl.HR)	$m^3/m^2/h$	**2,06**	-	**0,49**		**0,14**	-	**0,09**	-	**0,06**	-
Ref. for calc.purps	m^2	-		*57*		*57*		*93*		*137*	
		Thermal energy content exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth **cold**	$MJ/m^2/a$	284	-	68		19	-	12	-	8	-
Qth **average**	$MJ/m^2/a$	169	-	40		12	-	7	-	5	-
Qth **warm**	$MJ/m^2/a$	78	-	19		5	-	3	-	2	-
Qgain	$MJ/m^2/a$	57	-	20		6	-	6	-	6	-
		Primary energy consumption for heating of exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Qth;prim GCV **cold**	$MJ/m^2/a$	**378**	-	80		**23**	-	**10**	-	**4**	-
Qth;prim GCV **avera.**	$MJ/m^2/a$	**188**	-	**34**		**10**	-	**2**	-	**0**	-
Qth;prim GCV **warm**	$MJ/m^2/a$	**36**	-	0		**0**	-	**0**	-	**0**	-
		Electric energy consumption									
		monovalent	comb.	monovalent		monovalent	comb.	monovalent	comb.	monovalent	comb.
Qel (SPI, POM, AUX)	$kWhe/m^2/a$	**0,00**	-	**4,30**		**3,07**	-	**2,07**	-	**1,41**	-
Qel;pr-h **cold**	$kWhe/m^2/a$	**0,00**		**2,52**		**2,52**		**1,54**		**1,05**	
Qel;pr-h **average**	$kWhe/m^2/a$	**0,00**		**0,19**		**0,19**		**0,12**		**0,08**	
Qel TOTAL **cold**	$kWhe/m^2/a$	**0,00**		**6,82**		**5,59**		**3,61**		**2,46**	
Qel TOTAL **average**	$kWhe/m^2/a$	**0,00**		**4,50**		**3,27**		**2,19**		**1,49**	
Qel TOTAL **warm**	$kWhe/m^2/a$	**0,00**		**4,30**		**3,07**		**2,07**		**1,41**	

6.3.5
Design Options "Combining Systems"

INPUTS		C.2 Centralized mechanical exhaust unit+ natural supply Options:SPI = 0,10; RH sens.exh; ΔP corr. Supply grid		d.0 BaseCase Centralized mechanical HR unit		d.1 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25		d.2 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25; presence sensor per room unit		d.3 BaseCase Centralized mechanical HR unit Options: η = 90%; SPI = 0,25; CO2-sensor per room; convective airflow	
Type of ventilation system		C .		d BaseCase		d		d		d	
	unit	description	value	description	value	description	value	description	value	description	value
q_{ref}/m^2	$m^3/m^2/h$	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3	*Q ref*	1,3
AH	m^2	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1	heated surf.	1
$f_{sys;dw}$	-	system C	1,10	system d	1,00	system d	1,00	system d	1,00	system d	1,00
$f_{sys;rm}$		system C	1,10	system d	1,00	system d	1,00	system d	1,00	system d	1,00
f_{eff}	-	mech.driv.overfl	1,00	same fac.no conv	1,20	same fac.no conv	1,20	same fac.no conv	1,20	conv.airfl.	1,00
$f_{ctrl;sup}$	-	ΔP.sup.grid	0,90	man.switch	-	linked	-	presence sens	-	CO2 sensor	-
$f_{ctrl;exh}$	-	RH sens	0,90	man.switch	-	man.switch	-	linked	-	linked	-
f_{ctrl}	-	overall *f* cntr	0,81	overall *f* cntr	0,90	overall *f* cntr	0,90	overall *f* cntr	0,55	overall *f* cntr	0,45
f_{duct}	-	exh duct class B	1,10	no duct	1,00	no duct	1,00	no duct	1,00	no duct	1,00
$\eta_{HR;sys}$	-	no HR	0,00	η HR	0,65	η HR	0,90	η HR	0,90	η HR	0,90
$f_{\eta;adj;}$		no HR	1,00	no adjustment	1,00	no adjustment	1,00	no adjustment	1,00	no adjustment	1,00
Ref.flowrate vent.unit	m^3/h		56		80		80		80		80
SPI	$W/m^3/h$	fan(s)	0,10	loc..HR unit	0,35	centr.HR unit	0,25	centr.HR unit	0,25	centr.HR unit	0,25
POM	W	no standby	0,00	no standby	0	no standby	0	no standby	2	no standby	2
$P_{aux;sys}$	W	no aux.	0,00	no aux.	0	no aux.	0	no aux.	0	no aux.	0
		Share of operating time in case multiple vent. systems are combined									
Type / share	%		n.a.	d.0	50%	d.0	50%	d.0	50%	d.0	50%
Type / share	%		n.a.	C.1	50%	C.1	50%	C.1	50%	C.1	50%
MAIN OUTPUTS		System reference air exchange rates									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$q_{sys;ref}$	$m^3/m^2/h$	**1,40**	-	**1,40**	**1,40**	**1,40**	**1,40**	**0,86**	**1,13**	**0,59**	**0,99**
$q_{sys;ref}$ (incl.HR)	$m^3/m^2/h$	**1,40**	-	**0,49**	**0,95**	**0,14**	**0,77**	**0,09**	**0,74**	**0,06**	**0,73**
Ref. for calc.purps	m^2	*40*		*57*		*57*		*93*		*137*	
		Thermal energy content exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{th} **cold**	$MJ/m^2/a$	193	-	68	**131**	19	**106**	12	**103**	8	**101**
Q_{th} **average**	$MJ/m^2/a$	115	-	40	**78**	12	**63**	7	**61**	5	**60**
Q_{th} **warm**	$MJ/m^2/a$	53	-	19	**36**	5	**29**	3	**28**	2	**28**
Q_{gain}	$MJ/m^2/a$	57	-	20	**38**	6	**31**	6	**31**	6	**31**
		Primary energy consumption for heating of exchanged air									
		monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.	monovalent	comb.
$Q_{th;prim}$ GCV **cold**	$MJ/m^2/a$	**228**	-	80	**154**	**23**	**125**	**10**	**119**	**4**	**116**
$Q_{th;prim}$ GCV **avera.**	$MJ/m^2/a$	**98**	-	**34**	**66**	**10**	**54**	**2**	**50**	**0**	**48**
$Q_{th;prim}$ GCV **warm**	$MJ/m^2/a$	**0**	-	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Electric energy consumption									
		monovalent	comb.	monovalent		monovalent	comb.	monovalent	comb.	monovalent	comb.
Q_{el} (SPI, POM, AUX)	$kWhe/m^2/a$	**1,23**	-	**4,30**	**2,77**	**3,07**	**2,15**	**2,07**	**1,65**	**1,41**	**1,32**
$Q_{el;pr-h}$ **cold**	$kWhe/m^2/a$	**0,00**		**2,52**	**1,26**	**2,52**	**1,26**	**1,54**	**0,77**	**1,05**	**0,52**
$Q_{el;pr-h}$ **average**	$kWhe/m^2/a$	**0,00**		**0,19**	**0,10**	**0,19**	**0,10**	**0,12**	**0,06**	**0,08**	**0,04**
Q_{el} TOTAL **cold**	$kWhe/m^2/a$	**1,23**		**6,82**	**4,03**	**5,59**	**3,41**	**3,61**	**2,42**	**2,46**	**1,84**
Q_{el} TOTAL **average**	$kWhe/m^2/a$	**1,23**		**4,50**	**2,86**	**3,27**	**2,25**	**2,19**	**1,71**	**1,49**	**1,36**
Q_{el} TOTAL **warm**	$kWhe/m^2/a$	**1,23**		**4,30**	**2,77**	**3,07**	**2,15**	**2,07**	**1,65**	**1,41**	**1,32**

6.4 Life Cycle Costs

ANNEX 1 :
EU27 HOUSING STATISTICS

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EU Housing Characteristics 2003 (source: VHK compilation of "Housing Statistics of the European Union 2004", Boverket 2005)

