RESHYVENT

Cluster Project on Demand Controlled Hybrid Ventilation in Residential Buildings with Specific Emphasis on the Integration of Renewables

Contract No: ENK6-CT2001-00533

WP 5 Design parameters

Report Title:

Parameters for the performance assessment of hybrid ventilation systems

Performance criteria, target levels and design constraints

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CONTENT

1 INTRODUCTION

1.1 Purpose of this report

The purpose of this report is two-fold:

1. As an introduction, this report describes options and choices for performance assessment criteria, target values and constraints considered to be relevant for the EPBD related performance assessment of ventilation systems, specifically hybrid residential ventilation systems, and to give some background including reference to existing threshold and target values.
2. Based on this outline, the main purpose of the report is to specify in detail the performance assessment criteria to be used for the systems evaluations within RESHYVENT WP6.

1.2 Target audience

This report is intended to be mainly used by the Reshyvent partners, especially by the industrial partners involved in the Reshyvent project.

1.3 Content

This working document gives an overview on:

- Performance criteria and the respective performance parameters to be used for the performance assessment
- Threshold and target values for these performance assessment parameters (for different performance classes if applicable)
- Design constraints, type of input data and general assumptions to be considered

Building and ventilation system parameters as required within RESHYVENT for the performance assessment of the systems are outlined in a separate report, entitled “Description of reference buildings and ventilation systems”.

The description of the individual performance assessment parameter is divided into

1. a more general section with the description of the parameter, and overviews on existing philosophies, approaches, threshold and target values
2. a section which defines the parameter and values selected for the evaluation of the RESHYVENT systems

In the second section indications are given for each individual criterion whether this item should be evaluated and documented

- in the WP 5 Technical report (by a general description and qualitative evaluation of specific systems) or
- by computer simulation in the performance assessment evaluation, performed and documented in WP 6 (quantitative evaluation of specific systems including sensitivity analysis).
- by measurements made by the ICs

1.4 Basis and reference documents

The criteria and the respective parameters and target levels given here, are to a large extend derived from existing material, such as (see also References):

- CEN Standards
- Results of IEA Annex 27 and IEA Annex 35
- Results of EU projects such as TIPVENT, ENPER-TEPUC, ETIAQ, etc.
- The targets outlined in the RESHYVENT contract document "Description of work" (as best guesses at that time, but nevertheless in most cases not too bad)
- The performance specifications set up by the RESHYVENT ICs

1.5 Development of report

This report was kept as an evolving document throughout a large time proportion of the RESHYVENT project.

2 PERFORMANCE ASSESSMENT OF HYBRID VENTILATION SYSTEMS

2.1 Framework for the performance assessment

The search for improvement of the indoor air quality and the reduction of the energy consumption leads to the development of innovative ventilation systems. These improvements however are not covered and rewarded in the European standards and regulations. As the implementation of innovative systems in the standards is hardly achievable, the principle of equivalence is a suitable aid. There are no prescribed regulations how to judge the principle of equivalence. This can lead to quite various results. More uniform and well-founded basic guidelines and recommendations have been developed by workgroup A2 of IEA Annex 35 Hybvent, in the report [IEA A35-A2].

Based on the A35 report, a framework for the assessment of innovative ventilation systems (including residential hybrid systems) has been worked out by BBRI (WP4) together with WP 6, see RESHYVENT report [RHV-WP4567].

The major key words of this report are:

- EC Energy Performance of Buildings Directive
- Standardisation: Calculation procedures
- Legislation: Requirements, practical implementation
- Building performance assessment and assessment of systems
- Innovative solutions: Application of principle of equivalence
- Product data: Reliable/certified values and data bases are needed
- Activities: CEN, EOTA
- Goal: Single (European) assessment method for various performances
- Task: Assessment of (innovative) ventilation systems
- Unclear: Assessment of systems with time dependant performance (as hybrid ventilation)

2.2 Performance assessment topics

The two major topics considered in the performance assessment are:

1. Energy
2. Indoor environment
    - Indoor air quality
    - Thermal comfort
    - Acoustics

2.3 Performance assessment methods

For the performance assessment of an individual system, the following methods may be applied:

1. **Comparison** and assessment of system values **with target value**s set for individual criteria (compliance with standards and regulations)
2. **Comparison with values of a reference/standard system** (or set of systems) in regard to individual criteria (for proof of compliance by “Principal of Equivalence”)
3. **Classification** of the individual system on the basis of index numbers (e.g. 5 steps) for individual criteria (comparison and ranking of systems)
4. Establishing of a **performance index** for the system (e.g. energy performance index or IAQ performance index), based on an aggregation of the performance in terms of individual criteria.
5. Establishing of an **overall performance index** for the system according to an overall index scheme and making a comparison of systems (ranking of systems).

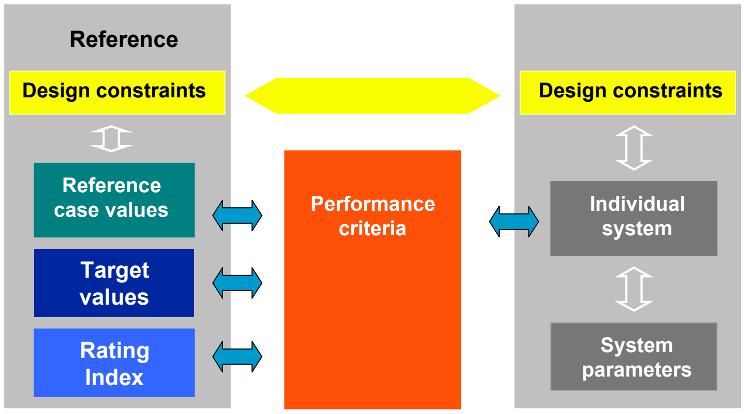


Figure 1: Performance of an individual system is assessed by applying the criteria to the individual system and comparing them with a reference case or with target values

The definition of the performance criteria and especially of the individual parameters and the respective target levels are dependant on the method selected for the assessment.

For the comparison of systems, all constraints (assumptions and boundary conditions) must be exactly identical, especially when applying method types 2 to 5. On the influence of different boundary conditions on energy performance, see e.g. [van der Aa 2002].

Boundary conditions may be set differently for the evaluation of individual criteria. As an example, for energy performance evaluations, indoor air quality related constraints and parameters can perhaps be handled in a simpler way than for IAQ related evaluations.

2.4 Classification of design parameters for the performance assessment

Design parameters as used for the performance assessment can be differentiated into:

1. Performance criteria and respective thresholds, allowables and target values
2. Design constraints (boundary conditions, assumptions)
3. Building and ventilation system design variables

Parameters can be defined on building, system and component level.

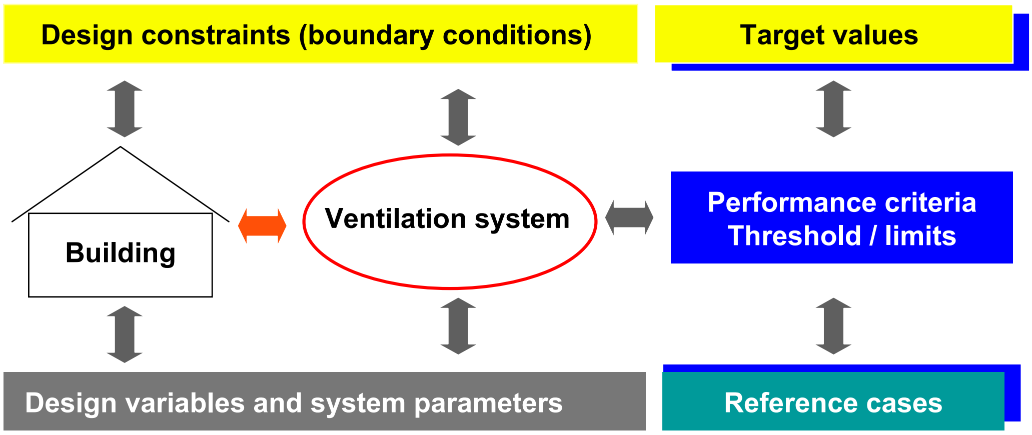


Figure 2: Design parameters can be differentiated into performance criteria, target values, design constraints, and building and ventilation system design variables and parameters

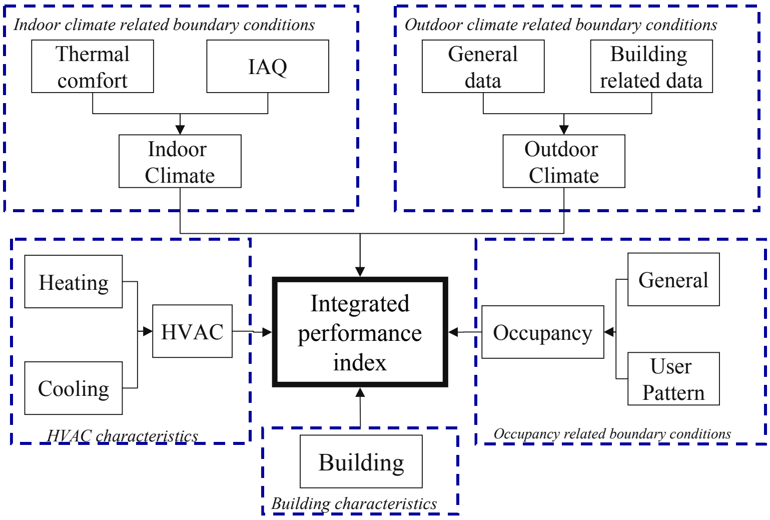


Figure 3: Boundary conditions which (may) influence the integrated performance index (source: [IEA A35-A2])

2.4.1 Performance criteria

The criteria are grouped according to the topics considered in the performance assessment, namely:

1. Energy
2. Indoor environment
   - Indoor air quality
   - Thermal comfort
   - Acoustics

2.4.2 Design constraints

Design constraints are boundary conditions and assumptions imposed and applied for the performance assessment.
In principle, the design constraints set may vary according to the performance assessment topic, e.g. for the energy performance assessment, occupant and indoor pollutant source schedules may be defined in less detail than for indoor air quality assessments. While for IAQ assessment mostly situations with low air flow rates are critical, the opposite is the case for energy performance assessments.

2.4.3 Design variables

The design variables are those over which the designer has control. These are the ventilation system variables and the construction characteristics of the building. They have to be selected and dimensioned considering the design constraints and the target values of the relevant performance criteria.

2.5 RESHYVENT principles and approaches for the performance assessment

The methodology and the approaches selected within RESHYVENT for the performance assessment of the IC systems are documented in more detail by WP6.

For the performance assessment within RESHYVENT, the following principles were set:

2.5.1 Purpose of performance assessments in RESHYVENT

- Give application examples for the criteria and methods defined
- Answer IC specific questions
- Show influence of choices in criteria, thresholds and targets on system performance
- Show feasibility of assessment methods
- Compare different reference systems for the basic ventilation systems (per country)
- Show performance improvements of innovative systems

IC systems are not compared directly. Simulations are made for each system, e.g. for several climates.

2.5.2 Performance assessment methodologies

Generally the target value approach is used (see above, method 1).

