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Assessing coated glazing for housing


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New types of coated glazing coming on to the market affect both heat losses and solar gain. From measurement work completed on many different types of such glazing, the authors from the Norwegian Building Research Institute identify the importance of the relative solar factor (insolation) as well as the k-value (heat transfer). They show how these two can be related to climatic and other data to predict relative energy consumptions by a simplified computer method. The result is in the form of design reference charts for different building types. Using the available data, a chart for particular house-types can be compiled for different locations in N. America, Japan and Europe.

Les nouveaux types de vitrages arrivant sur le marché réduisent les déperditions de chaleur et augmentent les apports solaires. A partir de mesures effectuées sur de nombreux types différents de tels vitrages, les auteurs, qui travaillent au Building Research Institute de Norvège, ont identifié l'importance du facteur solaire relatif (insolation) ainsi que le coefficient k (transmission de la chaleur). Ils montrent comment on peut les relier aux données climatiques et autres pour prévoir les consommations relatives d'énergie grâce à un calcul informatisé simplifié. Le résultat se présente sous forme d'abaques de référence pour les différents types de construction. Sur la base des données disponibles, on peut consulter des abaques pour un type de maison donné, qui, elle se trouve en Amérique du Nord, au Japon ou en Europe.

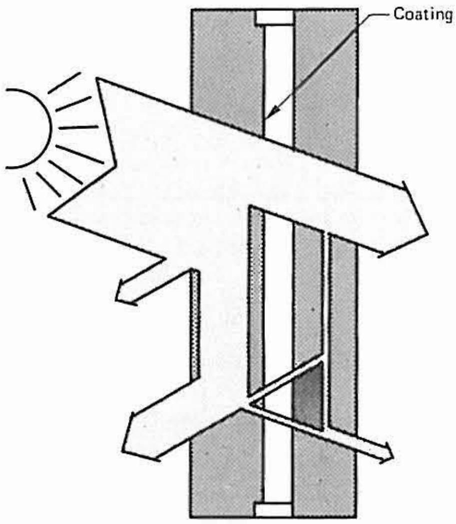
Windows are of great importance for energy savings as they are normally the part of the construction with the highest heat loss. It is usually found that the heat loss of the windows is some 25 per cent of the total energy losses in old houses. For new low-energy houses with extreme insulation thicknesses of 30-40 cm of mineral wool the loss may be as much as 50 per cent. To control energy consumption in building most building codes therefore have some defined upper limit for the k-value of the window.

The window has, however, a unique positive influence on energy consumption, as beneficial solar radiation is transmitted through the glazing. Here we do not consider commercial buildings, where the problem can be overheating. As the marketing of glazing has expanded to comprise many different types of thermal glass, it is important to select the right glazing for a house to achieve energy saving. This applies both to new houses and to retrofitting old houses. In this paper we show a design chart which could be used for this selection.

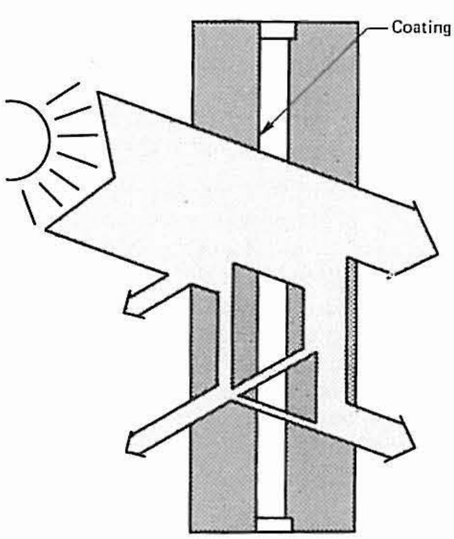
New coated glazing

A few years ago only clear glass would be used for residential buildings. One then had to decide if one wanted single, double or triple glazing. Only for special solar shading purposes was heat-absorbing gold coating used. In the last few years, however, a number of new coated glazings have been introduced on the market. These have in most cases k-values comparable to ordinary triple glazing or better. They also have low emissivity properties. Additionally, some types have gas-filled spaces to get a lower k-value. A description of these types is found in reference 1.