				AUSTRIA	BELGIUM	BULGARIA	CYPRUS	CZECH REP	DENMARK	ESTONIA	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRELAND	ITALY
	Parameter	*unit*	**EU-27**	**A**	**B**	**BG**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**
0.	**Population 2010**	*k#*	**489.071**	8.125	10.478	7.600	858	10.201	5.449	1.236	5.285	62.527	83.094	11.085	9.593	4.326	56.759
1.	**Dwelling stock 2003**	*k#*	**215.056**	3.280	4.820	2.714	299	4.366	2.561	624	2.574	29.495	38.925	5.465	4134	1.554	26.526
	of which																
1.1	Primary (= ca. #households)	*k#*	**194.559**	3.280	4.325	2.714	239	4.216	2.481	566	2.378	24.525	38.944	3.674	3.863	1.382	22.004
1.2	Secondary	*k#*		0	495	0	60	150	80	58	196	4.970	-19	1.791	271	172	4.522
1.3	Vacant dwellings	*k#*		na	na		72	537	128	68	237	2.006	3.192	514	347	182	5.199
2.	**Age of dwelling stock**																
2.1	Year of built <1919	*%*	***15%***	19%	15%	10%	28%	11%	20%	9%	2%	20%	15%	3%	14%	10%	19%
2.2.	Year of built 1919-1945	*%*	***12%***	8%	17%	13%	7%	15%	17%	14%	9%	13%	13%	7%	13%	8%	11%
2.3	Year of built 1946-1970	*%*	***32%***	27%	29%	27%	17%	26%	28%	30%	31%	18%	47%	32%	26%	16%	41%
2.4	Year of built 1971-1980	*%*	***20%***	16%	15%	18%	21%	23%	18%	22%	23%	26%	11%	25%	22%	18%	20%
2.5	Year of built >1980	*%*	***22%***	12%	9%	19%	27%	16%	10%	20%	20%	10%	15%	19%	18%	16%	10%
	of which																
2.6	Year of built > 1990	*%*	***13%***	18%	15%	13%	15%	8%	7%	5%	14%	12%	9%	14%	7%	32%	6%
3.	**Changes building stock**																
3.1	New built per year: period > 1980	*%*	***0,96%***	*0,52%*	*0,39%*	*0,83%*	*1,17%*	*0,70%*	*0,43%*	*0,87%*	*0,87%*	*0,43%*	*0,65%*	*0,83%*	*0,78%*	*0,70%*	*0,43%*
3.2	New built per year: period > 1990	*%*	***1,00%***	*1,38%*	*1,15%*	*1,00%*	*1,15%*	*0,62%*	*0,54%*	*0,38%*	*1,08%*	*0,92%*	*0,69%*	*1,08%*	*0,54%*	*2,46%*	*0,46%*
3.3	New built 1990	*k#*	**2.169**	42	43	n.a.	8	45	27	8	65	336	319	120	44	20	176
		%	***1,01%***	*1,28%*	*0,89%*	n.a.	*2,68%*	*1,03%*	*1,05%*	*1,28%*	*2,53%*	*1,14%*	*0,82%*	*2,20%*	*1,06%*	*1,29%*	*0,66%*
3.4	New built 2003	*k#*	**2.174**	42	41	*n.a.*	6	27	24	2	28	334	268	128	22	69	178
		%	***1,01%***	*1,28%*	*0,85%*	*n.a.*	*2,01%*	*0,62%*	*0,94%*	*0,32%*	*1,09%*	*1,13%*	*0,69%*	*2,34%*	*0,53%*	*4,44%*	*0,67%*
3.6	Demolished 2003 (incompl. data)	*k#*	**133**	16	2	*n.a.*	0	2	8	1	3	21	22	n.a.	5	11	n.a.
		%	**0,062%**	0,488%	0,041%	*n.a.*	0,000%	0,046%	0,312%	0,160%	0,117%	0,071%	0,057%	*n.a.*	0,121%	0,708%	*n.a.*
4.	**Type of dwellings**																
4.1	One & two family dwellings	*%*	**54%**	48%	75%	37%	54%	44%	61%	32%	42%	57%	46%	59%	66%	91%	25%
4.2	Multi family dwellings	*%*	**46%**	52%	25%	63%	46%	57%	39%	68%	58%	43%	54%	41%	34%	9%	75%
	of which																
4.3	high-rise > storeys	*%*	**16%**	18%	4%	39%	16%	34%	10%	*27%*	*21%*	16%	6%	*14%*	23%	*2%*	23%
4.4	Floor area per dwelling (stock)	*m2*	**87**	94	86		145	76	109	60	77	90	90	83	75	104	90
4.5	Floor area per dwelling (new built)	*m2*	**103**	101	119		198	105	112	89	90	113	114	125	94	105	82
4.6	Floor area per person (pr. stock)	*m2*	**35**	38	36		48	29	51	28	36	38	40	30	28	35	35
4.7	nr. of rooms per dwelling (stock)	*#*	**4,0**	4,1	4,3		5,4	2,9	3,8	3,6	3,6	4,0	4,4	3,8	n.a.	5,6	4,1
4.8	nr. of rooms per dwelling (new built)	*#*	**4,5**	3,5	5,8		6,1	3,9	3,4	4,0	3,8	3,9	5,1	3,1	4,0	5,6	3,8
4.9	Persons per household (stock)	*#*	**2,5**	**2,5**	**2,4**	**2,8**	**3,6**	**2,4**	**2,2**	**2,2**	**2,2**	**2,5**	**2,1**	**3,0**	**2,5**	**3,1**	**2,6**

Figures in grey were not available from Boverket and therefor estimated

EU Housing Characteristics 2003 (source: VHK compilation of "Housing Statistics of the European Union 2004", Boverket 2005)

				LATVIA	LITHUANIA	LUXEMB.	MALTA	NETHERL.	POLAND	PORTUGAL	ROMANIA	SLOVAKIA	SLOVENIA	SPAIN	SWEDEN	UNITED K.
	Parameter	*unit*	**EU-27**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**RO**	**SK**	**SLO**	**E**	**S**	**UK**
0.	**Population 2010**	*k#*	**489.071**	2.184	3.339	497	406	16.733	38.553	10.129	21.500	5.457	1.965	41.774	9.014	60.904
1.	**Dwelling stock 2003**	*k#*	**215.056**	967	1.292	176	127	6.811	11.764	5.318	7.679	1.885	785	20.947	4.351	25.617
	of which															
1.1	Primary (= ca. #households)	*k#*	**194.559**	915	1.346	171	129	6.996	13.337	3.651	7.679	2.072	685	14.187	4.454	24.346
1.2	Secondary	*k#*		52	-54	5	-2	-185	-1.573	1.667	0	-187	100	6.760	-103	1.271
1.3	Vacant dwellings	*k#*		58	48	4	na	150	623	564		219	79	2.912	74	871
2.	**Age of dwelling stock**															
2.1	Year of built <1919	*%*	***15%***	11%	6%	12%	15%	7%	10%	6%	10%	3%	15%	9%	12%	21%
2.2.	Year of built 1919-1945	*%*	***12%***	14%	23%	15%	11%	13%	13%	9%	13%	7%	8%	4%	20%	18%
2.3	Year of built 1946-1970	*%*	***32%***	28%	33%	27%	29%	31%	27%	23%	27%	35%	28%	34%	33%	21%
2.4	Year of built 1971-1980	*%*	***20%***	23%	18%	15%	17%	19%	18%	18%	18%	26%	24%	24%	17%	22%
2.5	Year of built >1980	*%*	***22%***	21%	14%	12%	16%	30%	19%	44%	19%	21%	16%	14%	10%	19%
	of which															
2.6	Year of built > 1990	*%*	***13%***	4%	6%	17%	12%	17%	13%	25%	13%	7%	9%	16%	7%	11%
3.	**Changes building stock**															
3.1	New built per year: period > 1980	*%*	***0,96%***	*0,91%*	*0,61%*	*0,52%*	*0,70%*	*1,30%*	*0,83%*	*1,91%*	*0,83%*	*0,91%*	*0,70%*	*0,61%*	*0,43%*	*0,83%*
3.2	New built per year: period > 1990	*%*	***1,00%***	*0,31%*	*0,46%*	*1,31%*	*0,92%*	*1,31%*	*1,00%*	*1,92%*	*1,00%*	*0,54%*	*0,69%*	*1,23%*	*0,54%*	*0,85%*
3.3	New built 1990	*k#*	**2.169**	13	22	3	n.a.	101	134	66	*n.a.*	25	8	281	58	205
		%	***1,01%***	*1,34%*	*1,70%*	*1,70%*	n.a.	*1,48%*	*1,14%*	*1,24%*	*n.a.*	*1,33%*	*1,02%*	*1,34%*	*1,33%*	*0,80%*
3.4	New built 2003	*k#*	**2.174**	1	5	2	n.a.	60	163	82	*n.a.*	14	7	459	24	190
		%	***1,01%***	*0,10%*	*0,39%*	*1,14%*	*n.a.*	*0,88%*	*1,39%*	*1,54%*	*n.a.*	*0,74%*	*0,89%*	*2,19%*	*0,55%*	*0,74%*
3.6	Demolished 2003 (incompl. data)	*k#*	**133**	3	0	*n.a.*	*n.a.*	18	5	1	*n.a.*	1	0	16	2	15
		%	**0,062%**	0,310%	0,000%	*n.a.*	*n.a.*	0,264%	0,043%	0,019%	*n.a.*	0,053%	0,000%	0,076%	0,046%	0,059%
4.	**Type of dwellings**															
4.1	One & two family dwellings	*%*	**54%**	29%	39%	71%	*54%*	69%	37%	77%	*37%*	49%	72%	53%	48%	81%
4.2	Multi family dwellings	*%*	**46%**	71%	61%	29%	*46%*	31%	63%	23%	*63%*	52%	28%	48%	52%	19%
	of which															
4.3	high-rise > storeys	*%*	**16%**	*23%*	*23%*	16%	*16%*	7%	39%	22%	*39%*	38%	12%	31%	*10%*	2%
4.4	Floor area per dwelling (stock)	*m2*	**87**	55	61	125	106	98	68	83	n.a.	56	75	90	92	87
4.5	Floor area per dwelling (new built)	*m2*	**103**	194	106	120	106	116	99	89	n.a.	118	114	96	128	83
4.6	Floor area per person (pr. stock)	*m2*	**35**	24	23	50	34	41	22	30	n.a.	26	30	31	44	44
4.7	nr. of rooms per dwelling (stock)	*#*	**4,0**	2,4	2,5	5,5	n.a.	4,2	3,7	4,3	n.a.	3,2	2,8	5,0	4,2	4,7
4.8	nr. of rooms per dwelling (new built)	*#*	**4,5**	4,3	3,5	5,2		3,9	4,2	4,9		3,1	3,4	5,4	4,2	4,5
4.9	Persons per household (stock)	*#*	**2,5**	**2,4**	**2,5**	**2,9**	**3,1**	**2,4**	**2,9**	**2,8**	**2,8**	**2,6**	**2,9**	**2,9**	**2,0**	**2,5**

