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A simple method for the estimation of energy savings through application of transparent insulation materials

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ABSTRACT

A simple method for estimating the effects of transparent insulation materials in buildings is presented. Based on monthly mean climatic data and a spreadsheet calculation, the method allows possible energy savings to be visualized in a diagram of transmission versus U-value. The method is meant for architects during the first phases of a design process.

INTRODUCTION

The calculation of the solar gains of a building using transparent insulation material (TIM) should be performed on three levels. On the two levels of scientific research and engineering detailed simulation is necessary on an hourly basis. On a third level, a simple method for architects has been developed for first estimates of auxiliary heating demands, based on monthly meteorological data. A personal computer and a spreadsheet calculation (Framework) have been used.

Good performance of a TIM is characterized by high solar transmission and a low U-value. In a diagram showing the transmission versus the U-value, best performing TIMs will be found in the upper left corner (see Fig. 1). However this information is not sufficient for the validation of different TIMs for different types of buildings in a specific climate.

INPUT: GIVEN PARAMETERS

For this estimate, a simple set of building parameters for a one-zone building is used with:

		U-value (W/m^2K)
–floor / roof area	$10x10=100\ m^2$	0.55 / 0.30
–total wall area	$88\ m^2$	1.75 (without insul.)
–windows (half N and S)	$22\ m^2$	3.00
–air change rate	0.7 /hr	
–base temperature	20 °C	
–internal gains	15 kWh/d	

With a conventional opaque insulation of 3 cm of polystyrene this building fits the German insulation standards (WSVO). According to these standards, which do not allow solar gains to be taken into account, the use of any TIM having a U- value higher than 1.5 W/m^2K has to be excluded for this particular building. This is indicated in Fig. 1 by the limit "minimum insulaton". Further calculations have only to be performed with TIMs left of this limit.

Monthly data of mean outdoor temperatures (1) and global irradiation on horizontal and vertical surfaces facing west, north, east and south (2) of the weather station of Trier, Federal Republic of Germany, have been chosen.

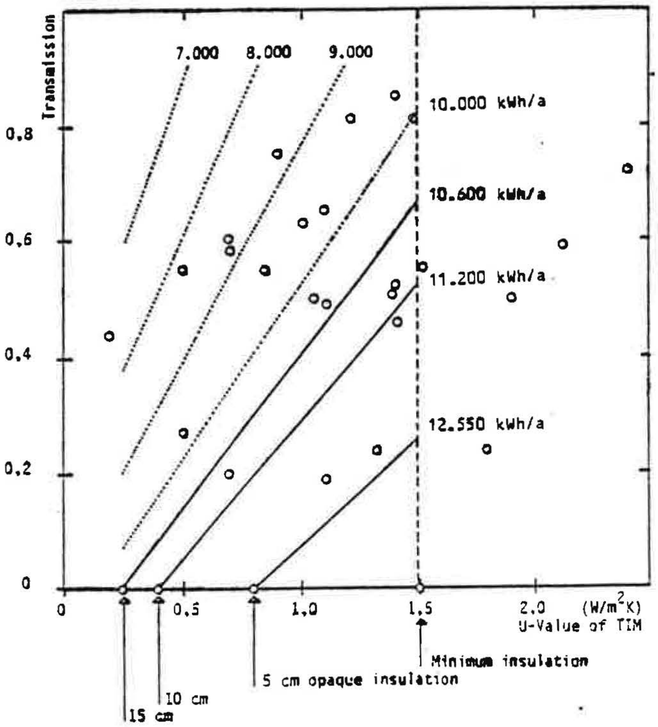

Fig. 1 "Curves" of equal auxiliary heating demand

OUTPUT: ENERGY BALANCE

The monthly total gain (including internal and solar gain) has been calculated and related to the total load using the Gain Load Ratio (GLR, instead of the solar load ratio, SLR).

The simple formula

$$FU = (1-\exp(-GLR)) / GLR$$

used here was given by Heidt (3). It is an estimation on the usable fraction FU of gains. According to Platzer (4,5) the formula seems to predict slightly conservative results with respect to the possible energy savings.

