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COMPARISON OF WINDOW PERFORMANCES

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1. Introduction

Several parameters have to be considered in order to optimize the energy balance of the windows of a building. These parameters are not limited to the window itself, but also include important factors such as :

- building type and utilisation,
- lighting requirements,
- heating mode and regulation,
- inhabitants behaviour,
- climate.

For this reason the determination of a precise energy balance requires a detailed computer code, and a complete set of hypotheses on the studied object.

The following results have been obtained within the project "Windows and Fenestration" [1] of the International Energy Agency.

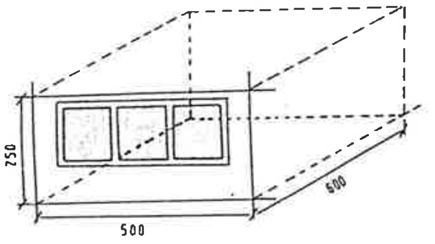
2. Object of the simulation

In order to analyse the effect of the window more precisely, the study was limited to a 75 m^3 single room located at the corner of a multi-storey building. The glazing type, size and orientation, building type and orientation, lighting requirements, heating regulation and the inhabitants behaviour (concerning ventilation and solar protection use) have been varied. In each case relevant quantities such as heating and lighting requirements, as well as comfort conditions have been analysed using the simulation code "PASSIM-4" [2].

Table 1 gives detailed informations on the room characteristics as well as on its utilisation. Five glazing types have been considered [3] : two double glazings and two triple glazings without and with a selective coating ($\varepsilon = 0.1$), and a high insulating window ($u = 0.65$ [W/m^2K]) composed of two glazings with two low emission films in between.

The last, but not the least, is to establish an appropriate inhabitant behaviour concerning the ventilation and the solar protection use. A constant air change rate of 0.6 [a.c/h] has been adopted with an extra ventilation rate of 10 [a.c/h] as soon as the indoor temperature reaches 26°C, this extra ventilation simulates the window opening to prevent overheating.

The index temperature [4] was monitoring the use of the solar protections. In the first part of this study the operation temperature was 23°C. Other inhabitants behaviours are considered in section 3.3.



Heated volume = 75 m^3

Floor area (S_F) = 30 m^2

Building thermal mass = 690 [kJ/K m^2 of floor area]

Outdoor walls u - value : 0.38 [W/m^2 K]
Window frames u - value (*) : 1.9 [W/m^2 K] (1.0 [W/m^2K] for HIT-S)
Ventilation : 0.6 [a.c/h]

Window area (S_W)	0	3	6	9	[m^2]
Window relative area (S_W/S_f)	0	0.1	0.2	0.3	[-]
Fraction of frames	-	30	25	20	[%]
Glazed area :	0	2.1	4.5	7.2	[m^2]

Solar protection : outdoor blind τ_E = 0.30

Room type	Living room	Office
Occupancy :	1 person 12 am - 6 pm (P = 100 W) 3 persons 6 pm - 10 pm (P = 300 W)	2 persons 8 am - 6 pm (P = 250 W)
Lighting : Switch on level Switch off level	7.5 [W/m^2] 200 [Lux] 300 [Lux]	15 [W/m^2] 300 [Lux] 500 [Lux]
Auxiliary heating Heating regulation	P = 1 [kW] (100 % convective) indoor sensor, T_{min} = 20°C	
Night temperature set back Min temperature	from 10 pm to 6 am 15°C	from 6 pm to 6 am 15°C

* for α_{in} = 8 [W/m^2 K] and α_{ext} = 23 [W/m^2 K]

Table 1 Main characteristics of the room considered for the simulations.

In each case the relevant quantities have been calculated over the whole heating season (from October 1st to May 30th) using the Geneva climatic conditions (winter 1980-81), 3086 degree-days (12/20°C), horizontal global solar radiation 2078 [MJ/m^2]).

3. Significant results

The following figures illustrate the influence of the main parameters on the energy requirements (in MJ per square meter of floor area, for the whole heating season).