However, for the individual IC systems, a reference case is defined for later sensitivity analysis and probabilistic evaluations. Reference cases may also be used for the later application of the “Principal of Equivalence”.

2.5.3 Target values

Wherever possible, target values are defined such that they are generally applicable to any ventilation system.

2.5.4 Classes of target values

Several classes of target values shall be applied if necessary.
In a later stage, different target values may be defined according to national requirements.

2.5.5 Weighting of criteria

Individual criteria shall not be weighted against each other at the moment (e.g. improvements in IAQ are not weighted against shortcomings in energy demand). However, for energy performance assessments, an acceptable IAQ level shall be maintained. This topic on weighting is further elaborated in the WP 4 framework report.

2.5.6 Sensitivity to input parameters

A reference case per IC system is defined, as a basis for later sensitivity and probabilistic evaluations.

2.5.7 Evaluation of IAQ parameter

Evaluation is done per building, per room, per person (dose), per room but occupancy related. This depends on criteria for each of the sources.

2.5.8 Reliability, safety, maintenance, cost, lifetime

These topics are to be considered mainly by the ICs and by WP8, but not in the frame of the performance assessment.

3 PERFORMANCE ASSESSMENT METHODS AND TECHNIQUES

3.1 General

The performance assessment method to be applied is dependent on the following aspects in terms of character of input data and in terms of required quality of results:

1. Required level of representation in terms of climate, building type etc.
2. Level of predictability of assumptions on boundary conditions.
   Boundary conditions with high uncertainties or high degrees of randomness may only be handled by probabilistic approaches while clearly defined conditions can be treated by deterministic methods
3. Models to be considered in the prediction, e.g. building thermal dynamics, hygroscopic effects, pollutant reactions etc.
4. Level of required predictability for the results in terms of
   - space (building, apartment, room)
   - time (average value, frequency distributions, profiles)

3.2 On the time dependent evaluation of criteria

Performance criteria can be evaluated for a

- specific operation mode
- specific period of time (mostly heating season or whole year)

For hybrid ventilation, it is obvious that a performance assessment has to be made over a certain time interval. Therefore, limits and required values outlined e.g. for steady state conditions are considered as thresholds, and the real performance criterion is whether these limits are exceeded, and for how much time.

A widely used approach to display results of time dependant performance are histograms, see figure for an example.

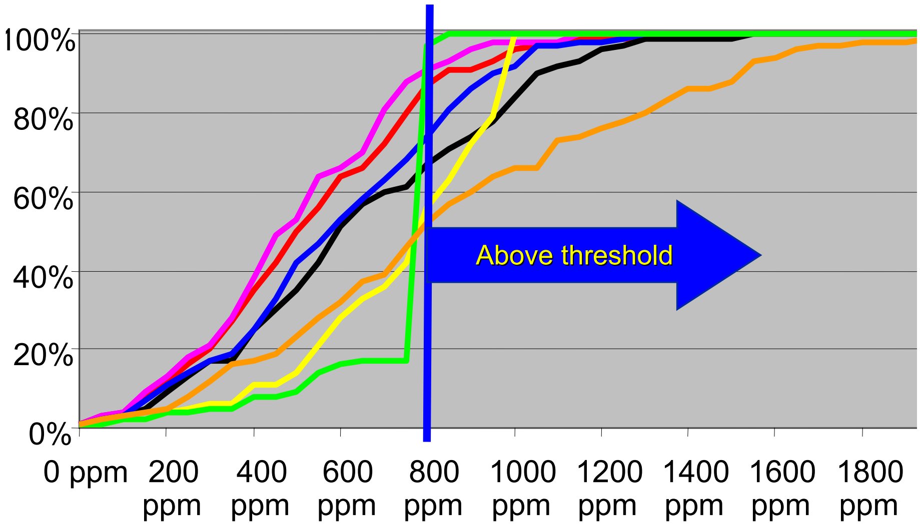


Figure 4: Example for the presentation of CO_2 concentration data in the form of a histogram.

In histograms, the percentage of time where certain threshold are exceeded or not reached are easily shown. However, the quantitative aspect of such times of not fulfilling certain limits or allowables, is more difficult to present. Therefore, it is proposed to determine an integral value for such exceedings.

The structure and the approach selected within RESHYVENT are outlined with the following example for the CO_2 concentration, as one of the parameters used for the characterisation of the indoor air quality.

Topic	Indoor Air Quality	
Performance criteria	CO_2 concentration	
Threshold / Limit	1000 ppm above outdoor level	
Performance parameter:		**Target value** (only example)
- No of hours with concentrations above threshold value		200 h
- Hours x concentration exceeding (room related)		100 kppm.h
- Concentration exceeding exposure (occupant related)		50 kppm.h

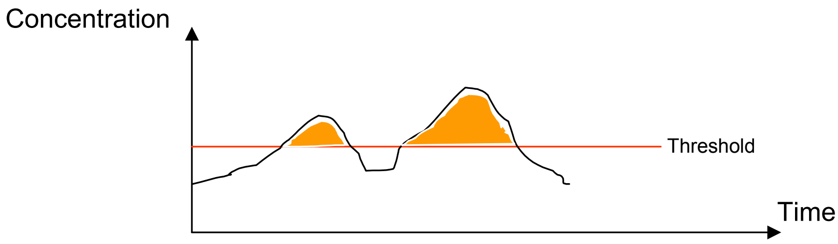


Figure 5: Performance in terms of concentrations is assessed by an integral value for the threshold exceeding

3.3 On the handling of uncertainties and spread in the constraints and building parameters

Especially in an early design stage of a building, many input data can be specified only within a certain bandwidth and/or with certain confidence levels. The effect of these uncertainties in the input on the resulting output must be considered.

3.3.1 Evaluation by factorial design for sensitivity analysis

With the factorial design method, effects of the individual input parameters can be evaluated. The factorial design consists of choosing the simulation points at the edge of the multi-dimensional domain defined by the input parameter ranges. The simulation results are fitted to an appropriate polynomial function corresponding to a Taylor series of the analyzed model:

$$Y = \alpha_0 + \sum_i \alpha_i X_i + \sum_{i \neq j} \alpha_{ij} X_i X_j + ...$$

Where X_i are the input parameters and Y is the output. With N input parameters 2^N experiments or simulations are necessary for a complete evaluation plan, which allows to determine all coefficients α_i, $\alpha_{i,j}$, etc. (main and all interaction effects). Fractional factorial design [Box, Hunter] using reduced experimental plans according to e.g. [Placket] can be used, if all main effects and only some of the interaction effects have to be determined.

For more information on the application of these methods, see final reports of IEA Annex 23 [IEA A23], [Fürbringer 1995] and [Fürbringer 1999].

3.3.2 Probabilistic methods

The effect of uncertainties in the input on the resulting output can be determined by probabilistic methods as e.g. the Monte-Carlo technique [Rubinstein], where for each simulation run random values for the input parameters (according to the probability distribution) are used and a probability distribution profile for each of the output parameters is determined.

Probabilistic methods may especially be applied for the evaluation of the influence of design constraints which have a high degree of randomness. This applies e.g. to occupancy and occupant related release of moisture and other pollutants.

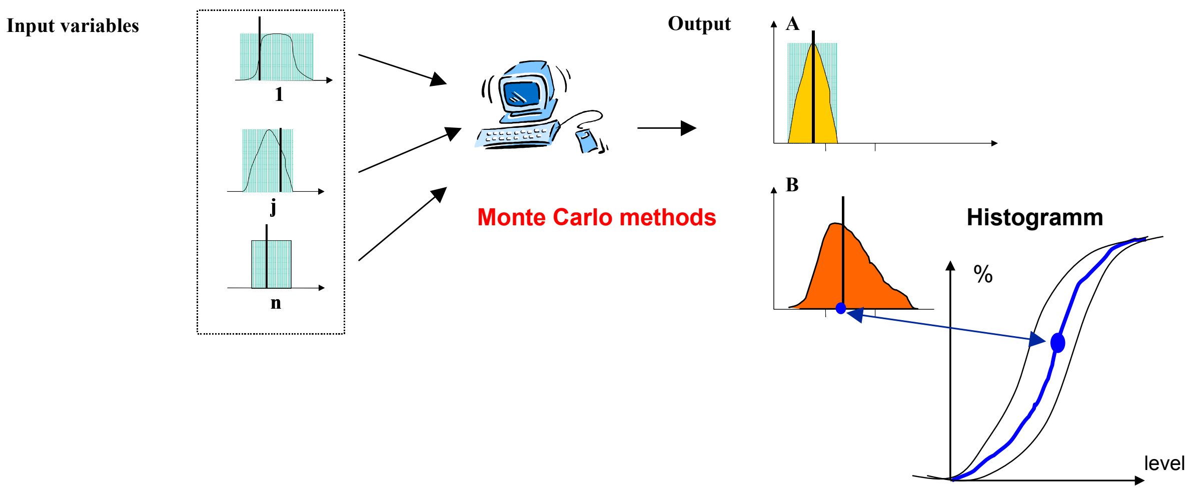


Figure 6: Probabilistic methods consider the uncertainty spread in the input values and give a probability distribution profile for each output parameter. Consequently, the histogram curve is complemented by uncertainty bands.

3.3.3 Probabilistic approach vs. parametric study

The question whether to use a probabilistic approach or a parametric study depends on the type of the performance prediction and the reason behind the assumed spread in the input data. Depending on the application case, also a combination of the two methods is possible (several classes of a parameter with a spread within each class).

For a comprehensive performance prediction of a certain system in a certain building type, made in order to compare the performance with a different system in the same building type, preference may be given to the probability distribution approach. If the impact of some constraints or building parameters has to be investigated, e.g. in order to optimize the system for certain situations, a parametric study is preferred. In the building design process, the choice of the method depends also on whether the value of a parameter is just uncertain in the present stage or whether the parameter has an unknown impact on the performance which has to be investigated first.

It makes also a difference whether the spread in the input data stems from the determination method of the values (e.g. uncertainty of a measurement method or a calculation model) or whether there is a spread in the occurrence in the reality (e.g. occupant pattern). In the first case the probability distribution approach would be the preferred method. In the latter however, it might be necessary or of interest to evaluate how the system performs in different cases (e.g. high or low occupant density), which calls for a parametric study. The temporal variation of input data (e.g. weather data) is taken into account automatically, if the performance prediction is made using a dynamic simulation tool.

