Ecological and energetic evaluation of transparent insulation systems

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ABSTRACT

In the paper we report on our joint efforts to perform an ecological and energetic evaluation of different transparent insulation systems. Solar gains have been calculated for different climatic zones in Austria, for different house types and orientations. The ecological evaluation of the systems is based on the methode of Life-Cycle-Assessment using a material and impact balance. In the catagory greenhouse effect, the CO_2 production is used as an indicator for environmental compatibility. Other categories of environmental impact will be treated qualitatively. It will be shown that TI can make a significant contribution to reducing the global greenhouse effect.

INVESTIGATIONS

By commission of the Austrian Federal Ministry of Environmental Affairs, a study was carried out on the ecological, energetic and economic evaluation of a variety of transparent insulation systems.
Six commercial available TI systems from five manufacturers and one do-it-yourself sytem were compared in this study. Most of these systems consist of TI elements (panels) attached to the wall by means of a frame construction. They differ in the type of TI material employed (high-transparency plastics and glass), in the type of frame construction of the elements (aluminium, plastics, wood), and in the type of façade frame construction (aluminium, wood). Furthermore, a transparent external insulation and finish system and a low-price system made of recycling material (cardboard honeycombs) were also investigated and the latter as a link between the efficient TI systems and conventional insulation. Data was collected from the manufacturers of these systems by means of a questionnaire as to material, energy consumption and emission data.
The basis for evaluation is the application of transparent insulation façades on external massive walls with an area ratio of standard wall to transparently insulated wall of less than 10 %. The buildings investigated are either typical Austrian two-family houses according to current building practice or the same type of houses built during the 50's and 60's, which have usually been renovated meanwhile.

ENERGETIC EVALUATIONS

The solar gains of the various systems have been calculated for five different climatic zones in Austria, for both house types and for different facing of the transparently insulated façade. The calculations were performed stationary and on a monthly basis in accordance with the European initial standard prEN 832.

Under these very favourable basic conditions it is possible to achieve around 100 - 180 kWh (climate Vienna) up to around 450 kWh (high mountains regions climate) per m² of façade and year with a south-facing orientation depending on the system and climate location; cardboard honeycomb systems, in contrast, achieve only approximately a quarter of these values.

ECOLOGICAL EVALUATIONS

The ecological evaluation of the complete systems is based on the methode of Life-Cycle-Assessment using a material and impact balance. In the category greenhouse effect, the primary energy requirements and CO_2 greenhouse gas potential were used as indicators for environmental compatibility. These values were compared with the heating energy and CO_2 emissions savings for building heating produced during the life span of the systems (at least 20 years) and payback times were computed for primary energy and CO_2 emissions.

Depending on the system, climate and facing, the energy payback times are somewhere between 0.5 to 9 years; system efficiency and particularly the amount of aluminium are of decisive importance. These payback times are by far exceeded by the expected life span, especially in the case of the highly efficient systems with low amounts of aluminium, with the effect that these systems provide many times the energy required for their production in the form of heating energy. Moreover, the CO_2 payback times are far lower where oil heating is used then the energy payback times.

The use of TI for building heating can thus make a significant contribution to reducing the global greenhouse effect.

In terms of eco-toxicology, production of the plastic polyurethane is particularly problematic, although it must be said that production of PMMA, polycarbonate, polystyrene and also processing of glass fibre tissue also involves certain risks. Aluminium and products made of fossil raw materials (plastics) must be categorised as particularly critical resources.

Currently there are no framework conditions for systematic recycling. Apart from that, not all systems can be recycled due to their specific mode of construction.

From the environmental point of view, the following aspects of TI systems are of particular importance; there is still great potential for development in this respect. Preferential use of indigenous timber instead of aluminium as a construction material, increased use of glass instead of plastic as a TI material, avoiding non-recyclable composites, creating of structures and framework conditions for recycling.

Table 1: TI systems investigated

System	Product	TI material	Cover material	Façade construction	Description
Okalux „conventional" [1])	Kapilux-SFP	Polycarbo-nate (PC)	Glass	Wood (post rail)	prefab TI system, element attachment in façade construction
Okalux „hermetic" [2])	Kapilux-H	PC	Glass	Aluminium	as above
Okalux „hermetic" [2])	Kapilux-H	PC	Glass	Wood (post rail)	as above
Schott	Helioran	Glass	Glass	Aluminium	as above
Sto (Stotmeister)	StoTherm Solar	PC	Glass-plastics	Polystyrol (PS)	TI material inserted directly in the surrounding con-ventional insulation (PS)
Do-it-yourself system [3])		Polymethyl-methacrylate (PMMA)	Glass	Wood (post rail)	prefab TI system, element attachment in façade construction
Energieberatungs-Institut (EBI) Linz	Solar-fassade	cardboard honeycombs	Glass	Wood (post rail)	TI material inserted directly in wooden façade construction

[1]) The TI element is in the form of a stepped panel.
[2]) The TI element has a hermetic sealing like a sealed double glazing.
[3]) After the system of Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Gleisdorf.

