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Introduction of Tools for Evaluating Domestic Ventilation Systems

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Synopsis

The IEA project Annex 27, Evaluation and Demonstration of Domestic Ventilation Systems, have come to the stage that simplified tools can be presented in a total scheme. At earlier AIVC conferences some of the tools have been presented in separate papers and still the tools are under development. In this paper a more general approach of the usage of the tools is to be presented.

The work is based on the joint work of participants from both AIVC countries (CAN, F, NL, S, UK, USA) and non-AIVC countries (I, J). The tools that are to be used are for indoor air quality, energy, noise, thermal comfort, life cycle cost, reliability, and building and user influences. A flow chart has been developed and is the procedure for the usage of the tools. The simplified evaluation tools are giving results both in a qualitatively and a quantitatively way. It has been applied on the four basic ventilation systems: adventitious, passive stack, mechanical exhaust, and mechanical supply and exhaust.

Background

The rate of outdoor air supply as well as comfort aspects associated with air distribution and the ability of the systems to remove pollutants are important factors to be considered at all stages in the building lifecycle. As distinct from a work place, residents can vary across a wide span from an allergic infant to a well trained sportsman, from active outgoing people to elderly confined to a life indoors. During the lifetime of a building the resident's pattern vary. This results in a varying need for supply air to obtain acceptable indoor climate and to avoid degradation of the fabric. Emis-sions from building materials are also time dependent. When the building is new or recently refurbished it may be necessary to dilute the emissions by extra outdoor air. In standards and codes the outdoor air needed in a dwelling is generally based on the maximum number of persons living in the dwelling, defined by the possible number of beds contained therein.

Dwellings represent about 25 - 30 % of all energy used in the OECD countries. In the near future domestic ventilation will represent 10 % of the total energy use. Thus even relatively small reductions in overall ventilation levels could represent significant savings in total energy use. Improvement of residential ventilation is of concern in both existing and future buildings. The functioning of the ventilation system may deteriorate at all stages of the building process and during the lifetime of the building. Research in the recent years and in particular the IEA annexes now makes it possible to formulate methods to evaluate domestic ventilation systems.

Objectives

The objectives of the IEA Annex 27 are: **to** develop tools to evaluate domestic ventilation systems; **to** validate the methods and tools with data obtained from measurements; **to** demonstrate and evaluate ventilation systems for different climates, building types, and use of the dwellings. The methods, tools, and systems are intended for existing and future residential buildings, that require heating. The target group is composed of standard and policy makers, developers in industry, and ventilation system designers. With this general objectives the Annex is divided in three Subtasks:

1. State of the Art,
2. Development and Validation of Evaluation Methods, and
3. Evaluation, Demonstration, and Application Ventilation Systems.

Introduction

With the above objectives and scopes of the three Subtasks the Annex started in April 1993 and has today eight participants: Canada, France, Italy, Japan, Netherlands, Sweden, UK, and USA. Based on the subtask "State of the Art" assumptions have been set up to develop simplified tools for:

1. Indoor Air quality
2. Energy
3. Noise
4. Thermal Comfort
5. Life Cycle Cost
6. Reliability
7. Building and User aspects.

With the State of the Art Review, ref. 1, it is possible to give realistic assumptions of the most frequently used ventilation systems, the design of the dwellings, how many residents there usually are and when at home, the behaviour and which person in which room at what time. With these assumptions we can cover about 90 % of all possible cases, that are influencing the need of outdoor air supply. The usual levels of different pollutants in the dwellings are also given based on the review. The review report is based on and giving references to about 400 reports.

The OECD countries (14 of them) have 700 million inhabitants, 280 million dwellings with a floor space of 32 000 million m^2. The habitable space varies greatly and goes from 65 m^2/dwelling (Italy) to 152 m^2/dwelling (USA). There is also a great variation between the countries weather the dwelling is in a single family house or in a multi family building.