For the input parameters described in the chapters 5 and 6, the following table gives an overview on the parameter variation specified in this report, and indicates for which parameters the use a probability distribution approach might to be considered within RESHYVENT:

Chapter	Input parameter	Variation as proposed in current version of report	Probabilistic approach with probability distribution (PD)
5.	**Design constraints**		
5.2	Climate	4 different climatic regions	No
5.4.1	Environment (wind profile)		PD for the transfer coefficient [Heijmans 2002]
5.4.2	Wind shielding	3 different shielding values	No
5.4.3	Outdoor level of CO_2	3 levels	No
5.4.4	Outdoor noise	3 levels	No
5.6	Occupant pattern: density, activity, airing, showering, cooking, user - system interaction, lighting	different patterns given (as given in [IEA A27-V2])	No
5.5.2	Pollutant sources from building and furniture	generic pollutant emission	No
6	**Building parameters and variables**		
6.3	Cp-values	TBD for reference buildings	PD for each Cp-value, considering the correlation between Cp's of different façade elements
6.5	Leakage - overall - distribution	- 3 leakage classes - distribution in relation to envelope area	PD for each leakage class
6.x	Building		
6.x	- Thermal mass of envelope and furniture	No variation	No
6.x	- U- value	No variation	No
6.x	- Windows: area, glazing type, shading, frame	No variation	No
7	**Ventilation system parameters and variables**		
7.1.1	Air flow rates	TBD for reference buildings	PD specified by ICs
7.2.1	Component characteristics	TBD for reference buildings	PD specified by ICs
	Set point values of control system	TBD for reference buildings	PD for each set point value

Table 1: Overview of the parameter variation specified in this report, and indication which parameters might be defined by a probability distribution approach

The topic of probabilistic methods is covered in much more detail in a specific RESHYVENT report [RHV-WP4567]. The report deals also with the related issues of which parameters are to be considered in a probabilistic approach, and the topic of the implications of such approaches in the context of the EPBD.

3.4 Evaluation period for the performance assessment

The performance criteria must be determined considering the relevant time periods of the constraint parameters.
For energy, the heating season is used in many cases. However, in detailed analysis, the time where heating of the building is required, actually is not a time constraint but an output of the simulation itself.

Also, heating and cooling may be required within a short interval of time, even within one full day. Therefore, it may be necessary to evaluate heating and cooling demand in parallel over a long period, perhaps over the whole year.

For IAQ evaluations, longer time periods are necessary if occupant exposures and long term effects (e.g. of moisture) are considered.

3.4.1 RESHYVENT evaluation periods

Within RESHYVENT, the following time periods for the performance assessment are proposed, if the time period is specified in more detail in relation to the specific criteria which is assessed.

<u>Energy</u>

- Heat Year
- Cooling Year
- Electricity Year

<u>Indoor air quality</u>

- Humidity etc. Year
- Pollutants Year
- Pollutants, effects of control Year

<u>Thermal comfort</u>

- Year
- Passive cooling mode of ventilation system (or summer period)

3.5 Humidity/moisture model

Several levels of sophistication can be considered in regard to humidity and moisture absorption by furniture and internal wall surfaces.

3.5.1 RESHYVENT approach

First step: Humidity transport purely by air.

Later: Include moisture ad-/desorption model, calculated from moisture balance equation, considering also the sorption/desorption processes from walls and furniture.
If calculated air humidity > 100%: RH is set to 100% and remaining water is considered as water gain in the next time step [IEA A27-V2].
Another possibility is to directly use the moisture absorption model within Type 56 of TRNSYS.
However, this model has to be evaluated before it can be used for the RESHYVENT simulations.

3.6 Dynamics of control

Not only the control algorithms themselves require time steps of less than 1 h, but also simulation time steps shorter than the usual 1 h time step may be needed to consider the effects of the control.

<u>RESHYVENT approach</u>

Dynamics of control are checked by WP6, making specific comparative simulations using different time steps, and interpolation schemes.
The aim is to clearly identify the cases where the time step for the system simulation has to be shorter than 1 h.

4 PERFORMANCE CRITERIA AND TARGET LEVELS

4.1 Introduction

The purpose of this section is to outline criteria and respective thresholds and target values for the two general evaluation topics energy and indoor environment.

For all criteria, there are two parts:

1) a more general part giving an outline of different options, the reasons behind, the description of the specific evaluation parameter, and references to existing criteria, threshold and target values, and
2) a section, giving the specific parameters, threshold and target values used for the evaluation of the RESHYVENT IC systems

4.2 Description scheme

The individual performance criteria are described according to the following scheme:

<u>Philosophy and Background</u>
Reasons for selected criteria and parameters

<u>Existing criteria, thresholds, target values</u>
Reference to relevant existing criteria, threshold and target values. Further information, especially on national level, may be found in the documents of RHV WP4

<u>Proposed approach and options</u>
Description of selected criteria, of options for the criteria, and of the according parameters for the performance assessment, the threshold and the target values

<u>RESHYVENT approach</u>
Here the specific approach and the values as selected for the performance assessment work within RESHYVENT are given

Performance criterion:	Specific performance assessment topic	
Evaluation parameter:	Physical parameter to be used for the performance assessment. Targets are expressed using the same parameter	
Assessment method:	Performance assessment approach and methods selected within RESHYVENT	
Threshold value(s):	Threshold value(s)	see figure 5 in §3.2
Target value(s):	Target value(s) related to evaluation parameter	see figure 5 in §3.2
Specific IC target value(s):	Target values to be considered by the ICs for the working prototype	
Considered by RHV WP:	To be considered in <u>which WP</u> and with <u>which priority level</u> (in relation to time and progress within the project) and with <u>which relevance</u> (in terms of energy and indoor air quality evaluation)	

4.3 Energy demand

The energy criteria are expressed as energy targets for the building (in relation to EPBD and the Principle of Equivalence) as well as energy and power related targets for the ventilation system and for specific components of the system.

4.3.1 Heat use of building (heating power and heat demand)

<u>Philosophy and background</u>
In cold climates the energy input needed to heat the building is the major part of the energy consumption in buildings. Requirements for the heat demand of the building are set out in many national standards and laws. Ventilation losses are an important heat loss factor of the building.
Therefore, ventilation rates have to be accurately determined and considered when determining the space heat demand. In fact, ventilation rates have to be determined such that the accuracy of the ventilation loss value is in the same order as the one for the transmission losses. In many cases however, this is not accomplished by the methods applied. Often pre-set or even fixed values for the ventilation rate are used. Internal temperatures can have a major influence on system performance (e.g. for heat recovery), therefore the assumptions on the internal temperature conditions in both spacial and time related dimensions have to be carefully specified.

Existing criteria, thresholds, target values

In general, thresholds are defined for the heat demand, often related to the heated floor area of the building. Mostly a steady state energy calculation is performed for typical climatic conditions. According to [EN ISO 13790] the heat demand - to be covered by an ideal heating system to maintain the pre-set internal temperatures - is calculated with monthly averaged climatic conditions. Hourly values are used in combination with a dynamic thermal model of the building.

Proposed approach and options

For systems with time dependent performance as a function of specific control functions, the heat demand has to be calculated on an hourly time base.

Pre-set internal temperatures may be assumed in the calculation. The thermal dynamic behaviour of the building has not to be considered in any case, a quasi steady-state may be sufficient. However, with the requirement for the 1 h time step, the use of full thermal dynamic simulation may be more convenient. This may lead to differences in the calculated heat demand when compared to steady state calculations.

The heating season may be a fixed period defined for each climate and building type. A different approach is, to switch on the heating system only on those days when the daily averaged heat gains using a conventional utilisation factor do not balance the averaged heat losses. On days with heating system switched off, the room temperature might fall temporarily below the set point.

The 1 h time step simulation allows to determine the heating power as a function of time or as frequency distribution. In thermal dynamic simulations the maximum heating power has to be restricted to a realistic value. This leads to a "non ideal" heating system with some delay of the actual room temperature in cases of abrupt changing of set point temperatures.

RESHYVENT approach

Within RESHYVENT, two separate criteria are evaluated in regard to heating energy:

1. Overall heat demand as a global figure for the time period of the assessment
2. Heating power profile

Overall heat demand:

Performance criterion:	Heat demand: heat to be delivered to the heated space by an ideal heating system to maintain the pre-set internal temperatures
Evaluation parameter:	Heat demand per m^2 heated floor area
Assessment method:	Thermal dynamic simulation with one hour time step, pre-set temperatures, ideal control system and restricted heating power. Fixed heating season defined for each climate and building type.
Threshold value(s):	Thresholds are set according to national requirements.
Target value(s):	No target, but comparison with reference cases
Considered by RHV WP:	WP 6

Heating power profile

Performance criterion:	Time dependent heating power to be delivered to the heated space by an ideal heating system to maintain the pre-set internal temperatures
Evaluation parameter:	Time dependent heating power per m^2 heated floor area
Assessment method:	Thermal dynamic simulation with one hour time step, pre-set temperatures, ideal control system and restricted heating power. Fixed heating season defined for each climate and building type.
Threshold value(s):	Thresholds are set according to national requirements.
Target value(s):	No target, but comparison with reference cases
Considered by RHV WP:	WP 6

4.3.2 Energy use for space cooling of building (cooling demand)

Philosophy and Background

In warm climates, energy demand for cooling is increasing, especially in the residential sector. Therefore, besides the evaluation of the space heat demand, also the space cooling demand has to be considered in all cases, where mechanical cooling is applied.

Existing criteria, thresholds, target values

Criteria are known only for office buildings. However, the criteria can be adapted to the residential sector.

Approaches and options

If the building is actively cooled, the space cooling demand must be determined by dynamic simulation. Both the cooling demand and the respective electric energy input for the generation of cold (chilling) can be determined. There is the question of related floor area: floor area of cooled space is more obvious, however comparison with energy values for heating, related to floor area of heated space, are difficult in this case.

RESHYVENT approach

Performance criterion:	Space cooling demand: heat required to be extracted from rooms in order to keep the building below the maximum temperature.
Evaluation parameter:	Space cooling demand per m^2 cooled floor area
Assessment method:	Full thermal dynamic simulation with free floating room temperatures below temperature maximum.
Threshold value(s):	Threshold according to national regulations, if available
Target value(s):	No target, but comparison with reference cases
Considered by RHV WP:	WP 6

4.3.3 Ventilation energy loss

Philosophy and Background

Ventilation energy losses are a major contributor to the space heat demand. Therefore, ventilation losses are treated as separate performance criterion, even if ventilation losses are included in the building heat demand criterion.

Existing criteria, thresholds, target values

For steady state calculation [EN ISO 13790] averaged values of the indoor and outdoor air temperature are used to calculate the ventilation energy loss.

Proposed approach and options

For steady state calculation either monthly averaged values or average values for the whole heating period can be used. In both cases the averaging period includes periods with no heat demand. This means warm air leaving the heated space is regarded as ventilation loss in any case during the heating season, even if the heating power is zero because the internal and external gains will balance the losses, and the incoming cold outdoor air has not to be heated up.

In dynamic simulations with one hour time steps it is possible to take into account only those hours when the heating system is switched on. Depending on the thermal storage effect of the building a part of the ventilation losses during hours with heating system switched off, will also affect the heat demand. To keep the definitions of the steady state calculation it is suggested also in dynamic simulations to count the ventilation loss at any time during the heating period.

RESHYVENT approach

Performance criterion:	Ventilation energy loss: heat loss through warm air exhausted from the space during heating season, considering the heat recovery, if installed.
Evaluation parameter:	- Ventilation energy loss / m^2 heated floor area - Profile of ventilation energy loss / h / m^2 heated floor area in function of time
Assessment method:	Thermal dynamic simulation with one hour time step and pre-set temperatures
Threshold value(s):	TBD by IC or according to national requirements
Target value(s):	TBD by IC or according to national requirements
Considered by RHV WP:	WP 6

4.3.4 Electricity demand of ventilation system

Philosophy and Background

Electricity demand has to be evaluated separately, due to the different generation methods and the higher exergy level of electricity. For systems with heat recovery, there is a direct trade off between higher heat recovery efficiencies on the one hand and a higher electricity demand due to the higher pressure losses involved.