Figures in grey were not available from Boverket and therefor estimated

ANNEX 2 :
EU27 STOCK OF RESIDENTIAL VENTILATION SYSTEMS

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Stock of Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

				AUSTRIA	BELGIUM	BULGARIA	CYPRUS	CZECH REP.	DENMARK	ESTONIA	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRELAND	ITALY
Parameter		*unit*	**EU-25**	**A**	**B**	**BG**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**
0. Population 2010		k#	**489.071**	8.125	10.478	7.600	858	10.201	5.449	1.236	5.285	62.527	83.094	11.085	9.593	4.326	56.759
1. Dwelling stock 2003		k#	**215.056**	3.280	4.820	2.714	299	4.366	2.561	624	2.574	29.495	38.925	5.465	4134	1.554	26.526
of which																	
1.1 Primary (= ca. #households)		k#	**194.559**	3.280	4.325	2.714	239	4.216	2.481	566	2.378	24.525	38.944	3.674	3.863	1.382	22.004
1.2 Secondary		k#		0	495	0	60	150	80	58	196	4.970	-19	1.791	271	172	4.522
1.3 Vacant dwellings		k#		na	na		72	537	128	68	237	2.006	3.192	514	347	182	5.199
2. Basis for Estimates on Stock Ventilation Systems	assumptions																
2.0 Stock of primary Residential Dwellings: LOT 10 scope: TOTAL		k#	**163.429**	2.690	4.152	1.656	201	2.825	2.233	413	1.879	20.601	36.607	3.160	2.975	1.354	16.943
1 & 2 family dwellings		k#	**105.062**	1.574	3.244	1.004	129	1.855	1.513	181	999	13.979	17.914	2.168	2.550	1.258	5.501
Multi family dwelling (excluded high rise (>4 st.) buildings		k#	**58.368**	1.115	908	651	72	970	719	232	880	6.622	18.693	992	425	97	11.442
of which																	
2.1 Dwellings fully relying on airing& infiltr. (no dedicated.vent.syst)	dw. < 1970	%	**59%**	54%	61%	50%	52%	52%	65%	53%	42%	51%	75%	42%	53%	34%	71%
2.1.1 - of which later installed partial mech.exh.ventilation	**30%**	%	**18%**	16%	18%	15%	16%	16%	20%	16%	13%	15%	23%	13%	16%	10%	21%
2.2 Dwellings with dedicated air exhaust & supply provisions	dw. >1970	%	**46%**	52%	25%	63%	46%	56%	39%	68%	58%	43%	54%	41%	34%	9%	75%
of which																	
2.2.1 Dwellings with nat.supply & exhaust (syst. A) : TOTAL		%	**24%**	21%	17%	25%	25%	28%	21%	29%	28%	29%	17%	27%	24%	17%	28%
a. - all dwellings built between 1970-1980	1970-1980	%	**20%**	**16%**	**15%**	**18%**	**21%**	**23%**	**18%**	**22%**	**23%**	**26%**	**11%**	**25%**	**22%**	**18%**	**20%**
b. - per MS a fraction of the dwellinsg built > 1980	**15%**	%	**4%**	**5%**	**2%**	**7%**	**4%**	**5%**	**3%**	**7%**	**5%**	**3%**	**6%**	**2%**	**2%**	**-1%**	**8%**
2.2.2 Dwellings with mech. supply & nat. exhaust (syst. B): TOTAL		%	**0%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
- only in some MS fraction of dwellings > 1980	to be determ.	%	**0%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2.2.3 Dwellings with nat.supply & mech.exhaust (syst. C): TOTAL		%	**16,9%**	22,9%	22,5%	25,3%	23,3%	20,1%	13,0%	17,9%	26,7%	20,3%	7,4%	30,6%	23,2%	48,8%	0,7%
a. - of which local exhaust	to be determ.	%		20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	3,0%	20,0%	20,0%	20,0%	20,0%	20,0%
b. - of which centralized mechanical exhaust	to be determ.	%		80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	97,0%	80,0%	80,0%	80,0%	80,0%	80,0%
2.2.4 Dwellings with mech.supply & mech. exhaust (syst. D): TOTAL		%	**0,2%**	**1,7%**	**0,0%**	**0,0%**	**0,0%**	**0,0%**	**0,9%**	**0,2%**	**3,0%**	**0,1%**	**0,1%**	**0,0%**	**0,0%**	**0,6%**	**0,0%**
- estimated av. percentage of newly built in 1995-2003		%	**3%**	15%	0%	0%	0%	0%	20%	5%	35%	2%	2%	0%	0%	3%	1%
a. - of which centralized supply & exhaust with HR	to be determ.	%		95%	98%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
b. - of which local supply & exhaust with HR	to be determ.	%		3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
c. - of which supply & exhaust without HR	to be determ.	%		2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
3. Stock of Residential Ventilation systems (LOT10 Scope)																	
3.1 Dwellings without dedicated supply- and exhaust provisions (i.e. fully depending on airing and infiltration)		k#	**67.654**	1.017	1.773	580	73	1.028	1.016	153	552	7.355	19.219	929	1.104	322	8.421
3.2 Dwellings like 3.1 provided with retrofit exhaust provisoins		k#	**28.994**	436	760	248	31	441	435	66	237	3.152	8.237	398	473	138	3.609
3.2.1 *Related number of fans if av. installed number is:*	**1,6**	k#	***46.391***	*697*	*1.216*	*397*	*50*	*705*	*697*	*105*	*379*	*5.043*	*13.179*	*637*	*757*	*221*	*5.774*
3.3 Dwellings with nat.supply and exhaust provisions/ System A		k#	**37.357**	576	685	410	50	790	472	119	531	5.882	6.388	866	708	226	4.786
3.4 Dwellings with mech supply and nat. Exhaust provisoins / System B		k#	**716**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5 Dwellings with nat.supply and mech.exhaust / System C		k#	**26.389**	617	934	418	47	566	290	74	502	4.182	2.723	967	690	660	121
3.5.1 *Number of centr.extract fans based on assump 2.2.3.b*		k#	**21.822**	494	747	334	37	453	232	59	402	4.057	2.179	773	552	528	97
3.5.2 *Number of local extract fans based on assump 2.2.3.a*		k#	**11.874**	321	486	217	24	295	151	39	261	326	1.416	503	359	343	63
and on assumpt that average installed number is:	**2,6**																
3.6 Dwellings with mech.supply and exhaust / System D		k#	**451**	45	0	0	0	0	19	1	57	30	41	0	0	8	6
3.6.1 *Number of centr. HR-units based on assump 2.2.4.a*		k#	**428**	42	0	0	0	0	18	1	54	29	39	0	0	8	6
3.6.2 *Number of local HR-units based on assump 2.2.4.b*		k#	**16**	2	0	0	0	0	1	0	2	1	1	0	0	0	0
- and on assumpt that average installed number is:	**1,2**																
3.6.3 *Remaining mech. units without HR assuming 2.2.4.c*		k#	**27**	2,68	0,00	0,00	0,00	0,00	1,15	0,04	3,40	1,83	2,43	0,00	0,00	0,48	0,38
- and assuming that average installed number is:	**3**																

