Energy and Cost-Effective Retrofit of Ventilation Systems in Office Building, Apartments and Hospitals - Some Elements

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1. Introduction

In developed countries the number of buildings to be retrofitted is much larger than the potential of new buildings.

Four types of buildings are concerned :

- Apartment buildings
- Office buildings
- Industry buildings
- Hospitals

The reasons for a retrofit are often the following :

- Some elements of the building or its installations need to be changed (end of life) or do not correspond any more to the law.
- The use of the building has changed with time, and it does not correspond to the needs of the owners any more.

Of course when a building is retrofitted it is important to reduce its global energy consumption (heat and electricity), but energy is very seldom the primary reason for a retrofit.

When one element is changed in the building, it is important to analyse the consequences on all other parts or installations of the building. The most important building types which are concerned with retrofit are the flats and the office buildings when the ventilation system is concerned. In the case of industrial buildings it is easier to rebuild completely the ventilation system than to modify it because normally the spatial flexibility is much greater in such applications.

The ventilation retrofit covers a whole range of possibilities from pure natural ventilation by infiltrations, natural ventilation with purpose provided openings, assisted natural ventilation with mechanical exhaust, hybrid systems with both mechanical and natural ventilation, mechanical ventilation and mechanical air

assisted natural ventilation with mechanical exhaust, hybrid systems with both mechanical and natural ventilation, mechanical ventilation and mechanical air conditioning systems. Depending on building construction, building design, building use, indoor environmental requirements, interior loads, outdoor climate, and existing ventilation system, different approaches will be applicable. There is a need of guidance on choosing solutions which will give the best overall result considering indoor climate, air distribution energy use, costs, environmental impact, practical possibilities etc. in individual cases.

2. The Flats Situation

In Switzerland, for example, the target heat energy consumption defined by the Federal Office of Energy Research program 96-99 are :

- 230 MJ/m²year for new building
- 345 MJ/m²year for renovated building

With U-value of the following levels :

- $U_{externalwall}$ = 0.3 W/m²K
- U_{roof} = 0.3 W/m²K
- $U_{windows}$ = 1.6 W/m²K

and 0.6 ach/h for the air exchange rate with the outside.

The losses due to the air exchange with the outside are often more than 50 % of the overall heat energy of the building. The following figure illustrate the heat energy index for a typical apartment house (multiple flats) with the presented U-values and air exchange index.

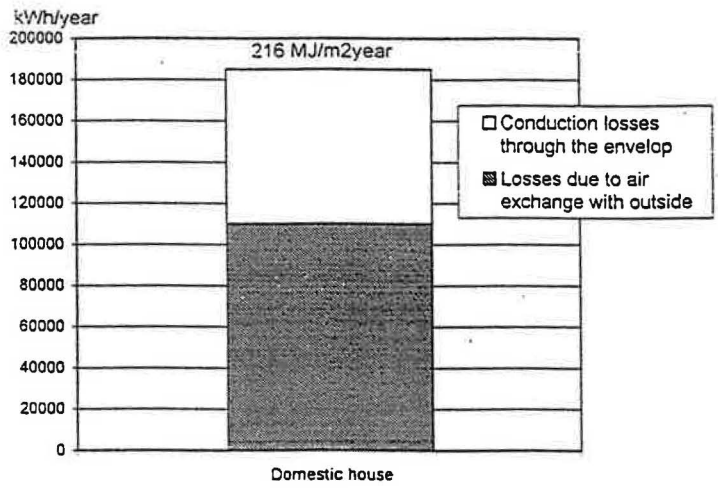


Figure 1: Heat energy index for a typical domestic house.

The target heat energy index of 230 MJ/m²year is reached. But in old buildings these low U-values are not easy to obtain with a renovation except for the new windows, and the saving potential being available in the air exchange rate becomes very important. As an example, it may be possible to reach an energy consumption as low as 100 MJ/m²year in a new building with a smart ventilation system (controlled ventilation with heat recovery). This is far below the 216 MJ/m²year of the existing apartment house of the previous figure. In old buildings, it would not be so easy to reach energy consumption near 100 MJ/m²year.

But the main potential for savings by retrofit is in heating energy, as shown by the following figure. (Heating energy has to compensate for transmission and air-exchange losses, as shown before).