In each case the total energy delivered to the space : heating and lighting is considered; despite the fact that these two energies are different, they are considered as equivalent :

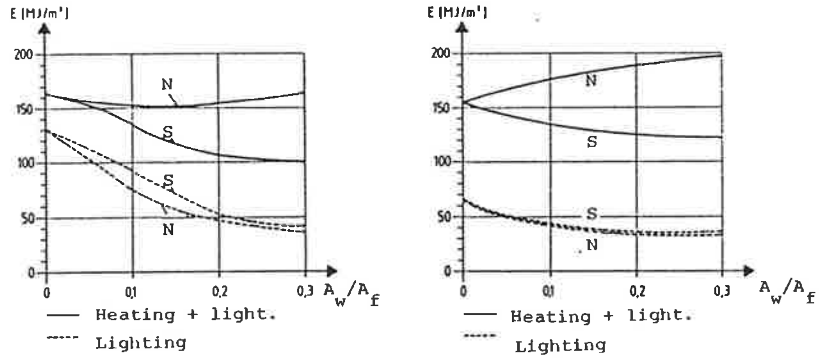
$$1\ MJ_{(thermal)} = 1\ MJ_{(electrical)}$$

In the next section we will analyse the effect of such an assumption.

3.1 Room type and lighting

The lighting requirements are strongly dependent from the considered room type : for residential use they are small compared to the heating requirements, for offices they are much larger and may exceed the heating requirements.

Figure 1 shows, for the two room types, the evolution of the specific energy requirements as a function of the relative window area (A_w/A_f). The dotted lines give the lighting requirements, the full lines correspond to the total (lighting + heating). For an office room the lighting requirements represent between 22 % and 70 % of the total energy need, depending on the window size and orientation. For the considered living room (occupied from 12 am to 10 pm) the lighting requirements never exceed 30 % of the total energy need.

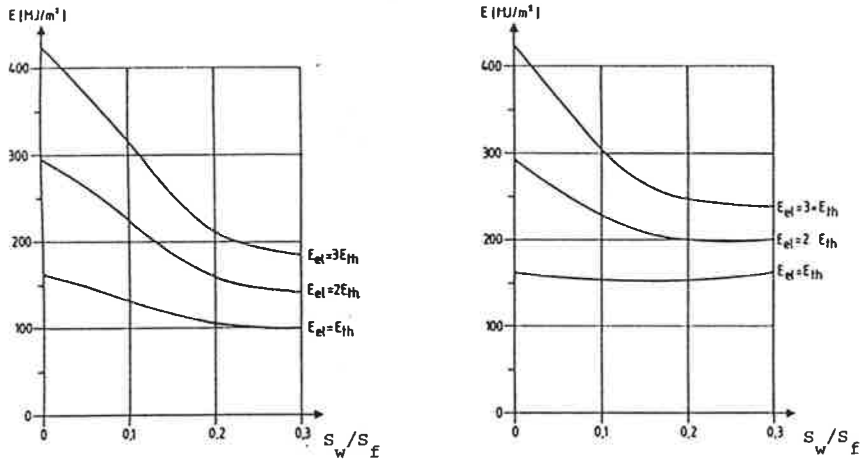


a) office room

b) living room

Figure 1 Specific energy requirements over the whole heating season as a function of the relative window area and of its orientation, for a coated double glazing.

The shape of the curves is strongly dependent on the weighting adopted between the thermal (heating) and the electrical (lighting) energy. Figure 2 presents the curves which are obtained for 1 MJ (electrical) = 1, 2 or 3 MJ (thermal).



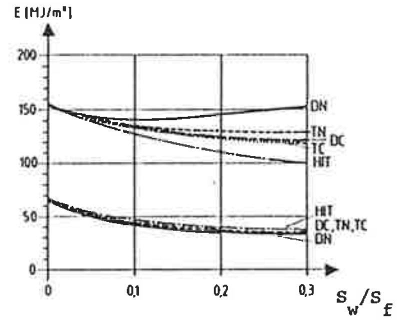
a) office room south oriented b) office room north oriented

Figure 2 Specific energy requirements over the whole heating season as a function of the relative window area, of its orientation, and of the weighting factor adopted between thermal and electrical energy, for a coated double glazing.

It is interesting to note the effect of such a weighting on the optimal window area : for a north oriented window if electrical and thermal energy are considered as equivalent, the total energy requirements are almost independent of the window area. As soon as a weighting is introduced ($E_{el} > E_{th}$) an optimum is observed between 0.2 and 0.3.

3.2 Glazing type and orientation

The influence of the glazing type and of its orientation have been analysed more carefully for the living room; figure 3 presents the effect of the glazing type for a south-oriented window.



