DESIGN PARAMETERS FOR THE PERFORMANCE ASSESSMENT OF HYBRID RESIDENTIAL VENTILATION SYSTEMS

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ABSTRACT

This paper summarizes the work within the EU RESHYVENT project in regard to design parameters for the performance assessment of hybrid ventilation systems. A framework for performance assessment based on simulation was developed. Performance criteria were defined for air flows, indoor air quality, thermal comfort, acoustics, energy, and emissions. These criteria were adapted to the time dependant performance of hybrid systems and were applied in the performance assessment of the systems developed within the project, together with a reference set of design constraints (boundary conditions) and building parameters. Probabilistic methods were evaluated and are proposed to account for uncertainties in the input parameters.

KEYWORDS

Hybrid ventilation, performance criteria, design parameter, probabilistic approach

INTRODUCTION

The assessment of the ventilation system is one aspect in a holistic building performance assessment task. In the frame of the EC Energy Performance of Buildings Directive (EPD) there are a number of standardisation activities in CEN, EOTA, and supporting projects. The aim is to achieve harmonized European assessment methods for various performances, including the assessment of (innovative) ventilation systems. While standardisation deals with calculation procedures, legislation sets the requirements, and handles the practical implementation.

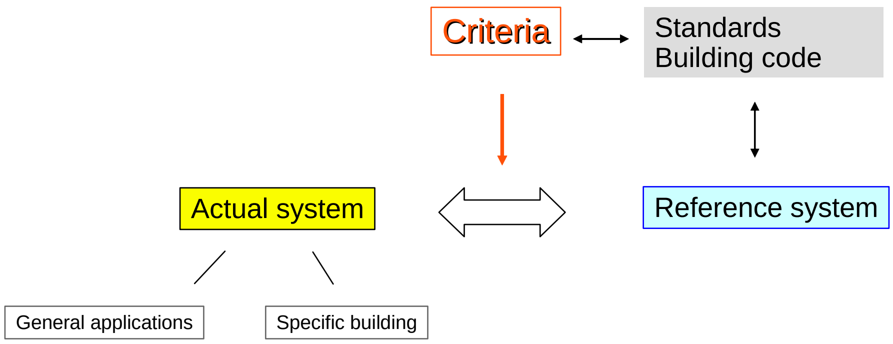

Figure 1: The Principle of Equivalence, applied to an innovative system by comparing the performance of the actual system with a reference system which is covered by the applicable standards and buildings codes

However, the assessment of systems with time dependant performance, like building automation, glazing, advanced cooling systems (tabs), adaptive materials and also hybrid ventilation, remains to be specified (Wouters 2000). In such cases, the Principle of Equivalence may be applied (Van der Aa 2002), comparing the system under consideration with a reference case which is covered by existing standards and regulation (figure 1).

DESIGN PARAMETER

Design parameters as used for the performance assessment can be differentiated into performance criteria and target values, design constraints (boundary conditions, assumptions), and building and ventilation system design variables (figure 2). Parameters can be defined on building, system and component level.

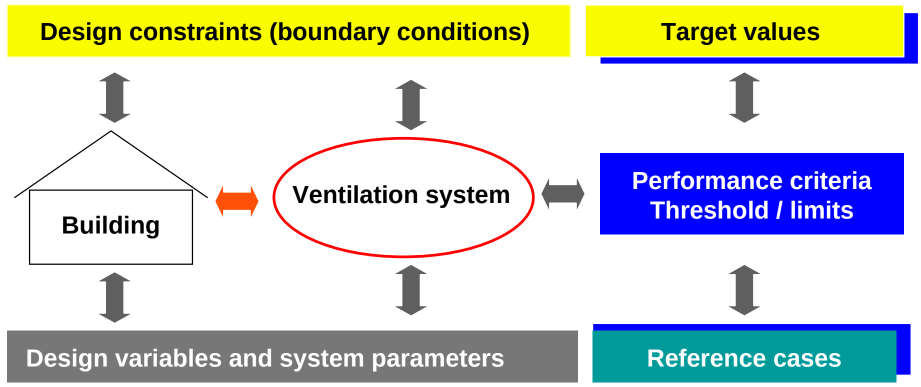

Figure 2: Design parameters for the performance assessment of ventilation systems

PERFORMANCE ASSESSMENT WITHIN RESHYVENT

Within the RESHYVENT project, a framework for performance assessment was proposed (Wouters 2004). This proposal is based on work performed in earlier projects such as IEA HYBVENT (Heiselberg 2002) and EU ENPER-TEBUC (ENPER 2003).