The major part of the electricity is used by the fan, however, the auxiliary energy for control, sensors, actuators, electrostatic filters and heat recovery with rotating wheels or by pump driven water circuit may significantly contribute to the electricity demand of the system. Therefore, not only the electricity demand of the fan has to be considered.

Existing criteria, thresholds, target values

Existing criteria are mainly related to specific fan power.

Proposed approach and options

Electricity demand for the operation and the control of the ventilation system including fan, and auxiliary components such as electric drives, electrostatic filters, actuators, sensors and control components. A reference design air flow rate shall be specified, to which the electricity demand can be related.

RESHYVENT approach

Performance criterion:	Electricity demand for the operation and the control of the ventilation system (energy)
Evaluation parameter:	Cumulated electric energy (kWh) for a reference air flow or (kWh per m^3 air supplied), considering fan(s) and auxiliary energy Reference air flow rates: A) Nominal flow, B) Hybrid ventilation C) Demand controlled A) Design air flow rates for mechanical ventilation The system is assumed to run according to the design air flow rates of the system B) Hybrid ventilation air flow rates The system is assumed to run according the design air flow rates in the individual rooms or zones and according to the control algorithms used for hybrid ventilation. Only parameter and driving forces which are not occupant dependant are considered C) Occupant related patterns Demand controlled systems are assumed to run with air flow rates according to the actual demand in relation to the occupancy, and according to the control algorithms, considering parameter and driving forces which are occupant dependant, especially IAQ parameter. Standardized occupancy profiles must be applied
Assessment method:	Simulation
Threshold value(s):	-
Target value(s):	-
Specific IC target value(s):	IC 2 has issued specific targets, see description of IC 2 system
Considered by RHV WP:	WP 6

4.3.5 Heat recovery performance factor

Philosophy and Background

Heat recovery is a major measure to reduce the heat demand of a building. In highly insulated buildings, ventilation losses can amount to over 50% of the space heat demand. However, heat recovery normally leads to higher pressure losses and the need for fan assistance is increased. Therefore, the heat recovered has to be weighted against the additional electricity demand. However, direct comparison of heat and electricity is not very evident. The comparison has to be performed on the basis of e.g. primary energy input for both heat and electricity, or on environmental impact criteria like greenhouse gas emissions.

Existing criteria, thresholds, target values

Methods in use compare the useful energy recovered in the heat exchanger with the electricity use of the fan. Normally, the total electricity demand of the fan is taken as the reference value, not only the additional fan power needed to transport the air through the heat exchanger element.

Evaluation time periods normally are the heating season or the complete year. State-of-the-art residential system reach factors of 8 to 10 ([ETIAQ], class 1).

Proposed approach and options

Options for energy:	a) heat demand b) cooling demand
Options for heat demand:	a) total heat recovered b) useful heat recovered For systems with recovery from exhaust to supply air useful recovered heat depends very much on the building (ratio of losses to gains, thermal inertia, allowed over temperatures). Furthermore, in systems with additional energy saving provisions, such as ground heat exchanger, the utilisation factor of the recovered heat changes with the additionally gained energy. Therefore it is questionable, whether the useful recovered heat is the correct criterion to assess the system. However at least for a certain building similar systems can be compared with this criterion.

Options for cooling demand: a) sensible heat
b) total heat (sensible and latent)

This topic is also considered by the heat and moisture recovery efficiency criteria for heat exchanger components

Options for electricity a) fan
b) total ventilation system (including control)
c) fan and heat pump (if installed)

Options for time period a) heating (cooling) season
b) total year

The time where heating is required may of course be significantly reduced if heat recovery is applied.

For the evaluation of the heat recovery performance, a balanced system would be first described by the efficiency of the heat exchanger device. In addition, heat gains from fans are also to be taken into account.

If R_{eff} is the heat exchanger efficiency and F_{eff} is the ratio of heat gain to the air to the electrical consumption, the heat gains depend on the position of the fan as follows :

- 1 supply fan in outer position : $F_{eff} \bullet (1-R_{eff})$
- 2 supply fan in inner position : F_{eff}
- 3 exhaust fan in inner position : $F_{eff} \bullet R_{eff}$
- 4 exhaust fan in outer position : 0

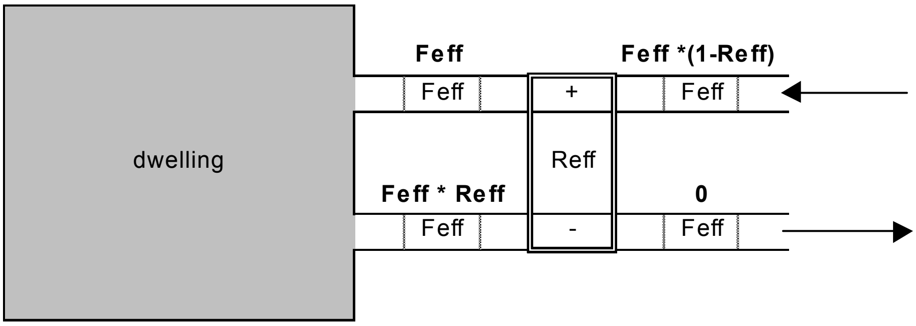


Figure 7: Different fan positions and the respective influence of heat gains from fans on heat recovery (Source: [IEA A27-V2])

In case of no heat recovery, case 2 and 4 will be applied.

The energy needed for de-icing of the heat exchanger has to be considered (both heat and electricity as far as applicable), either as a heat recovery reduction while using a bypass, or as the heat or electricity used to heat up the iced heat exchanger.

RESHYVENT approach

Performance criterion:	Heat recovery performance
Evaluation parameter:	Ratio of useful, sensible recovered heat to the total electricity demand of the ventilation system Reconsidered item Heat/ residual electricity Heat / electricity with HR and el. without HR
Assessment method:	Thermal dynamic simulation The useful recovered heat has to be evaluated depending on the recovery system: - For systems with heat recovery from exhaust air to supply air or to space heating system: The useful recovered heat is equal to the difference of the heat energy use with and without heat recovery. - For systems with heat recovery from exhaust air to hot water: the recovered heat can be calculated directly using the heat recovery efficiency (assuming that the whole heat recovery potential is used)
Threshold value(s):	No threshold
Target value(s):	No target
Specific IC target value(s):	No specific targets
Considered by RHV WP:	WP6

4.3.6 Renewable energy supply

Philosophy and Background

The major part of the electricity demand of the ventilation system is for the fan(s). However, controls, sensors, actuators, electrostatic filters, heat recovery with rotating wheels or pump driven water circuit will contribute to the electricity use of the ventilation system. Electricity consumption of each component has to be evaluated in detail. With these criteria the feasibility of “local” (stand-alone, autonomous, de-central, off-grid) generation of electricity by means of renewable energy is determined. The amount of renewable energy supply has to match the (overall) electricity use of the ventilation system or its component(s).

As the ventilation systems are applied in the built environment (residential areas) integration in the built environment is important in view of visual aspects. At present various initiatives are developed and tried for the use of small wind engines for the built environment These small wind engines are not accepted and proven yet. Moreover, they are not really fit for physical integration with (components of) the ventilation systems. Furthermore, there are both technical (vibrations, weight) and visual (height) constraints to the applications of small wind engines on roofs. Therefore, for the Reshyvent project we limited the possible use of Renewable Energy to the application potential of PhotoVoltaic (PV) solar energy.

Feasibility criteria, thresholds, target values

Feasibility criteria are related to the energy consumption and the energy consumption pattern of the fan(s) and auxiliary components during the day, the week and the year. The availability of fans and auxiliary devices with DC (Direct Current) operation rather than AC (Alternate Current) operation is an important criterion for the economic and trouble-free application of PV.
Thresholds are space (required area for solar module/-cell) and energy consumption. Target values may be defined as compensation of the extra costs for extra electricity for the ventilation system by applying PV. Applying PV may also reduce installation costs (e.g. cabling).

Proposed approach and options

For each defined climate type a ventilation concept will be defined. The ventilation concepts define the kind and number of devices that require electricity. For consideration to apply PV select only low consumption DC devices and/or find low consumption DC alternatives for AC devices. For each of the devices the electricity consumption profile is defined. Then PV requirement can be calculated and physical (space, orientation and location) and economic (initial and avoided costs) feasibility of PV can be determined.

For economic comparison purposes, PV vs. grid, the costs and use of the commercial grid for the electricity consumption of the ventilation system and the life cycle costs of the PV installation should be defined.
For environmental reasons and “image” the PV solution may be more expensive than the grid connect option. It is difficult to asses an acceptable difference on the basis of image. Subsidies may sometimes bridge the gap.

The criterion is the overall energy gained by applying PV against an acceptable (extra) cost.

Reshyvent approach

Performance criterion:	Renewable energy supply (kWh) compared to overall electric use of ventilation system
Evaluation parameter:	Avoided costs by applying PV instead of grid
Assessment method:	Calculation of electricity consuming devices of the ventilation system and calculation of PV system (size and costs) to supply electricity
Threshold value(s):	No defined threshold values as they are space, location and orientation dependent
Target value(s):	No target value. PV solution should be equal or better than connecting to the grid.
Specific IC target value(s):	PV for fans, actuators, sensors and controls
Considered by RHV WP:	WP 3

4.4 Energy performance characteristics of ventilation system components

4.4.1 Specific electric power demand of fan (SFP)

Philosophy and Background

Fan efficiency is a crucial element for the electricity demand of a mechanical ventilation system. New motor concepts and improved aerodynamics have lead to very efficient products.

Existing criteria, thresholds, target values

Best: 0.15 W/(l/s) [TipVent]

Proposed approach and options

The criterion is the electric power demand of the fan in relation to the transported air flow rate (specific electric power demand), at a given pressure difference level.
Options for data presentation are:
a) SPF for pre-set pressure difference
b) SPF for nominal pressure difference in the actual system
c) Characteristic curves of electric power demand vs. air flow rate for several pressure difference levels.

RESHYVENT approach

Performance criterion:	Specific electric power demand of fan (SPF)
Evaluation parameter:	Specific electric power demand of fan (SPF) at actual pressure difference level (W per l/s transported air)
Assessment method:	Measured according to standard [EN 13141-4], and product data
Threshold value(s):	No threshold
Target value(s):	No target
Specific IC target value(s):	No specific target
Considered by RHV WP:	ICs and WP5

4.4.2 Cooker hood – Electric power demand

RESHYVENT approach

Performance criterion:	Specific electric power demand of cooker hood
Evaluation parameter:	Specific electric power demand of cooker hood (W per l/s transported air)
Assessment method:	Measured according to standard [EN 13141-3], and product data
Threshold value(s):	No threshold
Target value(s):	No target
Specific IC target value(s):	No specific target
Considered by RHV WP:	ICs and WP5

4.4.3 Cooker hood – Extraction efficiency

<u>RESHYVENT approach</u>

Performance criterion:	Extraction performance of cooker hood
Evaluation parameter:	Odour extraction performance of cooker hood (odour reduction factor and odour dispersion time)
Assessment method:	Measured according to standard [EN 13141-3]
Threshold value(s):	No general threshold
Target value(s):	No target
Specific IC target value(s):	IC 1: 75 % odour extraction performance
Considered by RHV WP:	ICs and WP5

4.4.4 Heat recovery efficiency of heat exchanger

<u>Philosophy and Background</u>

The heat exchanger is the most important component to achieve a high heat recovery performance factor of the system. The heat exchanger should have the highest possible temperature efficiency and the lowest possible pressure drop. These are in a some kind contradictory requirements because increasing exchanger area increases both temperature efficiency and pressure drop. Therefore the temperature efficiency should be related to the additional electricity demand for transport of the exchanger. Internal leakage of the heat exchanger should be as small as possible.