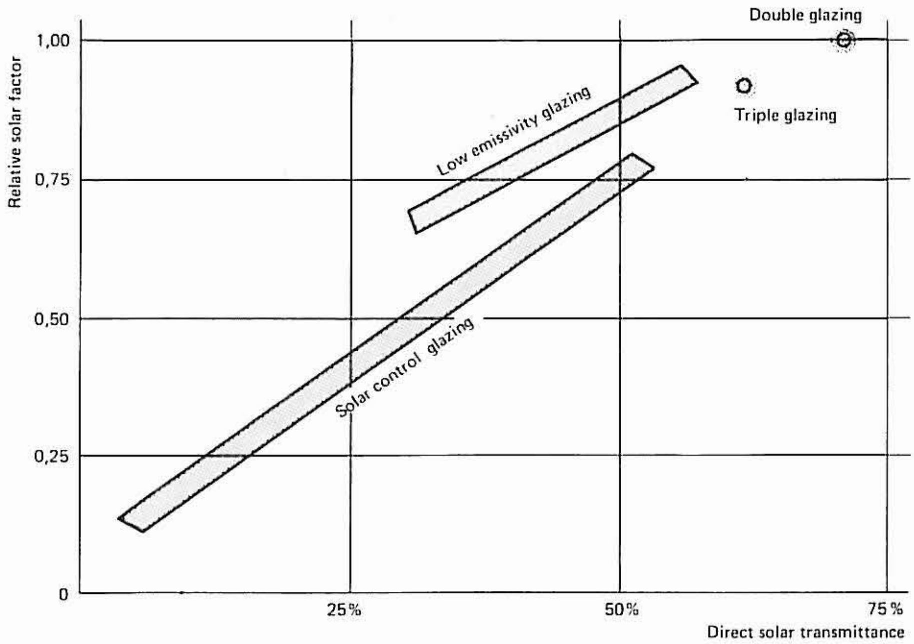
Solar control glazing
Coated glass outside



Low emissivity glazing
Coated glass inside



How some of the new type glazings are constructed and function



Some representative results for direct solar transmittance and relative solar factor

As the k-value is improved, it is expected that the energy consumption in houses will go down. This is not necessarily the case, because, while it is possible to improve the k-value of glazing by coating, this excludes some part of the heat gain into the house. The reduction of the insolation will increase the energy consumption and therefore counteract the energy savings from the improved k-value.

Parameters for selection

We apply two parameters to classify the glazing property in the context of reducing energy consumption:

- Heat transfer coefficient k-value (W/m^2K).
- Relative solar factor S (W/m^2K).

Both parameters can be calculated if all physical properties of the glazing are available. That is not normally the case, so some measurements may have to be done. Measurements are also necessary to test the commercial products in the market. The k-value is recommended to be measured in a guarded hot box.

The relative solar factor is defined as the ratio of insolation through the actual glazing to the insolation through normal double glazing with clear glass and 12 mm air space. Measurements of the insolation may be done outdoors in clear sunshine using a calorimetric device. In the following the relative solar factor is called the solar factor(S). The insolation consists of both direct and diffuse radiation and secondary heat from absorption in the glass.

Measurements of these two parameters are available (ref 1) for some commercial products on the Norwegian market. On clear glazing with 4 mm glass thicknesses and 12 mm space, the parameters are:

- 2 layers; k = 3.0 W/m^2K; S = 1.0,
- 3 layers; k = 2.1 W/m^2K; S = 0.9.

From this it is seen that with more layers of glass the k-value improves and the transmission heat loss goes down, but at the same time the solar factor is reduced causing a reduction in the insolation. In most residential buildings the insolation reduces the energy consumption, and both the k-value and the solar factor are important. An example is glazing with k = 1.6 W/m^2K and S = 0.6, better than normal triple glazing with k = 2.1 W/m^2K and S = 0.9. The k-value is improved but the solar factor is reduced, so the question could only be answered after calculations on actual building types. The result is given in the section on 'the design chart and its use'.

Energy calculation method

The calculation of energy consumption is made by a simple method EFB1 (ref 2). The calculation is made on monthly values by means of a desk calculator (ref 3) or a computer. The energy losses are calculated from transmission, and ventilation losses from knowledge of the indoor and outdoor temperatures and the actual construction. The method also takes into account the free heat, *ie* heat from insolation, from people and from electric light and appliances.

From this information is calculated the energy consumption of a house with 100 per cent heat accumulation, and that of a house without any heat accumulation. It has been found that calculations with a computer program on an hourly basis would always give results between these two limits. Using this information, the energy consumption can be calculated. The paper (ref 2) contains information on the theory and how to use the program.