The performance assessment of the systems developed within the RESHYVENT project was based on dynamic thermal building and ventilation simulation using TRNSYS (TRNSYS 2000) and COMIS (COMIS 2001), or TRNFLOW (COMIS integrated into the TRNSYS building type) (Weber 2003).

For this performance assessment task, a comprehensive set of criteria and target values in regard to energy and indoor environment (indoor air quality, thermal comfort and acoustics) was defined (Dorer 2004).

The most relevant parameters were adapted to this simulation approach. Other criteria could not be assessed by building simulation, but were measured or qualitatively assessed by the industrial consortia.

PERFORMANCE ASSESSMENT CRITERIA

Performance assessment of systems with time dependant performance

For hybrid ventilation, it is obvious that any 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.

The structure and the approach selected within RESHYVENT are outlined in the following example for the CO_2 concentration, as one of the parameters used for the characterisation of the indoor air quality. The performance is assessed transforming concentrations exceeding the threshold into an integral value (figure 3). The assessment can be room related or occupant related (dosis) (table1).

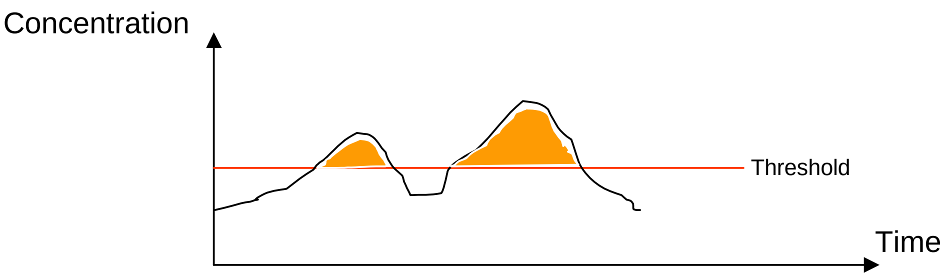

Figure 3: Performance in terms of concentrations is assessed by an integral value for the threshold exceeding

TABLE 1
Threshold and target values for the CO_2 concentration performance criteria

Threshold / limit:	700 ppm above outdoor level
Performance parameter: a) No of hours with concentrations above threshold value b) Hours times concentration exceeding (room related) c) Concentration exceeding exposure (occupant related)	 200 h 200 kppm.h 100 kppm.h

Performance criteria for air flows and air distribution

Direct outdoor air flow rates (habitable rooms) and exhaust air flow rates (wet rooms and kitchen) and the respective air flow stability are the key criteria. Pressure differences room – facade or room – ground are relevant for buildings with room placed stoves or gas appliances, and for buildings with risk of radon ingress.
Air exchange efficiencies can only be determined by CFD or by measurements for a specific point in time, but hardly for a prolonged period of time.

Performance criteria for indoor air quality

The parameters considered were: CO_2 concentrations (see above), low humidity (dryness feeling) and high room air humidity (risk of mould and house dust mite growth, condensation risk). The first two criteria are occupant related criteria. Pollutant spread from cooking, passive smoking and emissions from building and furniture materials may also be considered, but was not within RESHYVENT.

Performance criteria for thermal comfort

For thermal comfort evaluations, the steady state requirements set out in ISO (ISO 7730) and CEN (CR 1752) documents were adapted, considering values below and above the temperature or PPD limit values. The targets are expressed in terms of Kelvin-hours. Studies on adaptive thermal comfort 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), or adaptation of occupant to climate (Olesen 2002).

Draught risk can be evaluated by CFD simulation, but only for a specific configuration in terms of surface and air temperatures, and thus not over a prolonged time period.

Performance criteria for acoustic performance

As for other criteria, the acoustic indoor environment is a result of influences such as sound emitting sources, sound transport and respective attenuation measures, and outdoor noise levels.

Target values for ventilation systems are to be set 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. Most important is the sound pressure level in the room, and the related system parameters are the sound power level of the ventilation system and the outdoor noise reduction capabilities of outdoor air transfer devices.

In multifamily buildings, sound attenuation between individual apartments is of great relevance. The ventilation system, especially ducts, may play an important role in sound transmission.