<u>Existing criteria, thresholds, target values</u>

Best temperature efficiency at reasonable pressure drop and heat exchanger size: 90%

<u>Proposed approach and options</u>

To give the characteristic of the temperature efficiency vs. air transport power loss

<u>RESHYVENT approach</u>

Performance criterion:	Heat recovery efficiency
Evaluation parameter:	Temperature efficiency in relation to pressure drop [EN 308]
Assessment method:	Measurement, or product data
Threshold value(s):	No threshold
Target value(s):	No target
Specific IC target value(s):	No specific target
Considered by RHV WP:	ICs

4.4.5 Moisture recovery efficiency for regenerative heat recovery

With regenerative heat recovery there are possibilities to recover also moisture (e.g. by rotary wheel supplied by moisture ad/de-sorbent). This might be an important issue in colder climates, where high air flow rates compared to internal moisture source might lead to uncomfortable low relative humidity levels in the indoor air.

<u>RESHYVENT approach</u>

Performance criterion:	Moisture recovery efficiency
Evaluation parameter:	Moisture recovery efficiency [EN 308]
Assessment method:	Measurement or product data
Threshold value(s):	None
Target value(s):	No target
Specific IC target value(s):	IC 4 target is related to minimum RH
Considered by RHV WP:	ICs

4.5 Building air flows

Multi-zone air flows within the building have to be calculated because of the interrelation with design and dimensioning of the system and because performance criteria such as IAQ, energy demand, thermal comfort and room air flows are depending on the results of multi-zone air flow modelling. However, they are not considered as primary performance criteria and are therefore handled as intermediate results within RESHYVENT.

4.5.1 Room to room air flow

Air distribution within dwelling shall be from sleeping/living rooms to kitchen and wet rooms.

4.5.2 Multi-zone air exchange efficiency

The multi-zone air exchange efficiency characterises the air flow pattern within the building with just one value. Usually it is used to express the efficiency of the supply air distribution and the exhaust air collection in the whole building. But in respect to IAQ this is not a sufficient performance criterion. Depending on the presence of the sources in different rooms, buildings with the same multi zone air flow pattern can have totally different building IAQ. In addition to that, demand controlled systems will have low multi-zone air exchange efficiencies because only occupied zones are actually ventilated. Therefore it is not proposed to evaluate multi zone air flow pattern within RESHYVENT.
In order to asses the performance of the system in the whole building and not only in a particular room it is recommended to use occupant or more precisely group of occupants related IAQ criteria (see section 4.7.1). With this approach figures for whole building performance criteria can be generated with the additional possibility to weight the importance of the different rooms with the number of present occupants.

4.6 Room air flows

4.6.1 Direct outdoor air flow rate (habitable rooms)

<u>Philosophy and Background</u>
Outdoor air is required to remove polluted air and heat.
Most standards and regulations in some way or another include air flow rate requirements. In most cases these flows are understood as supply flows, were applicable, and as total flows otherwise.
However, air flowing from one room into another, may already be polluted/loaded and thus may not be considered as “fresh” air supply.

Outdoor air flow rate requirements are set out in many standard and regulations in terms of:
a) air flow per person (l/sec. person)
b) air flow per floor area (l/sec. m^2)
c) air flow per specified room (e.g. sleeping room or living room) (l/sec per room)

Air flow rates per person are based on assumed occupancy density.

For demand controlled ventilation it is unclear whether compliance with air flow requirements has to be met for assumed or for actual occupancy density.

Existing criteria, thresholds, target values

See [AIVC TN 55]

Proposed approach and options

The direct outdoor air flow into the individual room is considered. This means that certain rooms may have a direct outdoor air flow rate of zero. The actual performance criterion is the number of hours where minimum or maximum air flow rate requirements are not met. The evaluation can be performed a) for hours where the room is occupied or b) for all hours, dependent on how the required air flow is specified (per person or per floor area or per room).

RESHYVENT approach

Performance criterion:	Compliance to minimum and maximum outdoor air flow requirements
Evaluation parameter:	Number of hours with airflow rate below and number of hours with airflow rate above threshold (room related, only hours with occupancy are considered)
Assessment method:	Histograms, simulation output
Threshold value(s):	Minimum and maximum air flow rate as specified for room under investigation
Target value(s):	Target level classes: Min: 1) < 10% 2) 15% 3) 20% of time of occupancy Max: 1) < 10% 2) 15% 3) 20% of time of occupancy
Specific IC target value(s):	To be defined later by ICs
Considered by RHV WP:	WP 6, priority 2

4.6.2 Exhaust air flow rate (wet rooms and kitchen)

Many standards and regulations include also extract air flow rate requirements for wet rooms/kitchen, mostly in terms of extract air flow per specified room (toilet, bath room or kitchen) (l/sec per room)

Existing criteria, thresholds, target values

See [AIVC TN 55]

Proposed approach and options

The extract air flow out of the specified room is considered. The evaluation can be performed a) for hours where the room is occupied or b) for all hours.

RESHYVENT approach

Performance criterion:	Compliance to minimum extract air flow requirements
Evaluation parameter:	Number of hours with airflow rate below threshold (room related)
Assessment method:	Histograms, simulation output
Threshold value(s):	Minimum extract air flow rate as specified for room under investigation
Target value(s):	Target level classes: 1) < 10% 2) 15% 3) 20% of time of occupancy
Specific IC target value(s):	To be defined later by ICs
Considered by RHV WP:	WP 6, priority 2

4.6.3 Air flow stability

Philosophy and Background

This criterion is to evaluate how close design flow rates are met during operation of the system in both natural and mechanical ventilation mode. For demand controlled ventilation it is unclear whether compliance with air flow requirements has to be met for the assumed or for the actual occupancy density.

Existing criteria, thresholds, target values

Within +/- 5% of design value [IEA A27-V2].

Proposed approach and options

The evaluation can be performed a) for hours where the room is occupied or b) for all hours, dependent on how the required air flow is specified (per person or per floor area or per room). This criterion is perhaps not needed, or only for the evaluation of the control.

RESHYVENT approach

Performance criterion:	Compliance with design air flow rates
Evaluation parameter:	% of time in which air flows are within +/- X % tolerance band of design air flow rates
Assessment method:	Histograms, simulation output
Threshold value(s):	Within +/- 5% of design value
Target value(s):	Air flow rates within thresholds in class1) 50%, class 2) 25 of % of time
Considered by RHV WP:	General description in WP 5 Technical Report

4.6.4 Air distribution

Philosophy and Background

A specified delivery of supply air and removal of polluted air shall be achieved by as little outdoor or supply air flow as possible. Supply air shall be delivered to all parts of the occupant zone and possible pollutant sources shall be removed as directly as possible. To evaluate room air flow patterns in the respect to outdoor air distribution, the air exchange efficiency criterion can be applied.
With the low air flow rates commonly used in residential ventilation, displacement ventilation concepts can be realised only in specific cases. Therefore, air exchange efficiencies normally are close to the value for perfect mixing.
The efficiency is determined for specific steady state conditions.

Existing criteria, thresholds, target values

Target values for air exchange efficiencies are set out more in the field of office ventilation.
Germany: "This is done by general demands on the indoor climate (operative temperature, air quality, air moisture, velocity, pollution and ventilation efficiency)."
Sweden: "The air change efficiency is recommended to be not less than 40 %."

Proposed approach and options

Room air flow patterns may be evaluated by the air exchange efficiency criterion especially in cases where air supply and extract or transfer are close together, or where for other reasons a short-circuiting and/or zones with low air supply are expected.

RESHYVENT approach

Performance criterion:	Efficiency of supply air distribution in the room
Evaluation parameter:	Room air exchange efficiency
Assessment method:	Generic, based on results from measurements and CFD analysis
Threshold value(s):	None
Target value(s):	No general target IC 1 Sweden: Efficiency > 40% (fully mixed condition = 50%)
Specific IC target value(s):	No specific target
Considered by RHV WP:	WP 5 (and IC specific CFD simulations if necessary)

4.6.5 Pressure difference across building envelope (room – façade or room – ground)

Philosophy and Background

In rooms with atmospheric room heating appliances or for rooms where radon ingress must be considered, the risk for critical under pressures must be checked in the evaluation of the ventilation system.
In critical cases, these issues must be investigated in more detail.

Existing criteria, thresholds, target values

For less than 200h : Pressure difference across façade P_{diff} <-20 Pa, >+20 Pa [IEA A27-V2]

Proposed approach and options

The following pressure differences are to be checked, depending on the appliances installed and the risk to be evaluated:

a) room with appliance to other rooms (especially kitchen with cooker hood)
b) room with appliance to facade or above roof outside (depending on positions of air supply and exhaust of heating appliance)
c) room under investigation to ground (for radon ingress risk assessment)

Normally, the evaluation will be performed by computer simulation. For heating appliances, pressures have to be checked when appliances are on, for radon risk evaluation, the whole year period has to be considered.

RESHYVENT approach

Performance criterion:	Indoor – outdoor pressure difference across building envelope or room – ground
Evaluation parameter:	Minimum, maximum pressure difference for a specified threshold value of hours (Pa)
Assessment method:	Simulation output, frequency diagram or specific assessment algorithms, Evaluation only for room with appliance or room with radon ingress risk
Threshold value(s):	P_{diff} <-20 Pa, >+20 Pa [IEA A27-V2]
Target value(s):	In general: Pressure outside range for less than 200h When appliance on: pressure outside range at no time
Considered by RHV WP:	WP 5 Technical report

4.7 Indoor air quality

Indoor air quality is evaluated on the basis of

- perceived air quality
- pollutants which are not sensed, but are harmful to health

Indoor air quality is affected by

- bioeffluents from occupants due to their metabolism
- pollutants released due to activities of the occupants (cooking, cleaning, smoking etc.)
- pollutants released by building and furniture materials
- quality of outdoor air and of (filtered) supply air

Humidity in the indoor air has a direct and a indirect impact on the occupant. Humidity directly affects the thermal sensation of the occupants, and low humidity may cause sensation of dryness and irritation of skin. On the other hand high humidity may stimulate growth of mould and other species, and enhance release of pollutants. Condensation has an impact on the building structure as well as on mould growth.