Detached single-family house

The first example is a normal Norwegian detached single-family house situated in Oslo. The house is 120 m^2, insulated according to the latest building code. The transmission losses consist of:

	Area (m^2)	k-values (W/m^2K)	A . k (W/K)
Floor.......	114.3	0.3	34.3
Roof.......	114.3	0.23	26.3
Walls......	101.5	0.25	25.4
Door.......	2.0	2.0	4.0
Windows	18.0	2.1	37.8
		Total	127.8

The ventilation losses are 44.1 W/K with an air change of 0.5. The amount of free heat from people and electricity is 17.8 kWh/day. The glazing area of 18 m^2 with clear triple glazing is distributed with 9 m^2 facing south and 3 m^2 north, east and west. Indoor temperature is 21 °C.

The climatic data from Oslo consist of the mean monthly outdoor temperature and the insolation through clear double glazing facing north, south, east and west. Shading from the surroundings has not been taken into account.

Design chart and its use

For the house the energy consumption is calculated with glazing k-values 3.0, 2.0 and 1.0 W/m^2K. For these k-values the solar factor changes from 1.0 to 0.2 in steps of 0.2. All these cases are used for the construction of figure 1.

On the y-axis is the relative energy consumption where 100 per cent is the value for the house with normal clear double glazing. On the x-axis is the k-value of the glazing. On the chart are lines for the different solar factors. The use of a relative energy scale is found convenient, as the chart summarises all climatic areas of Norway with only minor deviations.

This chart could be used to find out which glazing gives the lowest energy consumption, *ie*:

k-value (W/m^2K)	S-factor	Relative energy consumption (%)
3.0	1.0	100
2.1	0.9	89
1.6	0.6	88

Here we can find that the energy consumption for the glazing with k = 1.6 W/m^2K is nearly the same as the normal triple glazing. If we had looked only at the heat losses, we would have expected an energy saving of 5 per cent from the change in k-value. That is not the case, because the solar factor is lower than for triple glazing. If the solar factor had been lower than 0.6, the energy consumption would have been higher than with triple glazing.

Other kinds of housing

The same diagram has been constructed for the single family house with 25 per cent glazing (fig 2). The sloping is found to be greater than for 15 per cent glazing and the energy savings potential should be greater. Calculations done for terraced-houses and flats with 15 per cent and 25 per cent glazing are shown in figures 3 to 6.

When we go from one-family houses to terraced-houses and flats, the slope of the curves in the diagrams changes. It has been found that the slope is proportional to the transmission losses of the windows in relation to the total ventilation and transmission losses. It should therefore be possible to construct design charts for other types of buildings without making a lot of calculations.

Other climates

This calculation has been done with climatic data from the Scandinavian countries, and it has been found that the design charts are very much alike. The same diagram is in fact valid for a wide geographical area.

By using climatic data from a number of countries we suggest that design charts could be constructed for other parts of the world. We have taken as examples countries in the northern hemisphere and mostly areas with winter heat requirements.

The mean monthly temperature and the global solar radiation have been taken from references 4 and 5. The radiation on walls facing north, south, east and west has been calculated using the method of Klein (ref 6). From the direct and diffuse radiation the insolation through normal double glazing has been calculated. These data and the same single-family house (as described above) have been used in the energy calculation.