Figures in blue bold are parameters that can be changed to fine-tune the calculation model
Figures in green relate to the number of installed mechanical ventilation units

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Stock of Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

				LATVIA	LITHUANIA	LUXEMB.	MALTA	NETHERL.	POLAND	PORTUGAL	ROMANIA	SLOVAKIA	SLOVENIA	SPAIN	SWEDEN	UNITED K.
Parameter		*unit*	**EU-25**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**RO**	**SK**	**SLO**	**E**	**S**	**UK**
0. Population 2010		k#	**489.071**	2.184	3.339	497	406	16.733	38.553	10.129	21.500	5.457	1.965	41.774	9.014	60.904
1. Dwelling stock 2003		k#	**215.056**	967	1.292	176	127	6.811	11.764	5.318	7.679	1.885	785	20.947	4.351	25.617
of which																
1.1 Primary (= ca. #households)		k#	**194.559**	915	1.346	171	129	6.996	13.337	3.651	7.679	2.072	685	14.187	4.454	24.346
1.2 Secondary		k#		52	-54	5	-2	-185	-1.573	1.667	0	-187	100	6.760	-103	1.271
1.3 Vacant dwellings		k#		58	48	4	na	150	623	564		219	79	2.912	74	871
2. Basis for Estimates on Stock Ventilation Systems	assumptions															
2.0 Stock of primary Residential Dwellings: LOT 10 scope: TOTAL		k#	**163.429**	705	1.036	144	108	6.506	8.136	2.848	4.684	1.305	603	9.931	4.009	23.859
1 & 2 family dwellings		k#	**105.062**	265	525	121	70	4.827	4.935	2.811	2.841	1.015	493	7.519	2.138	19.720
Multi family dwelling (excluded high rise (>4 st.) buildings		k#	**58.368**	439	511	22	39	1.679	3.201	37	1.843	290	110	2.412	1.871	4.139
of which																
2.1 Dwellings fully relying on airing& infiltr. (no dedicated.vent.syst)	dw. < 1970	%	**59%**	53%	62%	54%	55%	51%	50%	38%	50%	45%	51%	47%	65%	60%
2.1.1 - of which later installed partial mech.exh.ventilation	**30%**	%	**18%**	16%	19%	16%	17%	15%	15%	11%	15%	14%	15%	14%	20%	18%
2.2 Dwellings with dedicated air exhaust & supply provisions	dw. >1970	%	**46%**	71%	61%	29%	46%	31%	63%	23%	63%	51%	28%	47%	52%	19%
of which																
2.2.1 Dwellings with nat.supply & exhaust (syst. A) : TOTAL		%	**24%**	30%	24%	17%	21%	21%	25%	19%	25%	30%	25%	27%	22%	22%
a. - all dwellings built between 1970-1980	1970-1980	%	**20%**	**23%**	**18%**	**15%**	**17%**	**19%**	**18%**	**18%**	**18%**	**26%**	**24%**	**24%**	**17%**	**22%**
b. - per MS a fraction of the dwellinsg built > 1980	**15%**	%	**4%**	**7%**	**6%**	**2%**	**4%**	**2%**	**7%**	**1%**	**7%**	**4%**	**1%**	**3%**	**5%**	**0%**
2.2.2 Dwellings with mech. supply & nat. exhaust (syst. B): TOTAL		%	**0%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
- only in some MS fraction of dwellings > 1980	to be determ.	%	**0%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%
2.2.3 Dwellings with nat.supply & mech.exhaust (syst. C): TOTAL		%	**16,9%**	16,8%	13,6%	28,8%	23,7%	26,1%	25,2%	43,3%	25,3%	25,2%	24,4%	25,6%	11,5%	15,2%
a. - of which local exhaust	to be determ.	%		20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%	20,0%
b. - of which centralized mechanical exhaust	to be determ.	%		80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%	80,0%
2.2.4 Dwellings with mech.supply & mech. exhaust (syst. D): TOTAL		%	**0,2%**	**0,0%**	**0,0%**	**0,1%**	**0,0%**	**2,1%**	**0,1%**	**0,0%**	**0,0%**	**0,1%**	**0,0%**	**0,0%**	**1,3%**	**0,2%**
- estimated av. percentage of newly built in 1995-2003		%	**3%**	0%	0%	1%	0%	20%	1%	0%	0%	2%	0%	0%	30%	3%
a. - of which centralized supply & exhaust with HR	to be determ.	%		95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
b. - of which local supply & exhaust with HR	to be determ.	%		3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
c. - of which supply & exhaust without HR	to be determ.	%		2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
3. Stock of Residential Ventilation systems (LOT10 Scope)																
3.1 Dwellings without dedicated supply- and exhaust provisions (i.e. fully depending on airing and infiltration)		k#	**67.654**	261	450	54	42	2.323	2.847	758	1.639	411	215	3.267	1.824	10.021
3.2 Dwellings like 3.1 provided with retrofit exhaust provisoins		k#	**28.994**	112	193	23	18	995	1.220	325	703	176	92	1.400	782	4.295
3.2.1 *Related number of fans if av. installed number is:*	**1,6**	k#	***46.391***	*179*	*308*	*37*	*29*	*1.593*	*1.953*	*519*	*1.124*	*282*	*148*	*2.240*	*1.251*	*6.871*
3.3 Dwellings with nat.supply and exhaust provisions/ System A		k#	**37.357**	213	253	25	23	1.353	2.014	534	1.159	388	148	2.726	892	5.142
3.4 Dwellings with mech supply and nat. Exhaust provisoins / System B		k#	**716**	0	0	0	0	0	0	0	0	0	0	0	0	716
3.5 Dwellings with nat.supply and mech.exhaust / System C		k#	**26.389**	118	140	41	26	1.699	2.048	1.232	1.183	328	147	2.537	459	3.638
3.5.1 *Number of centr.extract fans based on assump 2.2.3.b*		k#	**21.822**	95	112	33	21	1.359	1.638	985	946	263	118	2.030	367	2.910
3.5.2 *Number of local extract fans based on assump 2.2.3.a*		k#	**11.874**	62	73	22	13	883	1.065	640	615	171	76	1.319	239	1.892
and on assumpt that average installed number is:	**2,6**															
3.6 Dwellings with mech.supply and exhaust / System D		k#	**451**	0	0	0	0	136	7	0	0	1	0	0	52	48
3.6.1 *Number of centr. HR-units based on assump 2.2.4.a*		k#	**428**	0	0	0	0	129	6	0	0	1	0	0	49	46
3.6.2 *Number of local HR-units based on assump 2.2.4.b*		k#	**16**	0	0	0	0	5	0	0	0	0	0	0	2	2
- and on assumpt that average installed number is:	**1,2**															
3.6.3 *Remaining mech. units without HR assuming 2.2.4.c*		k#	**27**	0,00	0,00	0,01	0,00	8,17	0,39	0,00	0,00	0,07	0,00	0,00	3,11	2,91
- and assuming that average installed number is:	**3**															

Figures in blue bold are parameters that can be changed to fine-tune the calculation model

Figures in green relate to the number of installed mechanical ventilation units

APPENDIX 3 :
ESTIMATED MARKET SIZE RESIDENTIAL MECHANICAL VENTILATION UNITS

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Assumption for determining Market Size / 1

Estimated 2003 Market Size Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

				AUSTRIA	BELGIUM	BULGARIA	CYPRUS	CZECH R.	DENMARK	ESTONIA	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRELAND	ITALY
Explanation		*unit*	**EU-27**	**A**	**B**	**BG**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**
Overall life time mechanical ventilation unit		*yr*	**17**														
ASSUMPTIONS																	
ASSUMPTIONS NEW BUILT																	
Average number of new built primary dwellings per year		*k#/yr*	**1.689**	45	50	27	3	26	13	2	26	226	270	40	21	34	102
ASSUMPTIONS 2003 SHARE OF VENTILATION SYSTEMS IN NEW BUILT																	
Estimated share of dwelling with nat.supply & exhaust		%	**1%**	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%	1%
Estimated share of dwellings with mech.supply or exhaust		%	**93%**	**79%**	**94%**	**97%**	**99%**	**97%**	**69%**	**89%**	**50%**	**97%**	**94%**	**98%**	**97%**	**94%**	**97%**
- of which centralized units		%	***90%***	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*
- of which room based (local) units *with average installed number of vent. units*	**2,6**	%	***10%***	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*
Estimated share of dwellings with mech.supply and exhaust		%	**6%**	20%	5%	2%	0%	2%	30%	10%	50%	2%	5%	1%	2%	5%	2%
- of which centralized units with HR		%	***93%***	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*
- of which room based (local) units with HR *with average installed number of vent. units*	**2,0**	%	***5%***	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*
- of which mechanical units without HR *with average installed number of vent. units*	**3,0**	%	***2%***	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*

ASSUMPTIONS RENOVATION

Dwellings that are submitted to major renovation (double glazing, insulation, improved air-tightness) need dedicated and energy efficient ventilation systems. All in all the share of the building stock without or with primitive ventilation systems is around 80% (150 million dwelling). Only a small part of this potential is adressed, mainly because the necessity for this air-exchange need is not recognised and ventilation is a "low interest" phenomena in residential dwellings. For this renovation segment, both the potential and the actual renovation market is estimated.