ZEITRAUM :	JAN	FEB	MAR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ	JAHR	HEIZZEIT
Heiztage :	31	28	31	30	31	0	0	0	30	31	30	31	273	273
Heizgradtage: :	570	512	434	321	195	102	47	84	165	316	426	512	3684	3452

V E R L U S T E (alle Energiewerte in kWh)

SÜD Fenster :	452	406	344	254	155	81	37	66	131	250	337	405	2918	2734
WEST Fenster :	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NORD Fenster :	452	406	344	254	155	81	37	66	131	250	337	405	2918	2734
OST Fenster :	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fenster Summe :	904	812	687	508	309	162	74	133	261	501	675	810	5835	5468
SÜD Wand :	131	117	99	74	45	23	11	19	38	72	98	117	844	791
WEST Wand :	218	196	166	123	75	39	18	32	63	121	163	195	1407	1318
NORD Wand :	131	117	99	74	45	23	11	19	38	72	98	117	844	791
OST Wand :	218	196	166	123	75	39	18	32	63	121	163	195	1407	1318
Wand Summe :	697	626	530	392	239	125	57	102	202	386	521	625	4502	4218
SÜD gesamt :	582	523	443	328	199	104	47	85	168	323	435	522	3762	3525
WEST gesamt :	218	196	166	123	75	39	18	32	63	121	163	195	1407	1318
NORD gesamt :	582	523	443	328	199	104	47	85	168	323	435	522	3762	3525
OST gesamt :	218	196	166	123	75	39	18	32	63	121	163	195	1407	1318
W+F Summe :	1601	1438	1218	901	548	286	130	235	463	887	1195	1435	10337	9686
:														
BebauteFläche B:	376	338	286	212	129	67	31	55	109	209	281	338	2431	2278
Dachfläche D:	411	369	312	231	141	73	33	60	119	228	307	368	2652	2485
Gesamtaußenfl.A:	2388	2145	1817	1344	818	427	195	350	691	1324	1783	2141	15421	14449
:														
Lüftungsverlust:	914	821	696	515	313	164	75	134	265	507	683	820	5906	5534
GESAMTVERLUSTE :	3302	2966	2512	1858	1131	590	269	485	955	1831	2466	2961	21327	19983

P O T E N T I E L L E G E W I N N E (aller Flächen und interne Gewinne)

Interne Gewinne:														
Zeile mit 100m2:	465	420	465	450	465	450	465	465	450	465	450	465	5475	4095
Sol.Gew.Fenster:														
SÜD :	202	335	467	519	542	506	558	566	546	409	209	177	5035	3406
WEST :	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NORD :	57	94	171	257	365	397	393	302	209	124	63	43	2475	1383
OST :	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fenster gesamt :	259	429	638	776	907	903	951	868	755	532	272	220	7510	4789
Solar.Potential:														
SÜD :	197	327	456	506	529	493	544	552	532	399	204	172	4913	3323
WEST :	153	291	527	748	914	940	977	853	655	380	167	125	6730	3960
NORD :	56	92	167	250	356	388	383	295	204	121	61	42	2415	1349
OST :	153	291	527	748	914	940	977	853	655	380	167	125	6730	3960
Wände gesamt :	560	1002	1677	2253	2712	2760	2882	2553	2047	1280	599	464	20788	12593
Dach :	28	51	97	144	188	195	202	170	123	69	31	22	1319	752
Solar Gesamt :	847	1482	2412	3172	3807	3858	4035	3591	2925	1881	902	705	29618	19133
GEWINNE Gesamt :	1312	1902	2877	3622	4272	4308	4500	4056	3375	2346	1352	1170	35093	22228

B I L A N Z (Solar-Last-Verhältnis, Nutzungsgrad, Heizbedarf)

anrech.(Heidt) :													Summe:	
nur interne Gw.:	434	392	425	400	381	315	221	299	359	411	411	430	4477	3642
int.Gw + D + F :	673	777	954	969	846	548	269	463	717	808	649	629	8300	7021
(alle Gewinne) :														
SLV :	,40	,64	1,15	1,95	3,78	7,30	16,72	8,37	3,53	1,28	,55	,40		
N (Heidt) :	,83	,74	,60	,44	,26	,14	,06	,12	,27	,56	,77	,83		
anrechenbar:	1082	1404	1713	1594	1105	590	269	484	927	1322	1041	967	12499	11155
davon TWD-Wände:	410	628	759	625	259	43	1	22	210	514	392	338	4199	4134
Rest-Heizbedarf:	2220	1562	799	265	26	0	0	0	28	508	1425	1994	8828	3828