Table 2: TI gains as the difference of the annual heating energy requirements of the conventionally insulated and TI insulated new building and the renovated old building, per m² of TI façade, south facing.

TI gains	[kWh/m²a]	Okalux „conv."	Okalux „herm."	Okalux „herm."	Schott	Sto	Do-it-yourself	EBI-Linz
façade constr.		Wood	Alum.	Wood	Alum.	PS	Wood	Wood
Wien, Hohe Warte	New build.	169	177	182	172	107	172	37
	Old build.	149	155	158	148	92	150	30
Graz, Flughafen	New build.	216	227	232	221	134	220	47
	Old build.	191	198	202	190	115	191	38
Innsbruck, Uni	New build.	264	277	283	273	165	268	61
	Old build.	234	243	246	235	142	235	50
Rauris	New build.	302	316	324	309	185	307	63
	Old build.	266	276	281	265	158	267	50
Obergurgl	New build.	428	449	459	441	255	435	85
	Old build.	378	393	398	378	219	379	69

These relatively high gains are the result of the favourable application conditions for TI upon which the investigation was based: low insulation standard, low TI surface percentage, low window surface percentage, no horizon shading and some high mountain regions with high level of irradiation and low outdoor temperatures. With a south-west facing, around 90 % of these vales are achieved and around 66 % with a west facing.

Table 3: Energy payback times of TI systems for south facing

Energy payback times [a]		Okalux „conv.“	Okalux „herm.“	Okalux „herm.“	Schott	Sto	Do-it-yoursel f	EBI-Linz
façade constr.		Wood	Alum.	Wood	Alum.	PS	Wood	Wood
Wien, Hohe Warte	New build.	3,8	3,9	2,1	4,7	1,2	1,4	6,7
	Old build.	4,0	4,1	2,1	5,0	0,8	1,2	6,5
Graz, Flughafen	New build.	3,0	3,0	1,7	3,6	0,9	1,1	5,3
	Old build.	3,1	3,2	1,7	3,9	0,6	1,0	5,1
Innsbruck, Uni	New build.	2,4	2,5	1,4	2,9	0,8	0,9	4,1
	Old build.	2,5	2,6	1,4	3,2	0,5	0,8	3,9
Rauris	New build.	2,1	2,2	1,2	2,6	0,7	0,8	4,0
	Old build.	2,2	2,3	1,2	2,8	0,4	0,7	3,8
Obergurgl	New build.	1,5	1,5	0,9	1,8	0,5	0,6	2,9
	Old build.	1,6	1,6	0,8	2,0	0,3	0,5	2,8

Table 4: Approximation ascertained CO_2 payback times of TI systems for the new building, location Graz, south facing, using a heating system with heating oil.

CO_2 payback times [a]	Okalux „conv.“	Okalux „herm.“	Okalux „herm.“	Schott	Sto	Do-it-yourself	EBI-Linz
façade constr.	Wood	Alum.	Wood	Alum.	PS	Wood	Wood
Graz, Flughafen	2,3	2,4	1,2	3,1	0,25	0,7	3,5