The number of persons/dwelling goes from 2.1 (Sweden) to 3.2 (Japan, Italy). Combined with the dwelling area it gives a floor space from 27 m^2/person (UK) to 61 m^2/person (USA). The crowdiness is defined by the number of persons/bedroom. From data can be seen that in 35 % - 50 % of all dwellings, there is less than 1 person/bedroom and in nearly all (90 - 95 %) less than 2 persons/bedroom.

A very important trend is that the number of one-person household is increasing. Today it goes from 20 % (Japan) to 40 % (Sweden). This trend has been observed during the last 45 years in all countries. A majority of the households have only two persons, except Japan (40 %). In the future it can be expected that we will have even more 1- and 2-person households as the number of persons older than 60 years during the next 40 years is growing from about 20 % today to 30 % of the population.

A survey amongst the AIVC countries gave that the most frequent ventilation system is either stack or simply window opening. However, in new constructions in most countries a fan is installed either for central exhaust or for local extraction in bath and/or kitchen.

Method

A complete computer simulation for various assumptions for the different parameters is never possible to be done for dwellings in the normal designing process. It is too expensive. With this in mind we are aiming at developing a set of tools that are easy enough to understand and use so that practitioner are able to use it even though not practised very frequent. The tools are to be used in the design of new buildings or renovating existing. With the tools it may also be possible to give guidance to explain problems.

With this in mind the development of the tools aimed at having simplified tools based on the most sophisticated computer simulation codes that could solve our purposes. The tools had to be a mixture of qualitative and quantitative tools. All tools will have at least a qualitative way to make a judgement between the various systems, see table 1. By this we are covering most of the systems existing and possible as it can be combined.

Table 1. Combination of variables

Parameter	**Window airing**	**Stack**	**Mech. exhaust**	**Mech. supply & exhaust**
Local bath fan	Yes/no	Yes/no	Yes/no	Yes/no
Kitchen fan	Yes/no	Yes/no	Yes/no	Yes/no
Window airing pattern	3 cases	3 cases	3 cases	3 cases
Climate	Ottawa, London, Nice	Ottawa, London, Nice	Ottawa, London, Nice	Ottawa, London, Nice
Number of residents	2, 4, 5 persons	2, 4, 5 persons	2, 4, 5 persons	2, 4, 5 persons
Houses, flats	Detached. Ground & top floor. 4 storeys	Detached. Ground & top floor. 4 storeys	Detached. Ground & top floor. 4 storeys	Detached. Ground & top floor. 4 storeys
Exhaust flow rate [l/s]	-	-	15, 30, 45	15, 30, 45
Air tightness [N50]	House 2.5, 5, 10 Flat 1, 2.5, 5	House 2.5, 5, 10 Flat 1, 2.5, 5	House 2.5, 5, 10 Flat 1, 2.5, 5	House 1, 2.5, 5 Flat 1, 2.5, 5
Supply flow rate [l/s]	-	-	-	15, 30, 45
Supply area [cm^2]	0, 101, 410	0, 100, 400	0, 100, 400	-

For some of the tools we need to rely on laboratory tests and with more general assumption. By giving a tool that the user can feed his on data sets or experiences a workable and always up-to-date tool can be at hand.

The procedure how to use the different tools is shown by a flow chart, see figure 1.
All the tools are very briefly introduced. Some are given a more detailed introduction at this conference, IAQ was introduced at the 17th conference 1996. A more lengthy and detailed description is planned to be given at the AIVC conference 1998. Here after follows a brief introduction of the tools to be given.

Thermal Comfort
Different supply air devices, for location in external walls and windows, have been tested in laboratory. The thermal comfort in different points in the room have been measured at various external temperatures: Based on this a qualitatively based judgement table in 5 steps is set up for different outdoor temperatures device types as well as background leakage.