Explanation		*unit*	**EU-27**	**A**	**B**	**BG**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**
POTENTIAL RENOVATION MARKET																	
Perc. of existing housing stock with first time installation each year		%	**3%**														
Dwelling stock without- or with primitive ventilation systems		*k#/yr*	**152.161**	2.296	3.287	1.846	174	3.162	2.059	425	1.546	18.884	33.492	2.462	2.897	719	20.024
Number of dwelling when …% of this stock is renovated			**4.565**	69	99	55	5	95	62	13	46	567	1005	74	87	22	601
Estimated share of dwellings with mech.supply or exhaust			**76%**	75%	75%	75%	75%	75%	75%	75%	60%	85%	75%	75%	75%	75%	75%
- of which centralized units		%	**30%**	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
- of which room based (local) units *with average installed number of vent. units*	**2,6**	%	**70%**	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Estimated share of dwellings with mech.supply and exhaust		%	**24%**	25%	25%	25%	25%	25%	25%	25%	40%	15%	25%	25%	25%	25%	25%
- of which centralized units with HR		%	**30%**	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
- of which room based (local) units with HR *with average installed number of vent. units*	**2,0**	%	**60%**	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
- of which mechanical units without HR *with average installed number of vent. units*	**3,0**	%	**10%**	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
ACTUAL MARKET SIZE																	
Perc. of existing housing stock with first time installation each year		%	**0,05%**														

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Assumptions for determining Market Size / 2

Estimated 2003 Market Size Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

			LATVIA	LITHUANIA	LUXEMB.	MALTA	NETHERL.	POLAND	PORTUGAL	ROMANIA	SLOVAKIA	SLOVENIA	SPAIN	SWEDEN	UNITED K.
Explanation	*unit*	**EU-27**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**RO**	**SK**	**SLO**	**E**	**S**	**UK**
Overall life time mechanical ventilation unit	*yr*	**17**													
ASSUMPTIONS															
ASSUMPTIONS NEW BUILT															
Average number of new built primary dwellings per year	*k#/yr*	**1.689**	3	6	2	1	91	133	70	77	11	5	175	24	206
ASSUMPTIONS 2003 SHARE OF VENTILATION SYSTEMS IN NEW BUILT															
Estimated share of dwelling with nat.supply & exhaust	%	**1%**	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Estimated share of dwellings with mech.supply or exhaust	%	**93%**	**97%**	**97%**	**97%**	**99%**	**74%**	**97%**	**99%**	**99%**	**97%**	**97%**	**99%**	**64%**	**92%**
- of which centralized units	%	***90%***	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*	*90%*
- of which room based (local) units *with average installed number of vent. units* **2,6**	%	***10%***	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*	*10%*
Estimated share of dwellings with mech.supply and exhaust	%	**6%**	2%	2%	2%	0%	25%	2%	0%	0%	2%	2%	0%	35%	7%
- of which centralized units with HR	%	***93%***	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*	*93%*
- of which room based (local) units with HR *with average installed number of vent. units* **2,0**	%	***5%***	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*	*5%*
- of which mechanical units without HR *with average installed number of vent. units* **3,0**	%	***2%***	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*

ASSUMPTIONS RENOVATION

Dwellings that are submitted to major renovation (double glazing, insulation, improved air-tightness) need dedicated and energy efficient ventilation systems. All in all the share of the building stock without or with primitive ventilation systems is around 80% (150 million dwelling). Only a small part of this potential is adressed, mainly because the necessity for this air-exchange need is not recognised and ventilation is a "low interest" phenomena in residential dwellings. For this renovation segment, both the potential and the actual renovation market is estimated.

Explanation	unit	EU-27	LT	LIT	LUX	MT	NL	PL	P	RO	SK	SLO	E	S	UK
POTENTIAL RENOVATION MARKET															
Perc. of existing housing stock with first time installation each year	%	**3%**													
Dwelling stock without- or with primitive ventilation systems	*k#/yr*	**152.161**	695	1.077	118	93	4.897	9.069	2.045	5.221	1.471	514	10.073	3.652	19.964
Number of dwelling when ...% of this stock is renovated		**4.565**	21	32	4	3	147	272	61	157	44	15	302	110	599
Estimated share of dwellings with mech.supply or exhaust		**76%**	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
- of which centralized units	%	**30%**	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
- of which room based (local) units *with average installed number of vent. units* **2,6**	%	**70%**	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Estimated share of dwellings with mech.supply and exhaust	%	**24%**	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
- of which centralized units with HR	%	**30%**	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
- of which room based (local) units with HR *with average installed number of vent. units* **2,0**	%	**60%**	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
- of which mechanical units without HR *with average installed number of vent. units* **3,0**	%	**10%**	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
ACTUAL MARKET SIZE															
Perc. of existing housing stock with first time installation each year	%	**0,05%**													

Estimate Market Size /1

Estimated 2003 Market Size Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

			AUSTRIA	BELGIUM	BULGARIA	CYPRUS	CZECH R.	DENMARK	ESTONIA	FINLAND	FRANCE	GERMANY	GREECE	HUNGARY	IRELAND	ITALY
Explanation	*unit*	**EU-27**	**A**	**B**	**BG**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**
CALCULATED MARKET SIZE BASED ON THE ABOVE ASSUMPTIONS																
Market Size New Built																
1. New built market for room based mech.ventilation units	*k#/yr*	**409**	9	12	7	1	7	2	1	3	57	66	10	5	8	26
2. New built market for centralized mech.ventilation units	*k#/yr*	**1.414**	32	42	24	2	23	8	2	12	198	228	35	18	29	89
3. New built market for centralized mech.ventilation units with HR	*k#/yr*	**94**	8	2	1	0	0	4	0	12	4	13	0	0	2	2
4. New built market for room based mech.ventilation units with HR	*k#/yr*	**10**	1	0	0	0	0	0	0	1	0	1	0	0	0	0
5. New built market for mech. supply&exhaust units without HR	*k#/yr*	**6**	1	0	0	0	0	0	0	1	0	1	0	0	0	0
TOTAL MARKET SIZE NEW BUILT	*k#/yr*	**1.933**														
Market Size Replacement (like for like)																
1. Replacement market room based mech. ventilation units (derived from stock figures divided by life time)	*k#/yr*	**3.469**	60	100	36	4	59	50	8	38	316	859	67	66	33	343
2. Replacement market centralized mech. ventilation units (derived from stock figures divided by life time)	*k#/yr*	**1.284**	29	44	20	2	27	14	3	24	239	128	45	32	31	6
3. Replacement market mech. ventilation units with HR (no significatnt replacements yet: < 15 yr)	*k#/yr*	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MARKET SIZE REPLACEMENT	*k#/yr*	**4.753**														
Market Size Renovation when first-time installation factor = 0,02%																
1. Renovation market for room based mech.ventilation units (exh (& sup))	*k#/yr*	**105**	2	2	1	0	2	1	0	1	15	23	2	2	0	14
2. Renovation market for centralized mech.ventilation units (exh (& sup))	*k#/yr*	**17**	0	0	0	0	0	0	0	0	2	4	0	0	0	2
3. Renovation market for centralized mech.ventilation units with HR	*k#/yr*	**5**	0	0	0	0	0	0	0	0	0	1	0	0	0	1
4. Renovation market for room based mech.ventilation units with HR	*k#/yr*	**22**	0	0	0	0	0	0	0	0	2	5	0	0	0	3
5. Renovation market for mech. supply&exhaust units without HR	*k#/yr*	**5**	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTAL MARKET SIZE RENOVATION	*k#/yr*	**155**														
TOTAL MARKET MECHANICAL VENTILATION UNITS 2003		**6.841**														