Design reference chart, detached house

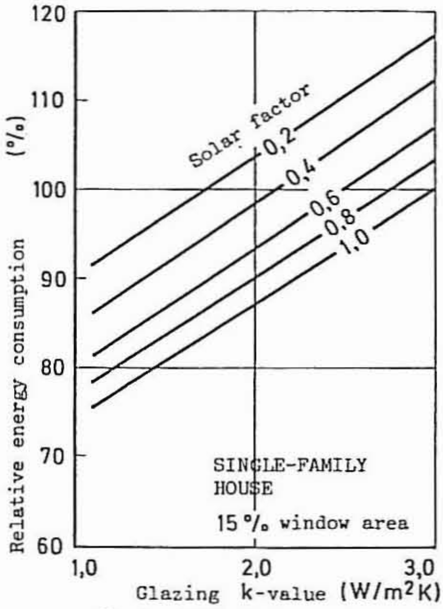


Fig. 1. 15 % window area

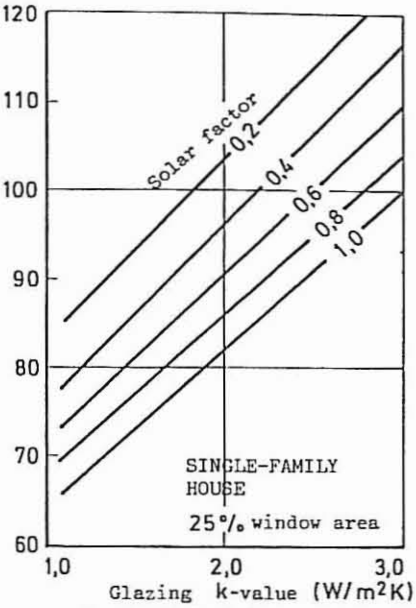


Fig. 2. 25 % window area

Reference chart for a terraced house

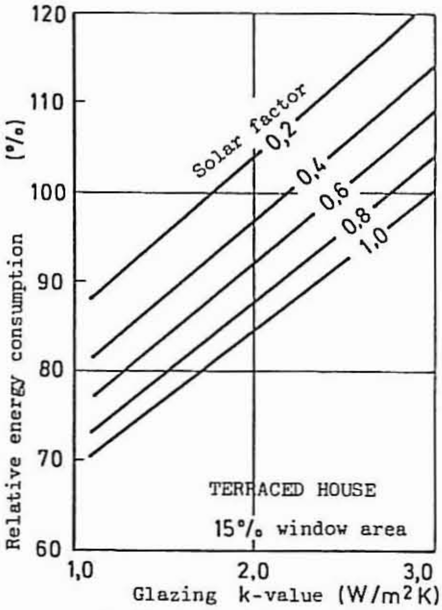


Fig. 3. 15 % window area

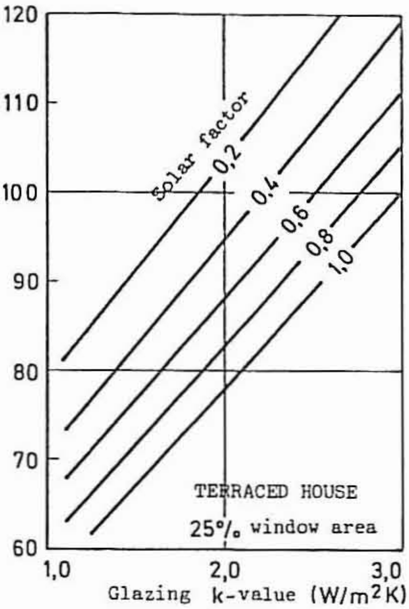


Fig. 4. 25 % window area

Reference chart for a multi-storey flat

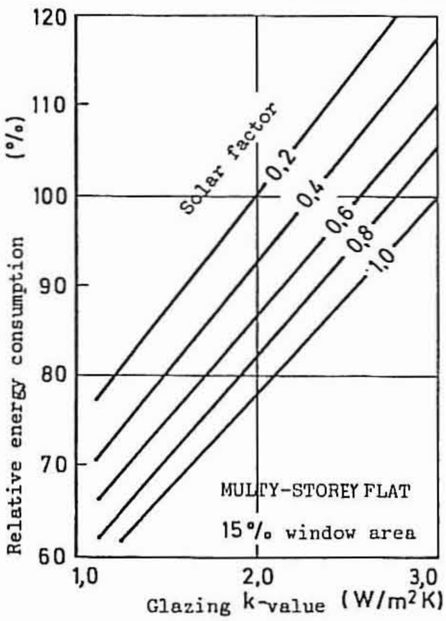


Fig. 5. 15 % window area

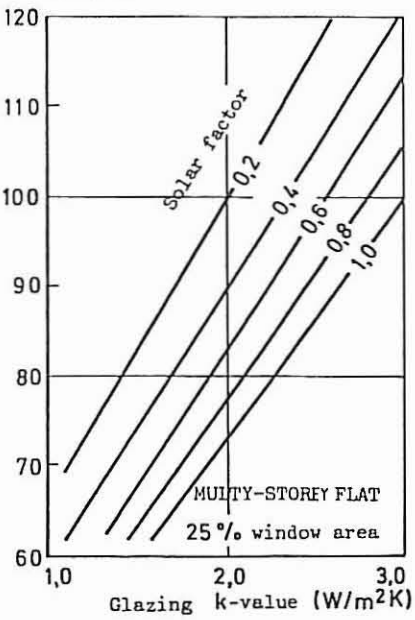


Fig. 6. 25 % window area

Table 1. Data for constructing design charts

120 m² detached single-family house with 15% window area				
Glazed area with: k-value (W/m²K) / Solar factor	3.0 / 1.0	2.0 / 1.0	3.0 / 0.6	2.0 / 0.6
Energy consumption (MWh/year)		**Energy savings (%)***		
Norway		%	%	%
Oslo 50° 56'	15.5	12.7	– 7.5	5.9
Tromso 69° 39'	20.0	12.3	– 6.4	6.5
Kautokeino 60° 00'	27.6	12.0	– 5.0	7.3
Sweden				
Stockholm 59° 20'	14.3	13.2	– 8.6	5.3
Denmark				
Tastrup 55° 40'	12.3	13.1	– 9.4	4.8
United Kingdom				
Eskdale 55° 19'	13.5	14.2	– 11.1	3.9
Kew 51° 28'	9.3	14.0	– 9.9	4.9
The Netherlands				
De bilt 52° 06'	10.7	13.6	– 9.8	4.9
Belgium				
Oostende 51° 12'	10.0	14.2	– 10.9	4.0
France				
Trappes 48° 46'	9.5	14.2	– 11.2	3.9
Carpentras 44° 05'	6.1	15.5	– 16.9	0.5
Italy				
Genova 44° 25'	4.2	16.6	– 17.8	– 0.2
Gagliari 39° 15'	2.8	17.3	– 22.6	– 2.5
Japan				
Sapporo 43° 03'	13.2	13.7	– 10.5	3.7
Fukuoka 33° 35'	5.4	15.3	– 14.0	2.6
USSR				
Moscow 55° 45'	18.9	12.4	– 7.1	5.9
Canada				
Edmonton 53° 34'	18.5	13.1	– 10.4	3.5
USA				
Madison WI 43° 09'	13.5	13.3	– 10.4	3.9
Mason City IA 43° 09'	14.1	13.2	– 10.0	3.7
Seattle WA 47° 39'	7.7	15.2	– 13.0	3.0
Albuquerque NM 35° 05'	5.1	17.3	– 23.1	– 4.5

* Energy savings are given as percentage of the energy consumption of the house with glazing k = 3.0 W/m²K and S = 1.0.

Other countries

The results are shown in table 1 for locations in Europe, Japan and North America. The results could have some minor faults because of the calculation method for solar radiation, but tests on data from Tåstrup, Denmark, have shown good correlation with measured values.

For each location the energy consumption in MWh/year is given for the single family house with 15 per cent windows of clear double glazing. For the same house with other glazing types the energy saving is calculated from the standard house.