4.7.1 General aspects of IAQ assessment

Minimum IAQ requirements vs. time integrated value

One approach is to apply strict maximum values for certain pollutants, e.g. not more than 1000 ppm CO_2. All systems which are not able to stay below this limit value are not tolerated. This approach has the advantage that it is rather simple to apply but it clearly has the disadvantage that certain strategies may be excluded even if they may lead during certain periods to pollution levels which are only slightly above the maximum value. This clearly is the case for natural ventilation systems, but may occur also for controlled natural ventilation.

Instead of using a fixed value, one can also focus on some kind of time integrated value.
Such kind of approach is applied in the Netherlands. When applying the principle of equivalence for ventilation system approval, the IAQ performances of the system should be equal or better than the reference system.

Spacial evaluation

IAQ evaluations can be performed per room, per building, per person (dose), or per room but occupancy related. The option has to be selected in accordance with the source pattern and schedules used for occupancy and for other pollutants.

Dose approach

When applying the dose approach, the system performance is not only dependant on source and air flow patterns, but also on the specified occupant patterns. Therefore, for a comprehensive evaluation, several different occupant patterns may be considered. Occupant patterns may be defined in terms of occupant individual type, presence time and space (in which room) and related individual activities.

4.7.2 CO_2 (Metabolism)

Philosophy and Background

CO_2 is the most important human bio-effluent, and a good indicator for the concentration of other human bioeffluents which affect the perceived indoor air quality. Therefore, CO_2 is a good indicator of the indoor air quality, where occupant metabolism is the main pollutant source.

Some adaptation takes place for bio-effluents during occupancy, while little or no adaptation occurs for other pollutants such as emissions from building materials and for tobacco smoke.

Existing criteria, thresholds, target values

Limits for CO_2 concentration levels are postulated in many standards and guidelines:

- [EN 13779]: 1) ≤ 400 , 2) 400-600, 3) 600-1000, 4) ≥1000 ppm CO_2 above outdoor level
- [CR 1752]: Class A: 460 , B: 660 , C: 1190 ppm CO_2 above outdoor level
- [IEA A27-V2]: 1) 700, and 2) 1400 ppm CO_2

These values are considered as room related concentrations. No existing approaches consider the occupant related exposure.

Proposed approach and options

The system performance is evaluated by determining the time and the amount of exceeding the given threshold values for the CO_2 concentration (for definition see figure 4 in §3.2).
This evaluation can be performed either 1) room oriented or 2) occupant related, considering the exposure of an occupant present in the room.

RESHYVENT approach

Performance criterion:	Time integrated CO_2 concentration exceeding (concentration above outdoor level)	
Evaluation parameter:	Hours above threshold x (actual concentration – limit concentration), accumulated per person present in the room (exposure per person) (k ppm.h)	
Assessment method:	Simulation output. Exposure profiles to be determined for all occupant types considered	
Threshold value(s):	700ppm and 1400ppm above outdoor concentration level	
Target value(s):	For 700ppm: 500 kppm.h,	For 1400ppm: 100 kppm.h
Considered by RHV WP:	WP 6, priority level 1	

4.7.3 Pollutants from cooking, passive smoking and emissions from building and furniture materials

Philosophy and Background

One major purpose of ventilation is to remove pollutants which are released by occupant activities and/or from building and furniture materials. Pollutants may have olfactory as well as health related effects.

Proposed approach and options

As a first approach, only the air transport of pollutants is considered. In this case, for the evaluation of ventilation systems, especially for comparative evaluations, it is not absolutely necessary to consider real pollutant concentrations. Generic sources may be introduced which are subject to the same distribution patterns as real pollutants. Such generic pollutants can be used for the evaluation of the ventilation system performance in regard to IAQ, but of course not for the evaluation of the IAQ itself. For this, source data for real pollutants have to be used.

However, as soon as wall and furniture adsorption/ desorption effects of the pollutants are considered in the source model, realistic room air concentrations are to be considered.

The threshold for these generic pollutants is set to zero. Thus the dose evaluation accounts for the total concentration in the occupied room.

The evaluation approach for these type of pollutants of course is very much dependent on the type of source data and models selected and used in the evaluation process, see paragraph on design constraints.

Existing criteria, thresholds, target values

Cooking: Class 1: 600 hours, Class 2: 1000 hours [IEA A27-V2]

RESHYVENT approach

Performance criteria:	Exposure to generic pollutant concentration for cooking, passive smoking and emissions from building and furniture material
Evaluation parameter:	Dose (hours x generic pollutant concentration above threshold)
Assessment method:	Simulation output. Exposure profiles for all occupants
Threshold value(s):	Threshold = 0
Target value(s):	No target value
Considered by RHV WP:	WP 6, to be considered with task priority level 1 (smoking is level 3)

4.8 Indoor air quality: Humidity

4.8.1 Low humidity (dryness feeling)

Philosophy and Background

Respiratory parts and the skin of humans may show symptoms of dryness when exposed to dry air over a longer period of time. Occupants may also complain about a dryness feeling. However, the dryness feeling is also linked to the concentration of dust and other irritants in the room air. In conclusion, the evaluation concentrates on the longer periods of low indoor air humidity levels.

Existing criteria, thresholds, target values

< 800 hours below 5g/kg AH [IEA A27-V2] or 30% RH (see "condensed index" in [IEA A27-V2])

Proposed approach and options

As the effect is clearly related to the occupant, an exposure or dose criterion should be applied. On the other hand, a system related criterion should focus on system performance. A relevant criterion in this case would be the number of hours with low humidity levels, when the room is occupied.

RESHYVENT approach

Performance criterion:	Periods of low room air humidity
Evaluation parameter:	1. Number of hours of exposure to relative humidity (RH) below threshold, to be evaluated for each person present in the room (exposure per person) 2. Number of hours with relative humidity (RH) below threshold, when room occupied.
Assessment method:	Simulation output. Exposure profiles to be determined for all occupant types considered.
Threshold value(s):	30% RH
Target value(s):	< 800 hours below 5g/kg AH [IEA A27-V2]
Considered by RHV WP:	WP5 TR and WP 6 (1^{st} priority)

4.8.2 High room air humidity

Philosophy and Background

The moisture content in the room air directly affects the comfort sensation of the occupant. High humidity and condensation may also lead to increased growth of mould, house dust mites, fungi, bacteria and other species which indirectly affect the health of the occupant. High humidity may also increase the source strength of certain pollutants. Moisture in exfiltrating air may also condense in the building structure, thus leading to structural damages.

Existing criteria, thresholds, target values

Threshold: 75% RH [IEA A27-V2]
Mould growth : RH (weekly average) > 75% ([IEA A27-V2], referring to IEA Annex 14 Source book page 2:16 – 17 [IEA A14])

Mould growth may depend on temperature as well. This is not considered in RESHYVENT.

Proposed approach and options

This effect is clearly related to the building construction. A room related criterion is appropriate. There are two criteria: a) for high room air humidity in general and b) for the risk of mould growth as proposed in Annex 27.

RESHYVENT approach

Performance criteria:	1. Time with high room air humidity 2. Risk for mould growth due to high indoor air relative humidity, 1 week average (RH-1wa)
Evaluation parameter:	1. Number of hours above 75% RH [IEA A27-V2] 2. No of weeks with 1-week-average of relative humidity (RH-1wa) > threshold
Assessment method:	Histograms, simulation output
Threshold value(s):	1. 75% RH 2. (RH-1wa) > 75 %
Target value(s):	1. No target 2. No of weeks ≤ 1
Considered by RHV WP:	WP 6 Priority 1

4.8.3 Condensation risk

Philosophy and Background

Condensation is an important criterion. It is related to the mould growth risk evaluation, as mould may grow when relative humidity levels close to the external wall surfaces are above 70 to 80 %. Thus, the criteria considers both to the building envelope and to the ventilation system performance.

Existing criteria, thresholds, target values

In many cases, condensation can be evaluated by using the temperature factor, based on monthly average temperatures, see [IEA A14] and [Wouters PhD, Chapt.5. p.64]. The temperature factor f_t is defined as a ratio between two temperature differences. A first definition of the temperature factor is related to the temperature of the inner surface of the critical external wall or wall element. A second definition is related to the dew point of the room air. The surface related temperature factor f_t is defined as follows:

$$f_t = \frac{\theta_{Surface,lowest} - \theta_{outdoor\ air}}{\theta_{Room\ air} - \theta_{outdoor\ air}}$$

considering the lowest temperature $\theta_{Surface,lowest}$ on the inside surface of a given structure in relation to the room air and the outdoor air temperature $\theta_{Room\ air}$, $\theta_{outdoor\ air}$.

Lowest surface temperatures are mostly found not on plain walls, but in configurations with thermal bridges. For the evaluation of the ventilation system, to avoid too detailed numerical heat flow analysis, condensation can only be checked for some typical and/or critical elements of the building envelope. In such simplified cases, the U-value of the element can be used for the evaluation of the condensation risk.

Proposed approach and options

It is proposed to apply the temperature factor approach also for the transient simulations on the basis of hourly or sub-hourly time step.

RESHYVENT approach

Performance criterion:	Condensation risk
Evaluation parameter:	Number of hours where condensation occurs for glazing with - temperature factor f_t = 1 (wet rooms) - f_t = 0.875 – 0.750 (habitable rooms) acc. to IC reference building parameters
Assessment method:	Histograms, output from transient building and ventilation simulation
Threshold value(s):	None
Target value(s):	No target
Considered by RHV WP:	WP 6, priority 2

4.8.4 Humidity levels in regard to house dust mites

Philosophy and Background

For house dust mites, it is often assumed that the average humidity on a long term period should remain below a certain limit. However, house dust mites can survive long periods of dryness and “awake” during very short humidity peaks.

Existing criteria, thresholds, target values

IEA Annex 27: 4 weeks average value of indoor absolute humidity calculated each week. The condensed output is the number of weeks with AH<7g/kg. The target is at least one 4 week period with AH< 7g/kg, [IEA A27-V2] and [J. Korsgaard, Aarhus].

Proposed approach and options

See RESHYVENT approach

RESHYVENT approach

Performance criterion:	Humidity in regard to house dust mites
Evaluation parameter:	4 week average of absolute room air humidity, calculated each week
Assessment method:	Simulation histogram
Threshold value(s):	AH< 7g/kg
Target value(s):	At least one 4 week period with AH< 7g/kg
Considered by RHV WP:	WP5 TR and WP 6 (1st priority)

4.9 Thermal comfort

Sensation prediction of thermal environment

The basis for thermal comfort evaluations are outlined in [ISO 7730] and [CR 1752]. The perceived thermal environment in a room is evaluated considering a) the human response for the body as a whole, and b) by evaluating local discomfort due to draught, high vertical temperature difference, high floor or ceiling surface temperature or high asymmetry in radiant temperature.