Figures in blue are parameters that can be changed

Potental Size Renovation Market when first-time installation factor = 3% (at shares per product according table Assumptions Renovation)																
1. Renovation market for room based mech.ventilation units (exh (& sup))	*k#/yr*	**6.321**	94	135	76	7	129	84	17	51	876	1.371	101	119	29	820
2. Renovation market for centralized mech.ventilation units (exh (& sup))	*k#/yr*	**1.042**	15	22	12	1	21	14	3	8	144	226	17	20	5	135
3. Renovation market for centralized mech.ventilation units with HR	*k#/yr*	**327**	5	7	4	0	7	5	1	6	25	75	6	7	2	45
4. Renovation market for room based mech.ventilation units with HR	*k#/yr*	**1.310**	21	30	17	2	28	19	4	22	102	301	22	26	6	180
5. Renovation market for mech. supply&exhaust units without HR	*k#/yr*	**327**	5	7	4	0	7	5	1	6	25	75	6	7	2	45
TOTAL MARKET SIZE RENOVATION	*k#/yr*	**9.328**														

Estimate Market Size /2

Estimated 2003 Market Size Residential Ventilation Systems (source: VHK compilation based on housing statistics and annecdotal market data)

			LATVIA	LITHUANIA	LUXEMB.	MALTA	NETHERL.	POLAND	PORTUGAL	ROMANIA	SLOVAKIA	SLOVENIA	SPAIN	SWEDEN	UNITED K.
Explanation	*unit*	**EU-27**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**RO**	**SK**	**SLO**	**E**	**S**	**UK**
CALCULATED MARKET SIZE BASED ON THE ABOVE ASSUMPTIONS															
Market Size New Built															
1. New built market for room based mech.ventilation units	*k#/yr*	**409**	1	2	1	0	18	34	18	20	3	1	45	4	49
2. New built market for centralized mech.ventilation units	*k#/yr*	**1.414**	2	5	2	1	61	116	63	68	10	4	156	14	171
3. New built market for centralized mech.ventilation units with HR	*k#/yr*	**94**	0	0	0	0	21	2	0	0	0	0	0	8	13
4. New built market for room based mech.ventilation units with HR	*k#/yr*	**10**	0	0	0	0	2	0	0	0	0	0	0	1	1
5. New built market for mech. supply&exhaust units without HR	*k#/yr*	**6**	0	0	0	0	1	0	0	0	0	0	0	1	1
TOTAL MARKET SIZE NEW BUILT	*k#/yr*	**1.933**													
Market Size Replacement (like for like)															
1. Replacement market room based mech. ventilation units (derived from stock figures divided by life time)	*k#/yr*	**3.469**	14	22	3	2	146	177	68	102	27	13	209	88	558
2. Replacement market centralized mech. ventilation units (derived from stock figures divided by life time)	*k#/yr*	**1.284**	6	7	2	1	80	96	58	56	15	7	119	22	171
3. Replacement market mech. ventilation units with HR (no significatnt replacements yet: < 15 yr)	*k#/yr*	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MARKET SIZE REPLACEMENT	*k#/yr*	**4.753**													
Market Size Renovation when first-time installation factor = 0,02%															
1. Renovation market for room based mech.ventilation units (exh (& sup))	*k#/yr*	**105**	0	1	0	0	3	6	1	4	1	0	7	2	14
2. Renovation market for centralized mech.ventilation units (exh (& sup))	*k#/yr*	**17**	0	0	0	0	1	1	0	1	0	0	1	0	2
3. Renovation market for centralized mech.ventilation units with HR	*k#/yr*	**5**	0	0	0	0	0	0	0	0	0	0	0	0	1
4. Renovation market for room based mech.ventilation units with HR	*k#/yr*	**22**	0	0	0	0	1	1	0	1	0	0	2	1	3
5. Renovation market for mech. supply&exhaust units without HR	*k#/yr*	**5**	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL MARKET SIZE RENOVATION	*k#/yr*	**155**													
TOTAL MARKET MECHANICAL VENTILATION UNITS 2003		**6.841**													

Figures in blue are parameters that can be changed

Potental Size Renovation Market when first-time installation factor = 3% (at shares per product according table Assumptions Renovation)

1. Renovation market for room based mech.ventilation units (exh (& sup))	*k#/yr*	**6.321**	28	44	5	4	201	371	84	214	60	21	412	150	818
2. Renovation market for centralized mech.ventilation units (exh (& sup))	*k#/yr*	**1.042**	5	7	1	1	33	61	14	35	10	3	68	25	135
3. Renovation market for centralized mech.ventilation units with HR	*k#/yr*	**327**	2	2	0	0	11	20	5	12	3	1	23	8	45
4. Renovation market for room based mech.ventilation units with HR	*k#/yr*	**1.310**	6	10	1	1	44	82	18	47	13	5	91	33	180
5. Renovation market for mech. supply&exhaust units without HR	*k#/yr*	**327**	2	2	0	0	11	20	5	12	3	1	23	8	45
TOTAL MARKET SIZE RENOVATION	*k#/yr*	**9.328**													

APPENDIX 4 :
ECOREPORTS BASECASES

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Appendix 4.1 : EcoReport Room based mechanical exhaust unit

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: **RESULTS**
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average)

Nr	Life cycle Impact per product:	Date	Author
0	Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average)	0	vhk

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**235**			212	24	**235**	**0**
2	TecPlastics	g			**110**			99	11	**110**	**0**
3	Ferro	g			**560**			28	532	**560**	**0**
4	Non-ferro	g			**70**			4	67	**70**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**25**			25	0	**25**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**1000**			367	633	**1000**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	79	25	**104**	**54**	**93792**	25	17	**8**	**93957**
9	of which, electricity (in primary MJ)	MJ	19	15	**34**	**0**	**3124**	0	0	**0**	**3158**
10	Water (process)	ltr	16	0	**16**	**0**	**208**	0	0	**0**	**224**
11	Water (cooling)	ltr	25	7	31	0	8330	0	1	-1	8361
12	Waste, non-haz./ landfill	g	1950	99	**2049**	**52**	**3642**	61	1	**61**	**5804**
13	Waste, hazardous/ incinerated	g	18	0	**18**	**1**	**72**	311	0	**310**	**402**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	4	1	**6**	**5**	**5149**	2	1	**1**	**5160**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	33	6	**39**	**12**	**2265**	4	2	**2**	**2318**
17	Volatile Organic Compounds (VOC)	g	0	0	**0**	**0**	**67**	0	0	**0**	**68**
18	Persistent Organic Pollutants (POP)	ng i-Teq	15	2	**17**	**0**	**21**	0	0	**0**	**38**
19	Heavy Metals	mg Ni eq.	6	4	**10**	**3**	**54**	7	0	**7**	**73**
	PAHs	mg Ni eq.	5	0	**5**	**3**	**9**	0	0	**0**	**16**
20	Particulate Matter (PM, dust)	g	4	1	**5**	**7**	**43**	32	0	**32**	**86**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	15	0	**15**	**0**	**20**	2	0	**2**	**38**
22	Eutrophication	g PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

Appendix 4.1 : EcoReport Room based mechanical exhaust unit

Table . EU Total Impact of NEW Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average) produced in 2005 (over their lifetime)

Nr	EU Impact of New Models sold 2005 over their lifetime:	Date	Author
0	Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average)	0	vhk

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**2**			0	2	**2**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**4**			2	3	**4**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**385**	0	0	**0**	**385**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**13**	0	0	**0**	**13**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	0	0	**34**	0	0	0	34
12	Waste, non-haz./ landfill	kt	8	0	**8**	**0**	**15**	0	0	**0**	**24**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**2**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**21**	0	0	**0**	**21**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**9**	0	0	**0**	**10**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

***=Note: mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9g; ton(metric)= 10^9g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

Table . EU Total Impact of STOCK of Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average) in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**2**			0	2	**2**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**4**			2	3	**4**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**334**	0	0	**0**	**334**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**11**	0	0	**0**	**11**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**30**	0	0	**0**	**30**
12	Waste, non-haz./ landfill	kt	8	0	**8**	**0**	**13**	0	0	**0**	**22**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**2**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**18**	0	0	**0**	**18**
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**8**	0	0	**0**	**8**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

****=mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9g; ton(metric)= 10^9g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

*****=simplified model assuming produced=EOL**

Table . Summary Environmental Impacts EU-Stock 2005, Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average)

main life cycle indicators	value	unit
Total Energy (GER)	**334**	PJ
of which, electricity	1,1	TWh
Water (process)*	1	mln.m3
Waste, non-haz./ landfill*	22	kton
Waste, hazardous/ incinerated*	2	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**18**	mt CO2eq.
Acidifying agents (AP)	**8**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

Table . Life Cycle Costs per product and Total annual expenditure (2005) in the EU-25