Fig. 2 Calculation table

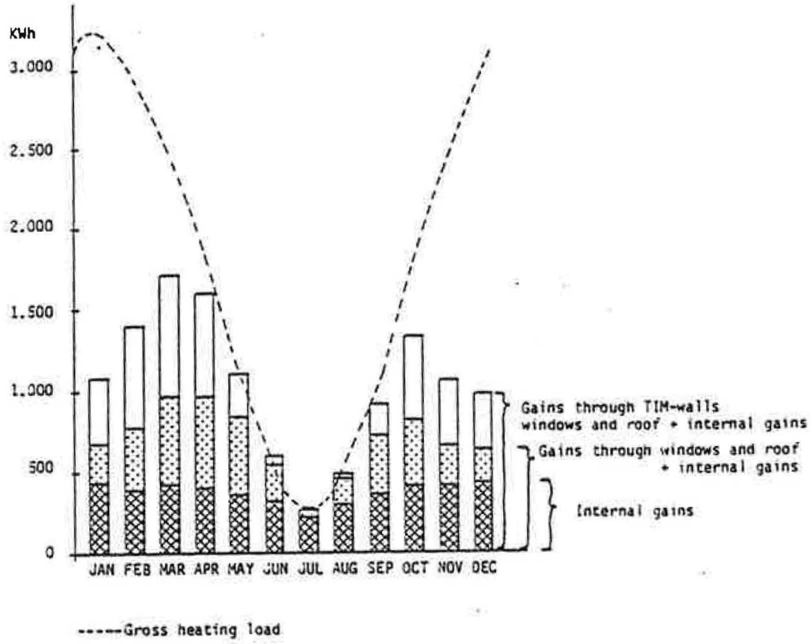

Fig. 3 Bar diagram showing the net gains and gross heating loads

Loads minus usable gains provide the monthly auxiliary heating demand which can be summed up to a yearly amount. Fig. 2 shows an example of a calculation table containing losses, gains and balances for every month, the entire year and the traditional heating period of the year (Sept. to May). Fig. 3 shows the distribution of monthly loads and usable gains.

DISCUSSION OF FIRST RESULTS

For this particular case, TIMs with different combinations of transmission and U-values that lead to the same yearly amount of auxiliary heating demands are shown as lines in Fig.1.

Full lines denote TIMs that render a result equal to an opaque insulation of 5, 10 and 15 cm (see circles on the x-axis). Beyond the range of conventional insulation, additional energy savings are possible (regime of dotted lines). The amount of savings is given by the spacing between any two curves of equal auxiliary heating demand.

It must be noted that the lines do not have to be straight lines but can be curved in other cases. Positions and spacings of the lines visualize a classification scheme of different TIMs for a special building and climate: they depend on the chosen formula of estimating the usable fraction of heat gain.

FUTURE DEVELOPMENTS

Subject to a final estimation formula, found by fitting results of applications and simulation programmes, an economic validation can be given.

TIMs falling within the full lines have to compete with the corresponding opaque insulation in price. Additional savings can be evaluated economically by attaching (current or expected) energy costs to the corresponding curves of equal auxiliary heating demand. Thus the method presented provides a quick evaluation of possible energy and cost savings of a TIM application for a particular building.

REFERENCES

1. Achard, Patrick; Gicquel, Renauld (Eds.) for the Commission of the European Communities: European Passive Solar Handbook, Brussels, 1986
2. Palz, Wolfgang (Ed.): Atlas über die Sonnenstrahlung Europas, Vols. 1 and 2, Verlag TüV Rheinland, Köln, 1984
3. Heidt, Frank-D: *Effective solar U-values of walls, windows and facades based on a solar savings correlation.* E. Bilgen, K.G.T. Hollands (Eds), Proc. 9th Biennial Congress ISES, Vol. 1. Pergamon Press, pp 417-424, Montreal, 1985
4. Platzer, Werner J.: Personal communication
5. Platzer, Werner J.: *Utilization of heat gains from transparently insulated collector-storage walls.* To be published in the Proceedings of the 10th Biennial Congress, ISES, Hamburg, 1987