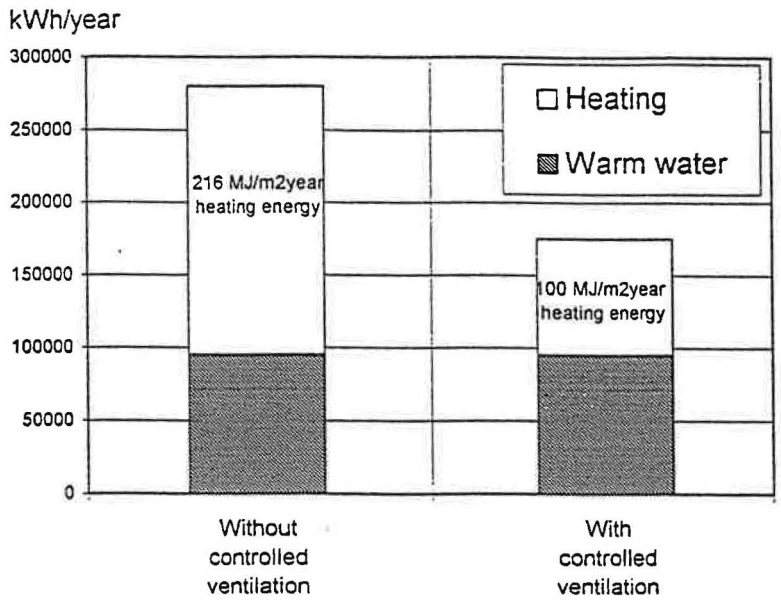


Figure 2: Heat energy saving potential in ventilation system.

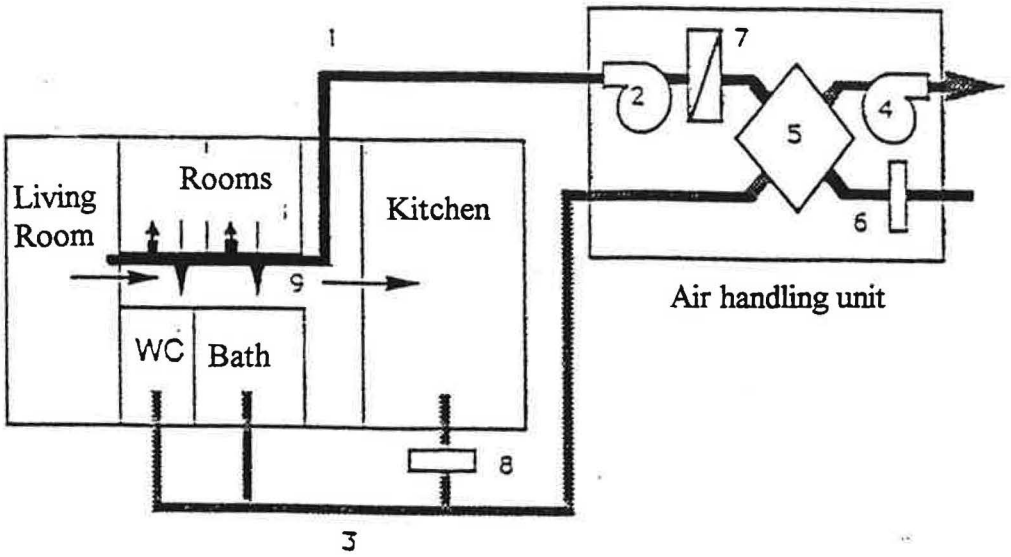
Secondly in many retrofitted buildings, ventilation problems are encountered because new windows (one of the easiest element to renovate) are no more adapted to the wall insulation and occupant behaviour, used to untight window (they do not need to open the window because of the large infiltration). The air quality in these flats is compromised and moisture problems can occur due to underventilation.

So, together with other retrofitting measures, ventilation openings and/or systems should be planned and installed. Installation of dual duct ventilation in existing buildings is not simple, and tricky simplifications with respect to usual rules and

standard systems used in new buildings should be adapted. There is no certainty that these simplifications will work properly.

In cities where the noise of the traffic has reached unacceptable levels, such solutions can be very interesting for the retrofit of residential house.

There is also a need on developing pure natural ventilation systems or mechanical assisted natural systems which are controllable, comfortable and energy efficient (with heat recovery).