The energy saving is from 12 to 17 per cent if the k-value is changed from 3 to 2 W/m^{2}K. The highest savings are found in mild climates with much sun, where the energy requirements for heating are small. If we use windows with a solar factor S = 0.6, we would have an extra consumption 5 - 23 per cent for glazing with k = 3. Again, the highest values are found in mild climates. If the k-value had been 2 W/m^{2}K the saving varies between 7 per cent and - 5 per cent.

If we exclude the most southerly locations with mild climates and a lot of sun, we could get nearly the same design chart for all areas which have heat requirements in the winter.

From the values in table 1 design charts can be constructed for different locations. They are data for the construction of two lines with solar factors of S = 1.0 and S = 0.6. By taking a specific product one may calculate the energy consumption from the relative energy consumption in the design chart and multiply it by the energy consumption of the standard house in table 1. One can also use the design chart for comparison of different products when one knows the respective k-values and solar factors.

Glazing selection and building regulations

The design chart is a useful tool for engineers and architects for the selection of glazing. If one knows the products (as from reference 1) it is easy to find out what happens to energy consumption when a certain product is used. This diagram could be used both for old and new houses. The diagram should of course be constructed for the particular building type and the normal insulation standard used in different countries. The chart is basically dependent on the climate and the ratio between the heat loss through the window and that from the whole building.

Building codes today often state only the k-value for windows. This may lead to wrong conclusions if the architect takes into account only this k-value and not the influence of the solar factor. It is, however, possible with building regulation to develop some kind of equivalent k-value to take the solar factor into account; this solution comes into effect in Norway this year.

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