To predict the thermal sensation, the PMV (predicted mean vote) or PPD (predicted percentage of dissatisfied) indices are introduced, considering the following six parameter::

- Physical activity of occupant (met)
- thermal resistance of clothing (clo)
- air temperature
- mean radiant temperature
- air velocity
- partial water vapour pressure

Local discomfort

Local discomfort is evaluated considering the following aspects:

- draught risk
- high vertical air temperature difference
- high floor or ceiling surface temperature
- high asymmetry in radiant temperature

Evaluation of thermal environment and local discomfort: Approaches and options

For the definition of thermal environment assessment procedures several aspects have to be considered:

- Which parameters are to be considered?
  Air and mean radiant temperatures can be merged into one parameter, the operative temperature. This operative temperature normally can be determined by thermal building simulation.
  However, this is not the case for air velocity. Therefore, draught evaluations have to be performed separately.
  Humidity might be considered in the PPD approach, see below.
- Relation of selected met and clo parameters to ambient and room conditions?
  The PPD index is determined for one set of clo and met values. However, especially the clothing may be adjusted by the occupant to outdoor and indoor conditions, especially in residential buildings. Thus, for evaluations over time, the relation of clo and met to outdoor and indoor thermal conditions and the respective distributions have to be considered.
- How to handle the time related aspects?
  Time related aspects are handled by specifying a threshold for the PPD and by evaluating the upper deviation form the threshold.
- Thresholds and limits
  Different threshold and limits may be set according to the building type and use, the climatic regions, the cultural background and building construction tradition, etc.
- Adaptive thermal comfort
  Studies of [Brager] [de Dear] and [Olesen] show that thermal comfort may be dependant on elements such as
  - expectations of the occupant in relation to how the indoor environment is established
    (naturally ventilated or air conditioned building)
  - adaptation of occupant to climate (hot, cold, humid, arid).

  This has also been considered in an new Dutch guideline, see [Raue 2004].

For the evaluation of the thermal environment, two basic approaches are feasible:

1. PPD based approach.
   A threshold in respect to PPD is defined, considering different clo (and met) levels for the different seasons.
2. Temperature limit approach
   Upper and lower temperature limits are defined on the basis of given PPD rate and the relation of clo (and met) to the outdoor climate conditions.
   With this approach, any adaptive behaviour of the occupant is intrinsicly considered.

<u>RESHYVENT approach</u>

A PPD based <u>and</u> a temperature limit approach are applied. Temperature limits may be adapted to regional or national requirements.
Specific temperature limits for the natural ventilation mode are not considered, although there might be an allowance for higher PPD in the natural ventilation mode.

4.9.1 Thermal environment: PPD based

<u>Existing criteria, thresholds, target values</u>

PPD threshold:	Class 1: 6 % PPD	Class 2: 10% PPD	Class 3: 15% PPD	[CR 1752]
Clo and met:	Summer: 0.5 clo, 1.0 met Winter: 1.0 clo, 1.0 met			[ISO 7730]

<u>Proposed approach and options</u>

Different climatic conditions may be considered by adapting the clo (and met) values.
The influence of the ventilation system type on comfort sensation may be considered by selecting different rates for the permissible PPD (e.g. higher PPD value allowed for naturally ventilated buildings).

<u>RESHYVENT approach</u>

Performance criterion:	Exceeding of PPD threshold
Evaluation parameter:	No of hours with PPD above threshold, considering presence of occupants PPD to be determined based on PMV, considering met, clo and operative temperature based on surface area weighted mean radiant temperature. Air velocity and partial vapour pressure are not considered
Assessment method:	Simulation
Threshold value(s):	10% PPD for the selected met and clo [ISO 7730], [CR 1752], based on operative temperature Summer: 0.5 clo, 1.0 met Winter: 1.0 clo, 1.0 met
Target value(s):	Within limits for 90% of time, considering presence of occupants
Considered by RHV WP:	WP 6

4.9.2 Thermal environment: Temperature limit based

<u>Philosophy and Background</u>

Room temperatures, especially room air temperatures, can both easily be measured and determined by simulation. Therefore, it is quite logical to evaluate thermal comfort conditions on the basis of room air or operative temperatures.

<u>Existing criteria, thresholds, target values</u>

Upper and lower temperature limits (air temperature or operative temperature) as a function of outdoor conditions are given in many standards and regulations.
Examples are: [ASHRAE 55-2004] (USA), [DIN 1946-2] (German standard) , [SIA 382/2] (Swiss standard, see figure).

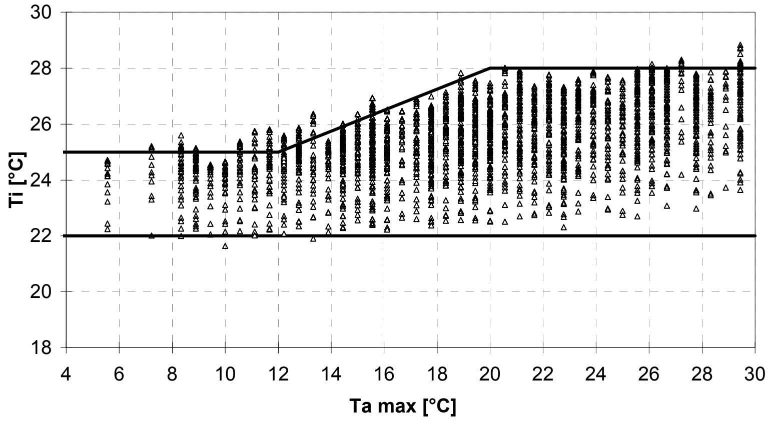


Figure 8:
Example of temperature limits as stipulated in Swiss standard [SIA 382/2], with results from a typical simulation (each dot represents the situation at a certain 1h time step during occupancy)

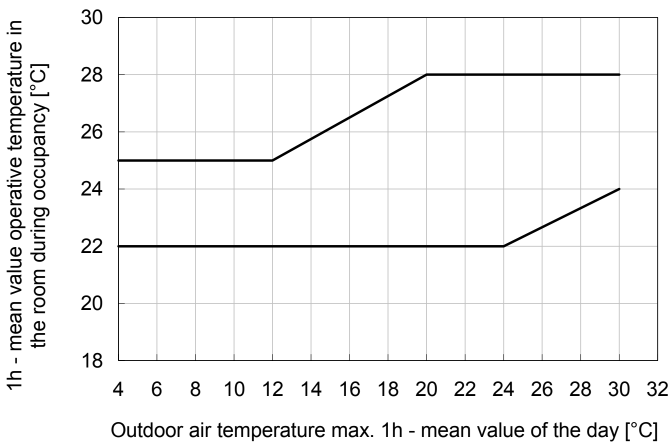
Ti: 1h mean value of the room air temperature during occupied time
Ta max: maximum 1h mean value of the outside air temperature of the day

<u>Proposed approach and options</u>
Different climatic conditions may be considered by adapting the temperature limits.

<u>RESHYVENT approach</u>

Performance criterion:	Exceeding or undershot of operative room temperature limits
Evaluation parameter:	Absolute value of temperature difference to threshold times no of hours, considering presence of occupants (K.h)
Assessment method:	Simulation, operative temperature based on surface area weighted mean radiant temperature
Threshold value(s):	Figure with limits for operative temperature (1h mean value during occupied time) as a function of outdoor air temperature (maximum 1h mean value of the day). The temperature limits are not identical to the design temperature target values. The temperature limit figures may be established according to the different climatic regions.

Below temperature limits for moderate climate are given.



Target value(s):	50 K.h. Cases with Ta max > 30 °C are not considered (this applies only for cold and moderate climates)
Considered by RHV WP:	WP 6 Simulations

4.9.3 Draught risk

Philosophy and Background

Draught is an element of local discomfort, caused by unwanted local cooling of the body due to air movement and temperature. Draught risk limits are set for the occupied zone of a space.

Existing criteria, thresholds, target values

Draught risk is also expressed in predicted percentage of people being bothered [CR 1752]. Besides air velocity and temperature draught is also dependent on the local turbulence intensity of the air.
PPD < 15 % for 85-95% of lattice points in room [IEA A27 H].

Thermal comfort requirements must in principle be met in the occupied zone. This zone has to be defined according to the actual needs.

Occupied zone

Definition of occupation zone as specified in EN 13141-1, chapter 3 : Definitions, paragraph 3.9 [EN 13141-1]:
occupied zone (for laboratory measurement purpose):

Occupation zone of the test room limited to:
- 1,8 m above floor level
- 0,5 m from any wall
- 0,1 m from floor.

Table 2 gives the definition of the occupied zone as defined in [EN 13779]. However, according to the "scope" in that document, the standard applies to the design of ventilation and room-conditioning systems for non-residential buildings subject to human occupancy.

Distance from inner surface of	
Floors (lower boundary)	0.10 m
Floors (upper boundary)	1.80 m
External windows and doors	0.50 m
Radiators	0.50 m
External walls	0.50 m
Internal walls	0.50 m
Doors, transit zones etc.	special agreement

Table 2: Definition of the occupied zone as given in [EN 13779]

Proposed approach and options

Draught risk has to be determined by either measurement and/or CFD calculations for a given situation in terms of air temperatures, velocities and turbulence intensities, for a number of points in the occupied zone of a given room or space.
Time dependent evaluations are only feasible for short time periods, especially for CFD.

RESHYVENT approach

Performance criterion:	Draught risk in the occupied zone for a critical configuration
Evaluation parameter:	Draught risk as a function of air temperature, air velocity, turbulence intensity, according to [ISO 7730] and [CR 1752] Occupied zone to be defined
Assessment method:	Results form measurements and CFD calculations, for steady state conditions. Evaluation with simplified tool. No evaluation of transient conditions and no long term evaluation
Threshold value(s):	No threshold
Target value(s):	PPD < 15 % for 85-95% of lattice points in room (or 100 % within occupation zone)
Considered by RHV WP:	WP 5 Technical report and IC specific evaluations

Within RESHYVENT, the occupation zone is defined as follows:

Distance from inner surface of	Typical range	Default value
Floors (lower boundary)	0.00 to 0.20 m	0.05 m
Floors (upper boundary)	1.30 to 2.00 m	1.80 m
External windows and doors	0.50 to 1.50 m	1.00 m
Radiators	0.50 to 1.50 m	1.00 m
External walls	0.15 to 0.75 m	0.50 m
Internal walls	0.15 to 0.75 m	0.50 m
Doors, transit zones etc.	special agreement	

Table 3: Definition of the occupation zone as used within RESHYVENT

4.10 Acoustics

General

As for other criteria, also the acoustic indoor environment is a result of several influences, e.g. sound emitting sources, sound transport and respective attenuation measures, and outdoor conditions (outdoor noise level).
Target values for ventilation systems are to be set according in relation to the acoustic quality of the building, i.e. poor acoustic quality of ventilation systems in dwellings with high acoustic quality of partitions are to be avoided.

4.10.1 Sound pressure level in room

Philosophy and Background

Sound pressure level in rooms are an important element of any indoor environment evaluation.