1. Fresh air duct
2. Fresh air fan
3. Extraction air duct
4. Extraction fan
5. Heat exchanger
6. Air filter
7. Heating coil
8. Air filter
9. Air exchange between rooms, under the doors

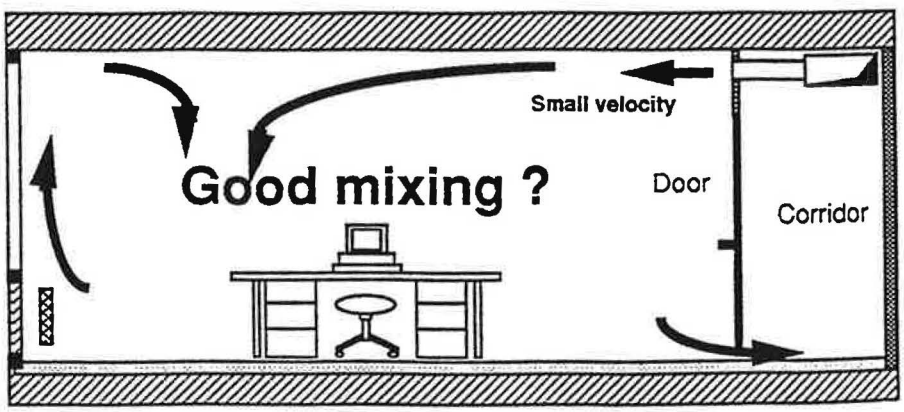


Figure 3: Controlled ventilation with simplified dual duct system in renovated building

3. The Office Building Situation

In the case of administrative buildings of the seventies, which will have to be renovated, the energy needs are often more important for the HVAC (Heating, ventilation and cooling system) systems than the building envelope losses. Such buildings have already a mechanical ventilation system. The aim of the retrofitting is therefore to modify the existing ventilation system or operation modes and strategies to decrease the energy consumption and to guarantee a certain comfort level in the offices. The next figure illustrated the heat energy fluxes in a building (bank) of the year 1970.

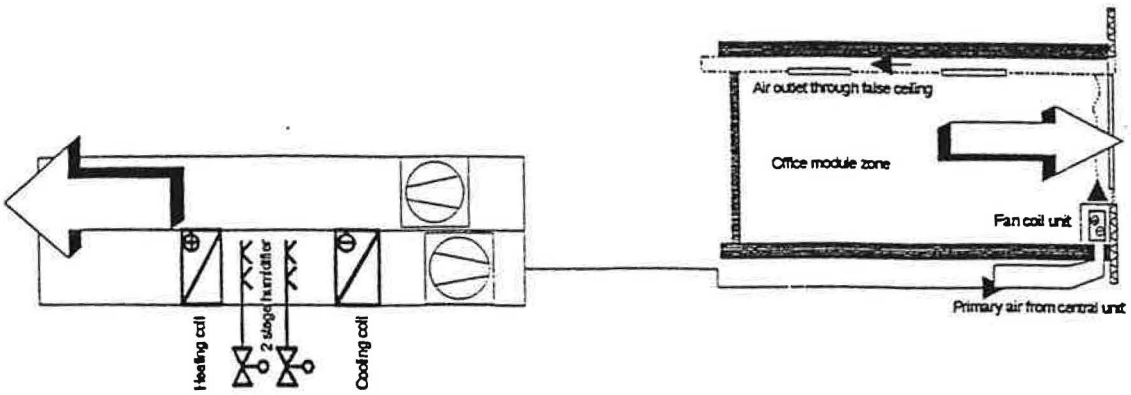


Figure 4: System for the offices.

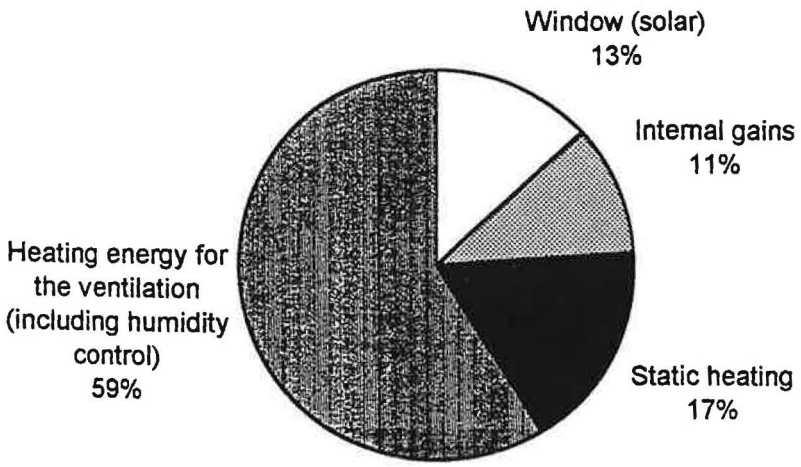


Figure 5: Heat fluxes in HVAC and envelope.