Performance criteria for energy and environmental impact

Criteria for energy are heat use of the building (heating power and heat demand), energy use for space cooling of the building (cooling demand), ventilation heat loss, electricity demand of the ventilation system, heat recovery performance factor and factor of renewable energy supply (mainly by system integrated photovoltaic panels).

DESIGN CONSTRAINTS

For the application of the Principle of Equivalence, the selection of the constraints is very crucial, as this selection must not lead to unjustified favouring or discrimination of a specific system under investigation. Some parameters may also be associated with high uncertainties.

For the performance assessment of the four systems developed within the RESHYVENT project, a set of reference or standard cases has been defined. Most of the design constraints were specifically related to the systems developed in this project, but reference was also made to the results of IEA A27 (Millet 2002, Månsson 2002), especially in regard to occupancy, occupant behaviour and indoor pollutant sources. In addition, procedures for the definition of probability distributions of the following parameters were proposed: Wind pressure coefficients, building envelope leakage distribution, occupancy, window opening behaviour.

INPUT DATA UNCERTAINTIES AND PROBABILISTIC METHODS

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.

Several methods can be applied: 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. For more information on the application of these methods, see results of the IEA Annex 23 (Fürbringer 1995 and 1999).

The effect of uncertainties in the input on the resulting output can also be determined by probabilistic methods, as e.g. the Monte-Carlo technique (Rubinstein1981), 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 (figure 4).

Probabilistic methods may be especially 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, or to wind pressures (Heijmans 2002). However, to get realistic results, correlations with time dependent parameter (e.g. outdoor temperature) and inter-correlations between the probability distributions of the individual parameters (e.g. the individual wind pressure coefficient values) must be considered.

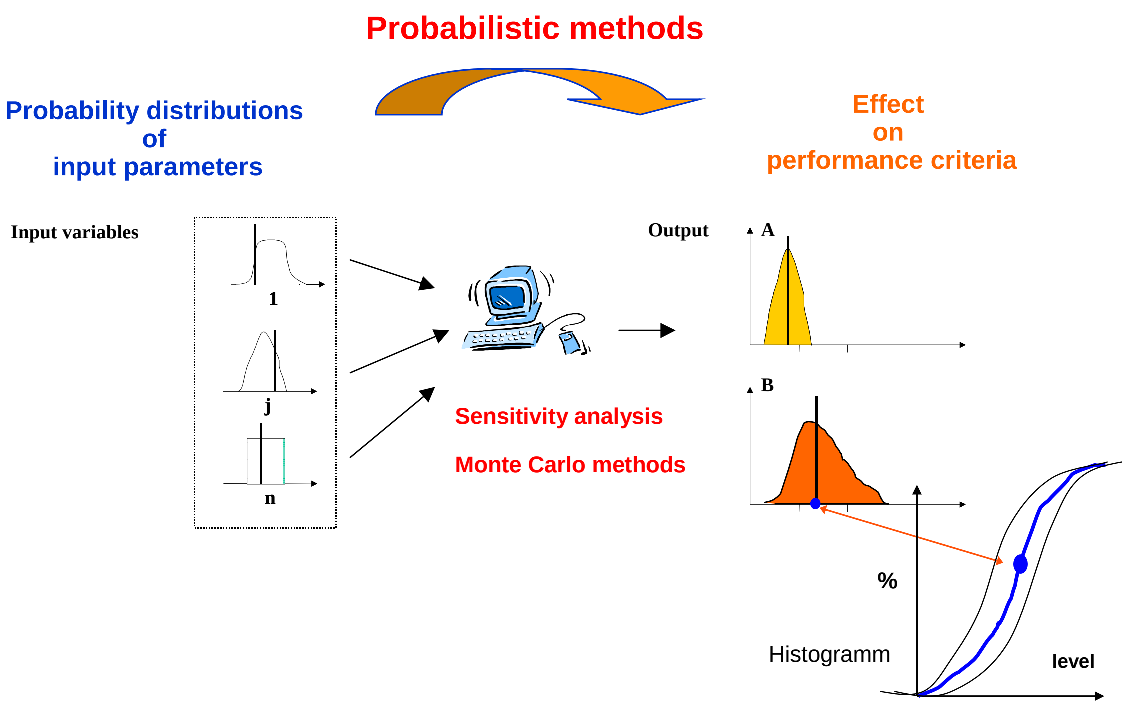

Figure 4: Probabilistic performance assessment approach based on Monte-Carlo techniques, with probability distributions for certain input parameters and for the result parameters

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