Noise
If the dwelling is situated in a noisy area like close to roads, rail - ways, airports also the choice of the ventilation system affects the noise reduction. A leaky house, windows with bad weather-stripping, or a device in the window or wall can ruin the good intentions. As the noise

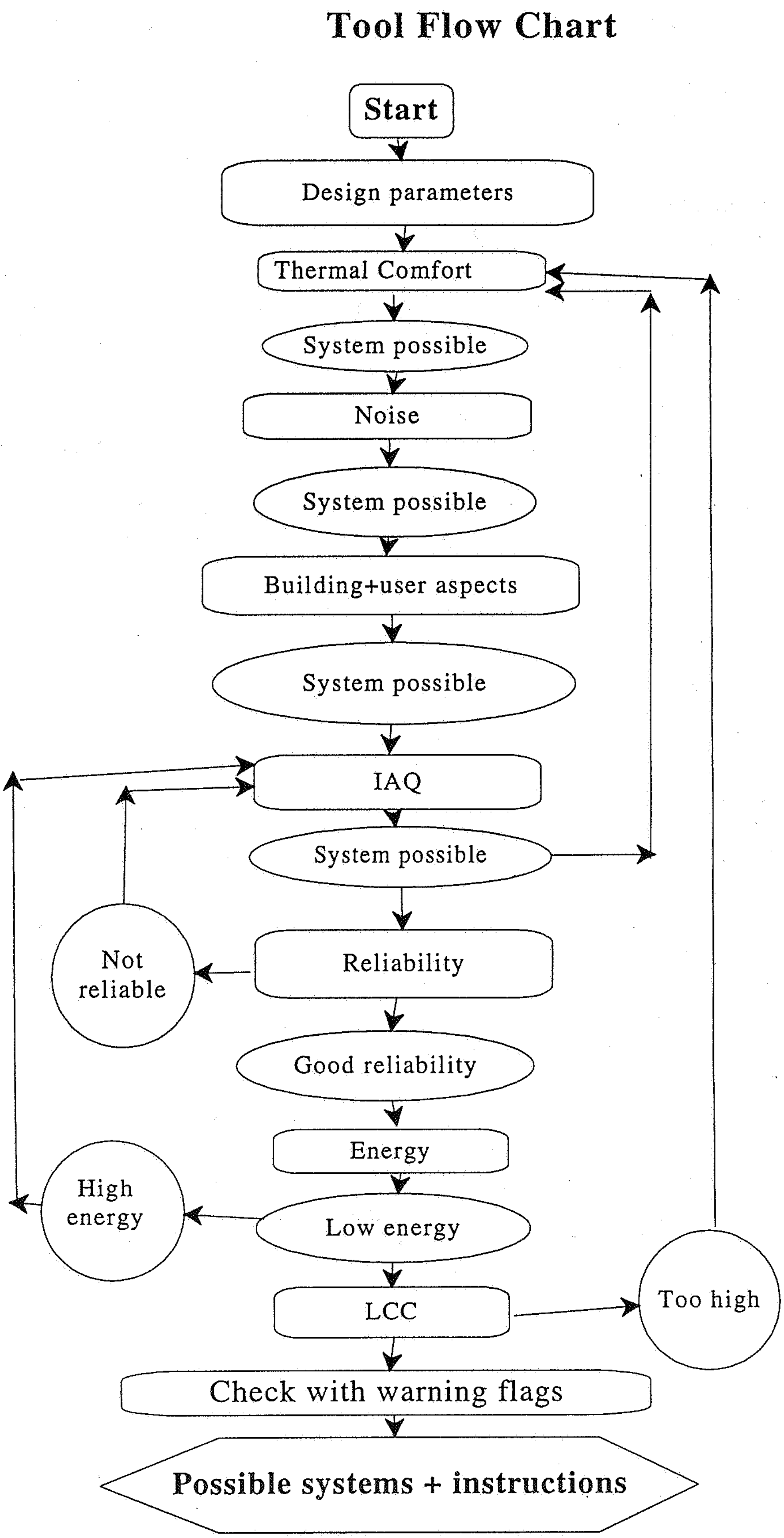

Figure 1. Tool flow chart for evaluating domestic ventilation systems

reduction is depending on many factors a set of cases have been calculated for the four main ventilation systems. Also the devices for outdoor air in stack and mechanical exhaust systems can be designed in many different ways giving more or less noise reduction. Tables are set up with the 5 step judgement to meet different required noise reductions taking into account the opening area for the devices with different noise reduction design. Ref 3.