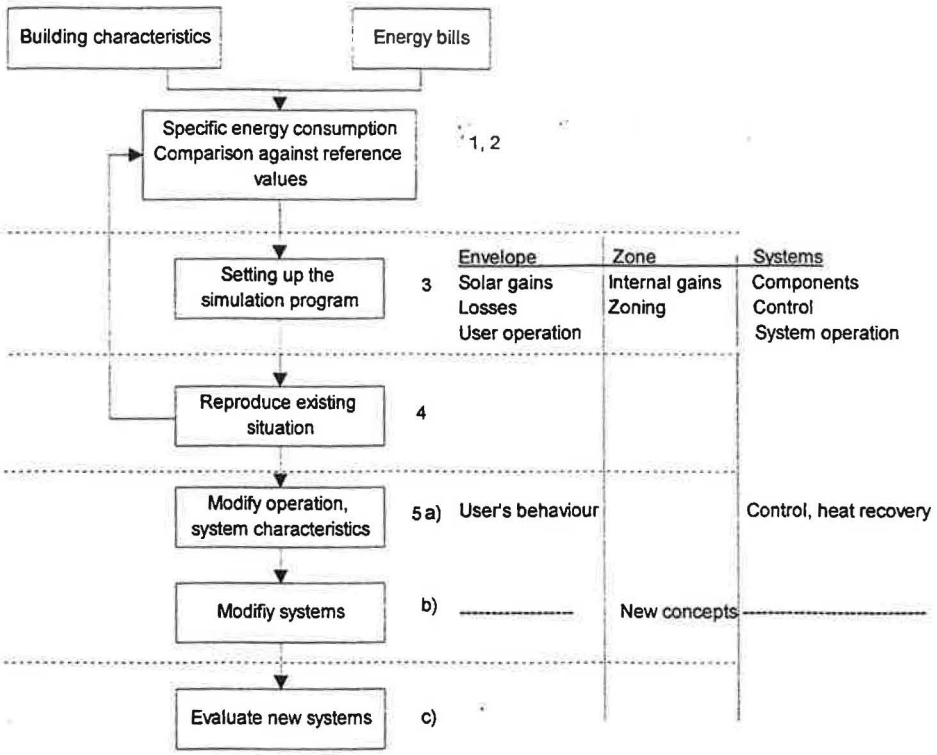


Figure 6: Flow chart of methodical approach.

After having done the steps 1 to 3 of the upper flowchart the actual and pass energy balance can be simulated and compared with the measured values (energy bills).

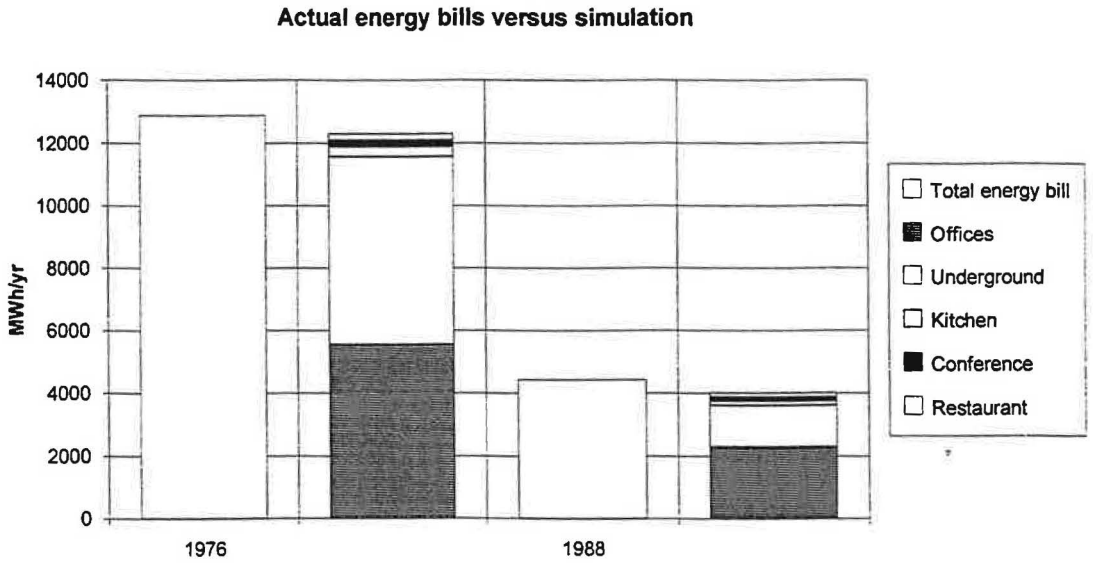


Figure 7: Comparison between actual heat energy bills and simulation for two different periods.