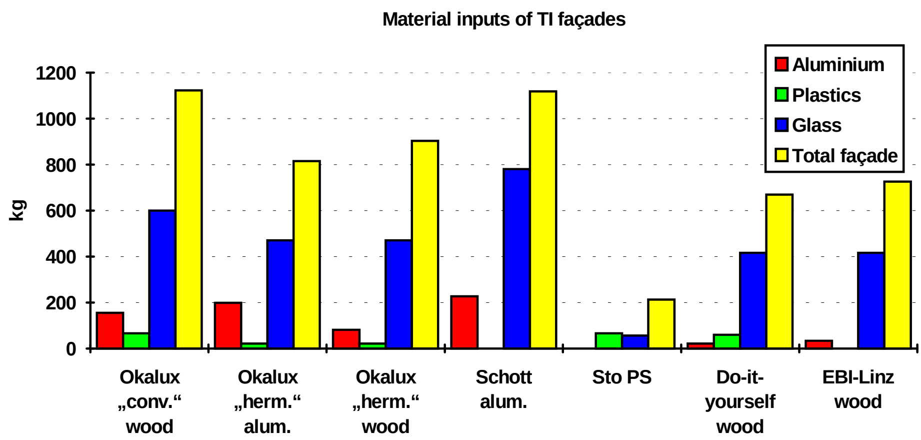

Fig. 1: Summary of material inputs (kg for 20 m² façade) of TI façades

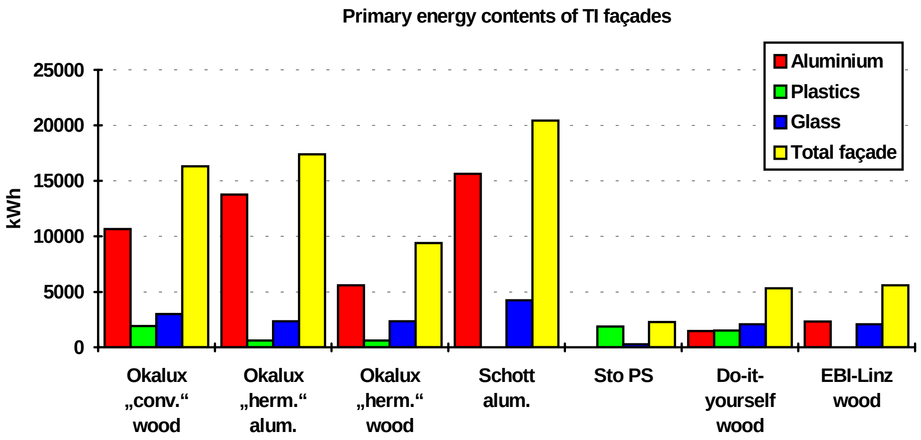

Fig. 2: Summary of primary energy contents (kWh for 20 m² façade) of TI facades

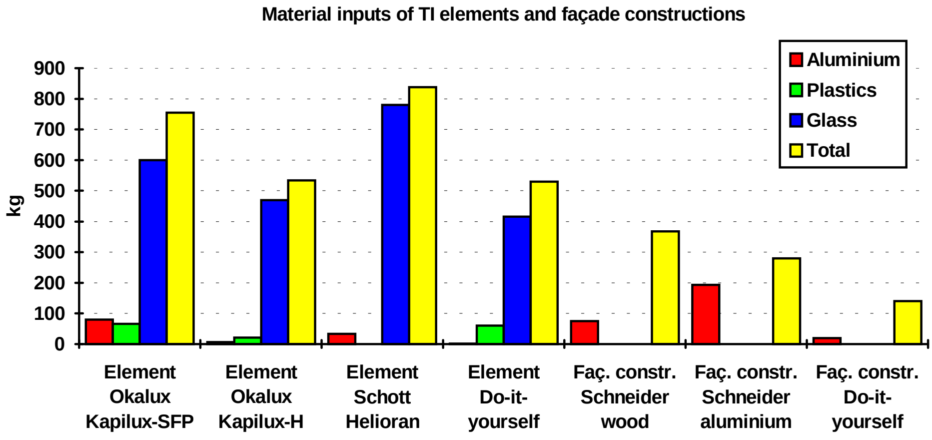

Fig. 3: Summary of material inputs (kg for 20 m² façade) of TI systems, divided according to elements and façade constructions (Kapilux SFP corresponds to Okalux „conventional” and Kapilux-H corresponds to Okalux „hermetic“).

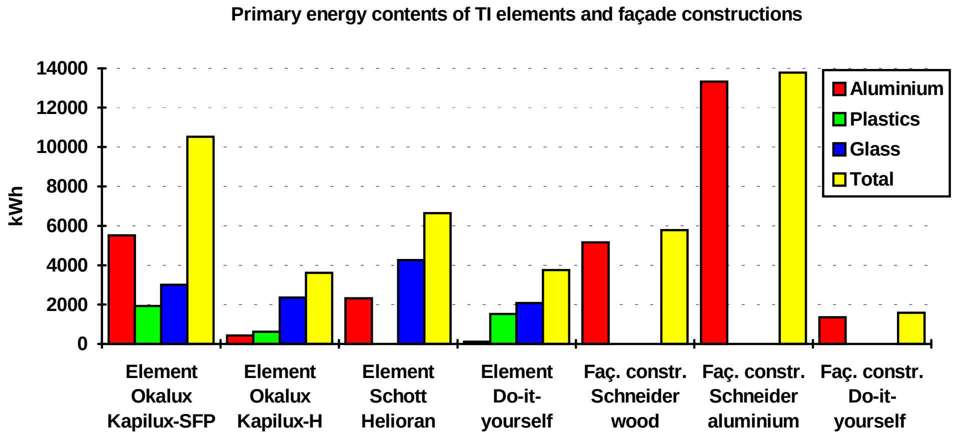

Fig. 4: Summary of primary energy contents (kWh for 20 m² façade) of TI systems, divided according to elements and façade constructions (Kapilux SFP corresponds to Okalux „conventional" and Kapilux-H corresponds to Okalux „hermetic").