Existing criteria, thresholds, target values

Swiss standard [SIA 181]:	night time	day time
Minimum requirements	30 dB(A)	35 dB(A)
Higher requirements	25 dB(A)	20 dB(A)
- recommended	20 db(A)	25 dB(A) depending on background noise situation

[CR 1752] (values for hotel rooms, no values are given for residential buildings)

Category A	25 dB(A)	30dB(A)
Category B	30 dB(A)	35 dB(A)
Category C	35 dB(A)	40 dB(A)

Proposed approach and options

See RESHYVENT approach

RESHYVENT approach

Performance criterion:	Sound pressure level	
Evaluation parameter:	A-weighted sound pressure level at specified location in the room	
Assessment method:	Measurement: Calculation:	[EN ISO 11200 - 11205] (To be defined in more detail) see [AIVC TN 52]
Threshold value(s):	None	
Target value(s):	25 dB(A) for sleeping rooms, for quiet environment	
IC Target value(s)	25 dB(A) for balanced systems	
Considered by RHV WP:	WP 5 (generic), individual IC (specific)	

4.10.2 Sound power level of ventilation system (see also components)

Philosophy and Background

Sound emissions from the ventilation system are a crucial element for user acceptance and thus an important element of any indoor environment evaluation. The starting point for a good acoustic performance of the system is of course the respective acoustic quality of the components.

Existing criteria, thresholds, target values

See [AIVC TN 52]

Proposed approach and options

See RESHYVENT approach

RESHYVENT approach

Performance criterion:	A-weighted sound power level (indoor and outdoor)
Evaluation parameter:	A-weighted sound power level (indoor and outdoor)
Assessment method:	measurement [EN ISO 9614-2]
Threshold value(s):	No specific threshold
Target value(s):	No specific target
Specific IC target value(s):	IC 1: Ventilation system 26 dB(A), cooker hood 35 dB(A) (Class B according to Swedish Standard) IC 2: same
Considered by RHV WP:	WP 5 (generic), individual IC (specific)

4.10.3 Outdoor noise reduction: Outdoor air transfer devices

Philosophy and Background

The sound attenuation capapbility of outdoor air transfer devices (OATD) is an important aspect for the evaluation of hybrid extract ventilation systems.

Existing criteria, thresholds, target values

See [AIVC TN 52]

Proposed approach and options

See RESHYVENT approach

RESHYVENT approach

Performance criterion:	Sound pressure difference
Evaluation parameter:	Sound pressure difference, normalized to $10m^2$ [dB]
Assessment method:	Measurement: [EN ISO 140-10] Evaluation: [EN ISO 717-1]
Threshold value(s):	Class 1: 35 dB, Class 2: 30 dB (see remark)
Target value(s):	as threshold
Considered by RHV WP:	WP 5 (generic), individual IC (specific)
Remark	Target levels depend on noise load on facade; in general indoor noise level caused by outdoor sources < 35 dB(A)

4.10.4 Outdoor noise reduction: Outdoor wall including air transfer devices

Philosophy and Background

The sound attenuation capability of outdoor air transfer devices (OATD) is an important aspect for the evaluation of hybrid extract ventilation systems. However, it is not the noise reduction capability of the OATD which determines outdoor noise reduction, but the overall performance of the wall including the OATD has to be considered. In fact, the sound attenuation capability is determined by on one hand the outdoor noise level, and on the other hand by the indoor noise level requirement. Therefore, the outdoor noise reduction requirement is not a principal requirement, but a requirement which is determined by other requirements.

Existing criteria, thresholds, target values

National regulations e.g. Swiss standard [SIA 181] or [DIN 4109/1-7]

Proposed approach and options
see RESHYVENT approach

RESHYVENT approach

Performance criterion:	Sound pressure difference
Evaluation parameter:	Required standard sound pressure difference for different outdoor noise conditions [dB]
Assessment method:	Measurement: [EN ISO 140-5] Calculation: [EN 717-1]
Threshold value(s):	depending in outdoor noise situation and required limit for indoor noise level (e.g. quiet area: 30 dB, noisy streets: 45 dB)
Target value(s):	as threshold
Considered by RHV WP:	WP 5 (generic), individual IC (specific)

4.10.5 Sound transmission: Internally from dwelling to dwelling

Philosophy and Background
In multifamily buildings, sound attenuation between individual apartments is of great relevance. The ventilation system may play an important role in sound transmission. In fact, the sound attenuation capability is determined on the one hand by the noise level of the adjacent dwelling (or room), and on the other hand by the required indoor noise level.

Depending on the ventilation system design, ducts may play the crucial role in this type of noise transmission.

Existing criteria, thresholds, target values
Class 1 55 dB [Source ??]

Proposed approach and options
see RESHYVENT approach

RESHYVENT approach

Performance criterion:	Overall sound reduction between dwelling
Evaluation parameter:	Sound pressure difference (dB)
Assessment method:	Measurement [EN ISO 140-4]
Threshold value(s):	
Target value(s):	Target value for the ventilations system to be set in relation to the acoustic quality of the building.
Considered by RHV WP:	WP 5 (generic), individual IC (specific)

5 DESIGN CONSTRAINTS

5.1 Introduction

Just a few constraints are described in this report, which allow for a general application of the performance assessment method to other (hybrid) residential ventilation systems.
For a comprehensive list of possible design constraints, see also RESHYVENT document [RHV-WP6-WR1] (by P. Schild).

Note:
For the performance assessment of the RESHYVENT IC systems, specific sets of constraints are defined in the RESHYVENT report “Description of reference buildings and ventilation systems” [RHV-WP5-WR4].

5.2 Outdoor climate

5.2.1 Climatic regions

Weather data are to be selected from a station as close as possible to the actual site or as representative as possible for the selected climatic region to be investigated.

5.2.2 Parameters

The following climatic data must be available in 1 h time step (e.g. TMY, DRY meteo files)

- Outdoor temperature and humidity
- Local wind speed and direction
- Solar radiation (global, beam)
- Outdoor level of CO2 and other pollutants
- Barometric pressure

On the transfer of wind data from meteo station to site see & 5.4. and RESHYVENT WP 5 Technical report .
On the reliability of wind data in the different meteo data file formats, see RESHYVENT WP 5 Technical report.

Time steps < 1h

For simulations with a time step < 1 h, the outdoor conditions are (TBD) are held a) constant for 1 h, b) are interpolated
This topic is handled by WP6 and WP7.
At the moment there is no time step < 1 h used in the simulations.

Weekdays, weekends

This issue may be considered in the specific input data for the boundary conditions, e.g. occupant data.

RESHYVENT approach

For the RESHYVENT IC system evaluation, four weather files according to the four IC regions are to be defined:

Climatic region		Weather station file
1	Cold	Stockholm
2	Moderate	Amsterdam, Brussels
3	Warm	Paris, Nice
4	Severe	Oslo

Table 4: Weather station files used in Reshyvent

This weather files can also be used for the climate evaluation of the other systems.

5.3 Heating season (and cooling season)

As outlined in chapter 4, the heating season may be a fixed period defined for each climate and building type. For space heating energy demand, a different approach is, to switch on the heating system only on those days when the daily averaged heat gains using a conventional utilisation factor do not balance the averaged heat losses. On days with heating system switched off, the room temperature might fall temporary below the set point.

Definition according to [IEA A27-V2]:

1. calculate for each day the average outdoor temperature on the period of 15 days before and 15 days after
2. start in summer
3. stop when this averaged daily temperature is equal to 13 °C. This is the starting day of the heating season, which is defined as Monday
4. restart the calculation of daily average temperature until spring
5. stop when it is equal to 13 °C . This is the last day of the heating season, whatever day it is.

For cooling, approaches similar to the heating season might be defined.

5.4 Building environment

5.4.1 Wind terrain boundary layer (wind profile)

The wind speed profile in the boundary layer is dependent on the upstream terrain roughness and can be described with different models (eqn 1 and 2).

Power law:

$$\frac{U_2}{U_1} = \left(\frac{z_2}{z_1}\right)^{\alpha} \qquad (1)$$

Logarithmic law:

$$\frac{U_2}{U_1} = \frac{\ln(z_2 / z_0)}{\ln(z_1 / z_0)} \qquad (2)$$

Table 5 shows values for the profile exponent α and the roughness height z_0 for different terrain roughness classes.

class	terrain description	α	z_0	z_u
1	sea, flat terrain without obstacles	0.1 - 0.15	0.005 - 0.05	240 - 320
2	open terrain with isolated obstacles	0.15 - 0.25	0.05 - 0.5	320 - 400
3	wood, small city, suburb	0.25 - 0.35	0.5 - 1.5	400 - 480
4	city centre	0.35 - 0.45	1.5 - 3	480 - 550

Table 5: Terrain roughness classes and the according profile exponent α roughness height z_0 and thickness of the boundary layer z_u [Wolfenseher]

The transfer of wind speed data from meteo location to the building site with the simple method uses only the wind profile from either locations. It may be applied for flat topography without any hill or mountain between the two places and building locations not to far from measurement site.

More information on wind data, e.g. for more complex terrain, is given in the RESHYVENT WP5 Technical report [RHV-WP5-TR5].

5.4.2 Wind shielding

<u>Philosophy and Background</u>

Shielding effect from surrounding structures must be taken into account for the determination of the wind pressure coefficients. That means wind speed v_{ref} at reference height has to be available from a place outside the disturbed area but with he same wind profile.
More information on shielding is given in the RESHYVENT WP5 Technical report [RHV-WP5-TR5].

<u>RESHYVENT approach</u>

Shielding is considered in the form of the plan area density (PAD) parameter, the ratio of built area to total area.

$$PAD = \frac{BuiltArea}{TotalArea} \cdot 100$$

This ratio has to be calculated within a radius R ranging from 10 to 25 times the height z of the considered building or:

$$R = \frac{76.7 - PAD}{2.7} \cdot z$$

Three levels of shielding are considered:

1) unshielded	PAD = 3-5 %
2) partially shielded	PAD = 12%
3) shielded	PAD = 40 %

5.4.3 Outdoor level of CO_2 and other pollutants concentration (if not provided on 1 h time step basis)

<u>Approach</u>

Three levels could be considered:
a) rural situation b) urban situation dispatched , c) close to busy road

CO_2

a)	rural situation (clean air)	CO_2 level	360 ppm
b)	urban situation dispatched	CO_2 level	400 ppm
c)	close to busy road	CO_2 level	500 ppm

Other outdoor air pollutants

Not considered

5.4.4 Outdoor noise

<u>Approach</u>

Three outdoor noise levels could be considered:

a)	quiet situation	outdoor noise level	40 dB(A)
b)	medium exposure	outdoor noise level	50 dB(A)
c)	heavy exposure	outdoor noise level	70 dB(A)

5.5 Moisture and pollutant sources

5.5.1 Water vapour sources

Water vapour production due to human activities

Water vapour production for cooking (including dish washes), showering, clothes washing (in the bathroom), clothes drying (in the bathroom). The production is related to the number of persons in the dwelling.

5.5.2 Emissions from building and furniture materials

Approach

This could be treated by assuming a generic pollutant U-emiss. This pollutant is based on a constant emission related to the room area. See [IEA A27-V2, section 4.1]

6 ABBREVIATIONS AND SYMBOLS

AH	Absolute humidity of air
ATD	Air transfer devices
EPBD	EC Energy Performance of Buildings Directive
IC	RESHYVENT Industrial Consortium
LCA	Life cycle analysis
OATD	Outdoor air transfer devices
PA	Performance assessment
PV	Photovoltaic
RH	Relative humidity of air
RHV	RESHYVENT
TBD	To be defined

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EN 13779	European standard EN 13779 "Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems". 2003
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