If possible, a simulation of two different years with different operating conditions, and/or different building characteristics allow to holder clerk if the simulation model built in the program represents the building behaviour correctly. One can then proceed to the retrofit analysis.

Once the building behaviour is well understood by simulation, and its results have been compared against energy bills, and that the results are satisfactory, one can then analyse the impact of different modifications to the operation, envelope, control, or system of the building or part of it.

The main interest of using simulation programs to analyse retrofit actions is the coupling between the different effects that could not be dealt with by traditional component approach.

Envelope Retrofit

As an example, one can show the impact of new glazing on the heat and cold demand. On one hand, improving the glazing thermal and optical properties diminishes the heat demand, but on the other hand, the solar gains being increased, the cooling demand does also increase. Figure 8 shows how these combined effects affect the office module zone specific energy consumption.

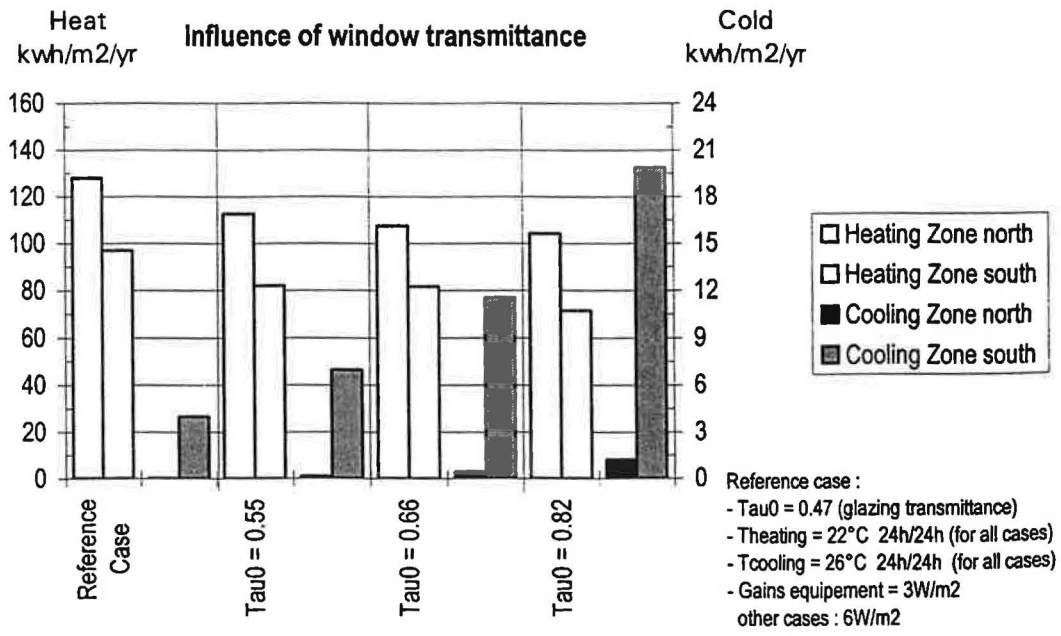


Figure 8: Glazing properties influence on specific energy consumption.

4. Hospitals Situation

Also in hospital the need and the energy saving potential are important in Switzerland.

The methodology proposed for administrative building as well as the substitution analysis are valid. Here this is more the special situation of the clean room which is new in comparison to the administrative building.

5. Conclusion

The number of building to be retrofitted is much larger than the potential of new building. The energy consumption due to ventilation losses (heat) in residential building and due to the mechanical ventilation system (heat and electricity) of old office building are important, therefore the energy saving potential in the retrofit of the ventilation system is relevant.

Attention and work need to be focused on these topics in the next years. Therefore in the frame of the Swiss Energy Conservation Programmes and under the funding of the Swiss Federal Office for Energy, it is likely that a research program on the retrofit of ventilation systems be initiated in the next months.

6. Literature

[1] "Simulation assisted retrofit study of administrative buildings, Methodical approach, case study" by P. Jaboyedoff, Sorane SA, Lausanne Switzerland.