	Room based mech exh unit (ref.dw.surf = 28m2 /Clim: Average) *Item*	LCC new product	total annual consumer expenditure in EU25
D	Product price	87 €	357 mln.€
E	Installation/ acquisition costs (if any)	55 €	226 mln.€
F	Fuel (gas, oil, wood)	1714 €	8525 mln.€
F	Electricity	34 €	169 mln.€
G	Water	0 €	0 mln.€
H	Aux. 1: None	0 €	0 mln.€
I	Aux. 2 :None	0 €	0 mln.€
J	Aux. 3: None	0 €	0 mln.€
K	Repair & maintenance costs	0 €	0 mln.€
	Total	**1890** €	**9276** mln.€

Appendix 4.2 : EcoReport Centralized mechanical exhaust unit

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average)

Nr	Life cycle Impact per product:	Date	Author
0	Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**2250**			2025	225	**2250**	**0**
2	TecPlastics	g			**400**			360	40	**400**	**0**
3	Ferro	g			**2405**			120	2285	**2405**	**0**
4	Non-ferro	g			**700**			35	665	**700**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**300**			300	0	**300**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**6055**			2840	3215	**6055**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	617	151	**768**	**190**	**325260**	183	135	**48**	**326266**
9	of which, electricity (in primary MJ)	MJ	201	90	**291**	**0**	**63013**	0	1	**-1**	**63303**
10	Water (process)	ltr	174	1	**175**	**0**	**4202**	0	1	**-1**	**4377**
11	Water (cooling)	ltr	168	41	**209**	**0**	**168030**	0	6	**-6**	**168234**
12	Waste, non-haz./ landfill	g	15181	556	**15738**	**108**	**73214**	372	4	**368**	**89429**
13	Waste, hazardous/ incinerated	g	210	0	**210**	**2**	**1454**	2385	1	**2384**	**4050**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	34	8	**42**	**13**	**17254**	14	9	**4**	**17313**
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	330	37	**367**	**37**	**20466**	27	12	**15**	**20885**
17	Volatile Organic Compounds (VOC)	g	2	0	**2**	**3**	**218**	0	0	**0**	**224**
18	Persistent Organic Pollutants (POP)	ng i-Teq	62	6	**68**	**1**	**414**	3	0	**3**	**485**
19	Heavy Metals	mg Ni eq.	58	15	**73**	**5**	**1134**	49	0	**49**	**1262**
	PAHs	mg Ni eq.	41	0	**41**	**8**	**184**	0	0	**0**	**233**
20	Particulate Matter (PM, dust)	g	26	6	**31**	**428**	**1302**	237	0	**237**	**1998**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	162	0	**162**	**0**	**408**	15	0	**15**	**585**
22	Eutrophication	g PO4	2	0	**2**	**0**	**2**	1	0	**1**	**5**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

Table . EU Total Impact of NEW Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average) produced in 2005 (over their lifetime)

Nr	EU Impact of New Models sold 2005 over their lifetime:	Date	Author
0	Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**6**			5	1	**6**	**0**
2	TecPlastics	kt			**1**			1	0	**1**	**0**
3	Ferro	kt			**6**			0	6	**6**	**0**
4	Non-ferro	kt			**2**			0	2	**2**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**1**			1	0	**1**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**16**			8	9	**16**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	2	0	**2**	**1**	**867**	0	0	**0**	**869**
9	of which, electricity (in primary PJ)	PJ	1	0	**1**	**0**	**168**	0	0	**0**	**169**
10	Water (process)	mln. m3	0	0	**0**	**0**	**11**	0	0	**0**	**12**
11	Water (cooling)	mln. m3	0	0	1	0	**448**	0	0	0	448
12	Waste, non-haz./ landfill	kt	40	1	**42**	**0**	**195**	1	0	**1**	**238**
13	Waste, hazardous/ incinerated	kt	1	0	**1**	**0**	**4**	6	0	**6**	**11**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**46**	0	0	**0**	**46**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**55**	0	0	**0**	**56**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**1**	0	0	**0**	**1**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**1**	0	0	**0**	**1**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**3**	0	0	**0**	**3**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**1**	**3**	1	0	**1**	**5**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**1**	0	0	**0**	**2**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

***=Note: mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9 g; ton(metric)= 10^9 g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

Table . EU Total Impact of STOCK of Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average) in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			6			5	1	6	0
2	TecPlastics	kt			1			1	0	1	0
3	Ferro	kt			6			0	6	6	0
4	Non-ferro	kt			2			0	2	2	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			1			1	0	1	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			16			8	9	16	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	2	0	2	1	392	0	0	0	395
9	of which, electricity (in primary PJ)	PJ	1	0	1	0	76	0	0	0	77
10	Water (process)	mln. m3	0	0	0	0	5	0	0	0	6
11	Water (cooling)	mln. m3	0	0	1	0	203	0	0	0	203
12	Waste, non-haz./ landfill	kt	40	1	42	0	88	1	0	1	131
13	Waste, hazardous/ incinerated	kt	1	0	1	0	2	6	0	6	9
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	21	0	0	0	21
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	25	0	0	0	26
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	1
19	Heavy Metals	ton Ni eq.	0	0	0	0	1	0	0	0	2
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	1	2	1	0	1	3
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

****=mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9 g; ton(metric)= 10^9 g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

*****=simplified model assuming produced=EOL**

Table . Summary Environmental Impacts EU-Stock 2005, Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average)

main life cycle indicators	value	unit
Total Energy (GER)	**395**	PJ
of which, electricity	7,3	TWh
Water (process)*	6	mln.m3
Waste, non-haz./ landfill*	131	kton
Waste, hazardous/ incinerated*	9	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**21**	mt CO2eq.
Acidifying agents (AP)	**26**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**1**	g i-Teq.
Heavy Metals (HM)	**2**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**3**	kt
Emissions (Water)		
Heavy Metals (HM)	1	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

Table . Life Cycle Costs per product and Total annual expenditure (2005) in the EU-25

	Centr.mech.exh.unit (ref.dw.surf = 101 m2 / Clim: Average) *Item*	LCC new product	total annual consumer expenditure in EU25
D	Product price	883 €	2353 mln.€
E	Installation/ acquisition costs (if any)	330 €	879 mln.€
F	Fuel (gas, oil, wood)	4954 €	8347 mln.€
F	Electricity	687 €	1158 mln.€
G	Water	0 €	0 mln.€
H	Aux. 1: None	0 €	0 mln.€
I	Aux. 2 :None	0 €	0 mln.€
J	Aux. 3: None	0 €	0 mln.€
K	Repair & maintenance costs	182 €	308 mln.€
	Total	**7036** €	**13045** mln.€

Appendix 4.3 : EcoReport Centralized mechanical Heat Recovery unit

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: **RESULTS**
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average)

Nr	Life cycle Impact per product:	Date	Author
0	Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**5650**			5085	565	**5650**	**0**
2	TecPlastics	g			**1200**			1080	120	**1200**	**0**
3	Ferro	g			**24500**			1225	23275	**24500**	**0**
4	Non-ferro	g			**3000**			150	2850	**3000**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**800**			800	0	**800**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**35150**			8340	26810	**35150**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	2499	749	**3248**	**385**	**119230**	539	347	**192**	**123055**
9	of which, electricity (in primary MJ)	MJ	577	436	**1013**	**1**	**75337**	0	3	**-3**	**76348**
10	Water (process)	ltr	464	6	**470**	**0**	**5026**	0	2	**-2**	**5495**
11	Water (cooling)	ltr	450	191	**641**	**0**	**200878**	0	14	**-14**	**201505**
12	Waste, non-haz./ landfill	g	69010	3267	**72277**	**187**	**88060**	2157	10	**2147**	**162671**
13	Waste, hazardous/ incinerated	g	559	0	**560**	**4**	**1741**	6165	2	**6163**	**8468**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	154	42	**196**	**24**	**5741**	40	24	**16**	**5978**
15	Ozone Depletion, emissions	mg R-11 eq				negligible					
16	Acidification, emissions	g SO2 eq.	996	184	**1180**	**72**	**20188**	81	31	**49**	**21490**
17	Volatile Organic Compounds (VOC)	g	9	1	**9**	**6**	**79**	1	0	**1**	**96**
18	Persistent Organic Pollutants (POP)	ng i-Teq	640	69	**709**	**1**	**501**	15	0	**15**	**1226**
19	Heavy Metals	mg Ni eq.	202	163	**364**	**10**	**1556**	147	0	**147**	**2077**
	PAHs	mg Ni eq.	260	0	**260**	**16**	**412**	0	0	**0**	**688**
20	Particulate Matter (PM, dust)	g	144	28	**172**	**1026**	**4838**	699	1	**699**	**6734**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	510	0	**510**	**0**	**491**	45	0	**45**	**1046**
22	Eutrophication	g PO4	7	0	**7**	**0**	**2**	3	0	**3**	**12**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