Glazing types :

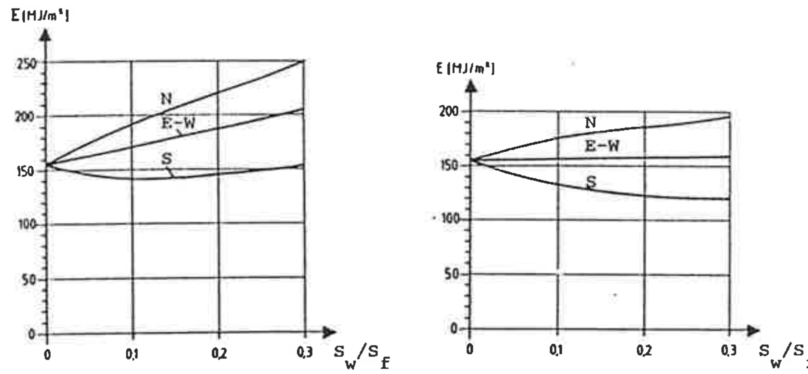
DN : double uncoated
DC : double coated
TN : triple uncoated
TC : triple coated
HIT : high insulating window with two selective films.

South oriented living room

Figure 3 Specific energy requirements over the whole heating season, as a function of the window size and of the glazing type.

For the uncoated double glazing, minimum energy requirements are achieved with a small window ($A_w/A_f = 0.1$), for all other glazing types the total energy requirements decrease as the window size increases. The spread between the curves results mainly from the windows thermal properties, the lighting requirements being in such a case almost independent of the glazing type.

Figure 4 allows a comparison with other orientations, it presents the results obtained for an uncoated and a coated double glazing.



a) uncoated double glazing b) double coated glazing

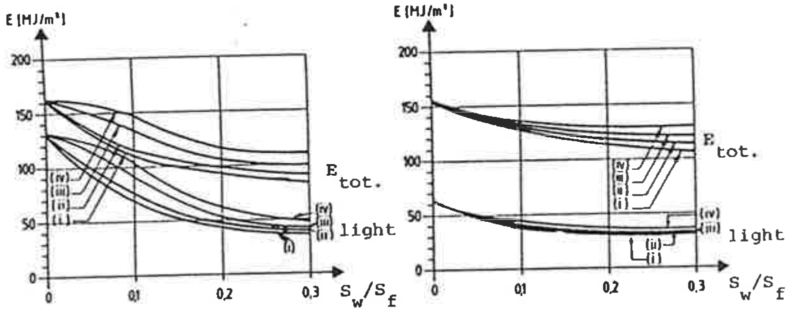
Figure 4 Specific total energy requirements over the whole heating season as a function of the window size and of its orientation.

3.3 Effect of the inhabitant's behaviour

Depending on the solar protection use, the inhabitant has a direct influence on the energy requirements. In order to estimate the importance of such an effect, four strategies of solar protection use have been simulated :

(i)	no solar protection, windows open as soon as	T_{air} > 26°C
(ii)	solar protection used as soon as	T_{index} > 25°C
(iii)	solar protection used as soon as	T_{index} > 23°C
(iv)	solar protection used as soon as	T_{index} > 21°C

Figure 5 illustrates the effect of such behaviour on the lighting and heating requirements.



a) South-oriented office b) South-oriented living room

Figure 5 Specific energy requirements over the whole heating season as a function of the window size, for various solar protection utilisation.
(Coated double glazing)

The largest variations, due to the inhabitants'behaviour, are observed for the office room where they can reach up to 35 % of the total energy requirements. For the living room these variations do not exceed 23 %.

4. Conclusions

Several factors have to be considered in order to optimise the window type and size of a building. These factors are not limited to the window solar and thermal properties but also include important factors such as heating mode and regulation and building type and regulation.

In this paper we have tried to show the influence of the building type and the lighting requirements, of the window type and orientation as well as of the inhabitants'behaviour.

For an office room the lighting requirements become crucial; depending on the window size and the required lighting level, they may reach between 30 % and 70 % of the total energy requirements. Therefore the choice of the optimum glazed area is strongly influenced by the weighting adapted between thermal and electrical energy.

The glazing type has a limited influence on the lighting requirements; its effect on the heating demand is much stronger. Between a coated and an uncoated double glazing an increase of the total energy demand from 8 to 25 % is observed, depending on the window size.

Depending on the solar protection use, the inhabitant has also a direct effect on the energy requirements; the largest influence is observed for the office room (35 %).

The effect of the other parameters has been analysed and presented in references [1] and [5].

5. References

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