Building and user aspects
The building aspects are listed and discussed how they might influence the various systems. The dwelling lay-out and height of the rooms are of more concern the more the ventilation is relaying on window openings. The system selection might also affect the architectural design for the room design, facades and roofs. Construction and services design are also depending on the ventilation system chosen.

Even though many assumptions are made also other aspects may influence the choice of the ventilation system. A check list or a qualitatively way of judgement is to be set up. The various aspects discussed are:

- User influence on how to use the system, obstruct the system, change the preadjustment
- Maintenance: Systems are more or less sensitive for cleaning the devices and filters or changing the filters.
- Furniture and decoration can make obstacles for the air flow. Most problems are caused by the curtains around the windows.
- User tendency to react on system failure either it is instant failure and slow degradation
- Cooking habit varies from country to country and over the long time. It is also affected by the family life stile. If a kitchen hood is used the sensitivity is less.
- Hygiene: There is a tendency to use more water giving a higher water vapour content in the dwelling. The use of chemical products are under the development to be less harmful.
- Redecoration interval. Usually it includes more or less extra water vapour to the dwelling in addition with extra VOCs. Usually it is linked to changing tenants or ownership.
- Other equipment installed or used: Here a lot of creativity is put in by quite another industries than the ventilation. Here can be foreseen many new machines that might affect the indoor environment more or less e.g. steam cleaners of floors, coffee machines, ovens not connected to the kitchen hood or gas fired grills not under a hood.
- Pets, the size and number varies a lot as well as the fur length and shedding
- Pot plants are giving some addition to the indoor water vapour content.
- Interest
- Knowledge how to handle the situation for improving the effectiveness of ventilation
- Manual capability
- Life style is affecting the family's attitudes towards all the behaviour. Some of the relationships are investigated. The life style can be divided into 10 styles. These are: Work geared, Nature-love, Family - attached, Well-informed, Consumption geared, Agrarian/Religious, Moralist, Collective bent, Climber, Economiser

IAQ
The intention is here to give both qualitative and quantitative tools. Calculations are made for the following parameters: Constant emission, CO2, cooking products (incl. NOx), tobacco smoke, pressure difference (positive and negative), relative humidity (mould growth & house dust mite growing risks), outdoor air change rate. The combination of all parameters and values gives 17 500 cases and are dealt with by multi-variat parametric study using COMIS and SIRÉN computer programs. Ref 2.

Reliability
Here assumptions have to be made on the lifetime of each component in the system selected. Also other the probability of a system to give the ventilation rate is here to be given. Sets of tables can be established for the probability and a computer code for the decrease of the flow rate at different replacement and maintenance intervals.

Energy
Fan and air heating energy is calculated taking into account flow rate, heat recovery efficiency, air leakage (n50), window airing habits, climate. A computer nomogram is to be the final tool for easy handling.

LCC
Mostly ventilation systems lack good maintenance. Some property owner have realised that each complaint cost money to deal with. In dwellings it is also a combination of maintenance made by the residents and by the professional organisations. A general trend is that it pays to do planned maintenance. The qualitatively approach is to combine the basic quality of the system for units, ducts, devices and possibilities to clean and adjust. After that the user's interest of the systems is estimated in three levels. By combining the two we will have three fields low, medium and high maintenance classes. The cost is estimated for the low and high for the various systems and building types. Planned maintenance costs is added with the cost for complaints.

Discussion
The tools are to be developed to a paper tool. Of course it is of great concern to go on to develop the tools to computer versions so that it can be easier to use and to include more climates and having a self - educating instruction for each tool. Our goal have been to give designers tools that they can bring with them at meetings giving answers on various questions that are arising in meetings concerning the choice of systems. There are still a few months of work before the final tools are fully developed. The tools are to be checked on the measurements made during the annex running.

References

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