Table . EU Total Impact of NEW Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average) produced in 2005 (over their lifetime)

Nr	EU Impact of New Models sold 2005 over their lifetime:	Date	Author
0	Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**3**			0	3	**3**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**5**			1	4	**5**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**16**	0	0	**0**	**17**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**10**	0	0	**0**	**10**
10	Water (process)	mln. m3	0	0	**0**	**0**	**1**	0	0	**0**	**1**
11	Water (cooling)	mln. m3	0	0	0	0	**27**	0	0	0	27
12	Waste, non-haz./ landfill	kt	9	0	**10**	**0**	**12**	0	0	**0**	**22**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**3**	0	0	**0**	**3**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**1**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

***=Note: mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9 g; ton(metric)= 10^9 g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

Table . EU Total Impact of STOCK of Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average) in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	**BUTION**		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**3**			0	3	**3**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**5**			1	4	**5**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**5**	0	0	**0**	**5**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**3**	0	0	**0**	**3**
10	Water (process)	mln. m3	0	0	**0**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**8**	0	0	**0**	**8**
12	Waste, non-haz./ landfill	kt	9	0	**10**	**0**	**3**	0	0	**0**	**13**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	1	0	**1**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

****=mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9g; ton(metric)= 10^9g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

*****=simplified model assuming produced=EOL**

Table . Summary Environmental Impacts EU-Stock 2005, Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average)

main life cycle indicators	value	unit
Total Energy (GER)	**5**	PJ
of which, electricity	0,3	TWh
Water (process)*	0	mln.m3
Waste, non-haz./ landfill*	13	kton
Waste, hazardous/ incinerated*	1	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**1**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

Table . Life Cycle Costs per product and Total annual expenditure (2005) in the EU-25

	Centr.mech HR-unit (ref.dw.surf = 122 m2 / Clim: Average) *Item*	**LCC new product**	**total annual consumer expenditure in EU25**
D	Product price	2924 €	395 mln.€
E	Installation/ acquisition costs (if any)	1320 €	178 mln.€
F	Fuel (gas, oil, wood)	807 €	43 mln.€
F	Electricity	821 €	44 mln.€
G	Water	0 €	0 mln.€
H	Aux. 1: None	0 €	0 mln.€
I	Aux. 2 :None	0 €	0 mln.€
J	Aux. 3: None	0 €	0 mln.€
K	Repair & maintenance costs	973 €	52 mln.€
	Total	**6845** €	**712** mln.€

Appendix 4.4 : EcoReport Room based mechanical Heat Recovery unit

Version 5 VHK for European Commission 28 Nov. 2005

Document subject to a legal notice (see below))

ECO-DESIGN OF ENERGY-USING PRODUCTS

EuP EcoReport: RESULTS
Assessment of Environmental Impact

Table . Life Cycle Impact (per unit) of Room based HR unit (ref.dw.surf = 56m2 / Clim: Average)

Nr	Life cycle Impact per product:	Date	Author
0	Room based HR unit (ref.dw.surf = 56m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**4700**			4230	470	**4700**	**0**
2	TecPlastics	g			**1200**			1080	120	**1200**	**0**
3	Ferro	g			**4150**			208	3943	**4150**	**0**
4	Non-ferro	g			**900**			45	855	**900**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**800**			800	0	**800**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**11750**			6363	5388	**11750**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1359	312	**1671**	**140**	**64816**	401	296	**105**	**66732**
9	of which, electricity (in primary MJ)	MJ	524	186	**709**	**0**	**32565**	0	2	**-2**	**33273**
10	Water (process)	ltr	459	3	**461**	**0**	**2175**	0	1	**-1**	**2635**
11	Water (cooling)	ltr	411	85	**497**	**0**	**86827**	0	12	**-12**	**87312**
12	Waste, non-haz./ landfill	g	22047	1115	**23161**	**88**	**37981**	722	9	**713**	**61944**
13	Waste, hazardous/ incinerated	g	555	0	**555**	**2**	**756**	5310	1	**5309**	**6621**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	74	17	**92**	**10**	**3210**	30	20	**9**	**3321**
15	Ozone Depletion, emissions	mg R-11 eq				negligible					
16	Acidification, emissions	g SO2 eq.	642	75	**717**	**28**	**8925**	60	27	**34**	**9704**
17	Volatile Organic Compounds (VOC)	g	6	0	**6**	**2**	**40**	1	0	**1**	**48**
18	Persistent Organic Pollutants (POP)	ng i-Teq	106	10	**116**	**0**	**215**	5	0	**5**	**336**
19	Heavy Metals	mg Ni eq.	109	24	**134**	**4**	**612**	108	0	**108**	**858**
	PAHs	mg Ni eq.	78	0	**79**	**6**	**118**	0	0	**0**	**202**
20	Particulate Matter (PM, dust)	g	53	12	**65**	**274**	**1071**	520	1	**519**	**1928**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	350	0	**350**	**0**	**213**	33	0	**33**	**597**
22	Eutrophication	g PO4	5	0	**6**	**0**	**1**	2	0	**2**	**9**
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

Table . EU Total Impact of NEW Room based HR unit (ref.dw.surf = 56m2 / Clim: Average) produced in 2005 (over their lifetime)

Nr	EU Impact of New Models sold 2005 over their lifetime:	Date	Author
0	Room based HR unit (ref.dw.surf = 56m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			0			0	0	0	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			0			0	0	0	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	0	2	0	0	0	2
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	1	0	0	0	1
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	3	0	0	0	3
12	Waste, non-haz./ landfill	kt	1	0	1	0	1	0	0	0	2
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	0	0	0	0	0
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

***=Note: mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9g; ton(metric)= 10^9g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

Table . EU Total Impact of STOCK of Room based HR unit (ref.dw.surf = 56m2 / Clim: Average) in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Room based HR unit (ref.dw.surf = 56m2 / Clim: Average)	0	vhk

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**0**			0	0	**0**	**0**
4	Non-ferro	kt			**0**			0	0	**0**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**0**			0	0	**0**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	**0**	**0**	**0**	0	0	**0**	**0**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**0**	0	0	**0**	**0**
10	Water (process)	mln. m3	0	0	**0**	**0**	**0**	0	0	**0**	**0**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**0**	0	0	**0**	**1**
12	Waste, non-haz./ landfill	kt	1	0	**1**	**0**	**0**	0	0	**0**	**1**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

***=Note: Recycling credits only relate to recycling of plastics and electronics (excl. LCD/CRT). Recycling credits for metals and other fractions are already taken into account in the production phase.**

****=mt= megatonnes (metric)= 10^9 kg; kt= kilotonnes (metric)= 10^9 g; ton(metric)= 10^9 g; g=gram= 10^9 ng ; mln. M3 = million cubic metres= 10^9 litres; PJ= petaJoules= 10^9 MJ (megajoules) = 10^{15} Joules.**

*****=simplified model assuming produced=EOL**

Table . Summary Environmental Impacts EU-Stock 2005, Room based HR unit (ref.dw.surf = 56m2 / Clim: Average)

main life cycle indicators	value	unit
Total Energy (GER)	**0**	PJ
of which, electricity	0,0	TWh
Water (process)*	0	mln.m3
Waste, non-haz./ landfill*	1	kton
Waste, hazardous/ incinerated*	0	kton
Emissions (Air)		
Greenhouse Gases in GWP100	**0**	mt CO2eq.
Acidifying agents (AP)	**0**	kt SO2eq.
Volatile Org. Compounds (VOC)	**0**	kt
Persistent Org. Pollutants (POP)	**0**	g i-Teq.
Heavy Metals (HM)	**0**	ton Ni eq.
PAHs	**0**	ton Ni eq.
Particulate Matter (PM, dust)	**0**	kt
Emissions (Water)		
Heavy Metals (HM)	0	ton Hg/20
Eutrophication (EP)	0	kt PO4

*=caution: low accuracy for production phase

Table . Life Cycle Costs per product and Total annual expenditure (2005) in the EU-27

	Room based HR unit (ref.dw.surf = 56m2 / Clim: Average) *Item*	LCC new product	total annual consumer expenditure in EU25
D	Product price	1143 €	39 mln.€
E	Installation/ acquisition costs (if any)	110 €	4 mln.€
F	Fuel (gas, oil, wood)	605 €	5 mln.€
F	Electricity	355 €	3 mln.€
G	Water	0 €	0 mln.€
H	Aux. 1: None	0 €	0 mln.€
I	Aux. 2 :None	0 €	0 mln.€
J	Aux. 3: None	0 €	0 mln.€
K	Repair & maintenance costs	304 €	2 mln.€
	Total	**2517** €	**53** mln.€