

# Investigation of a Solar active glass facade

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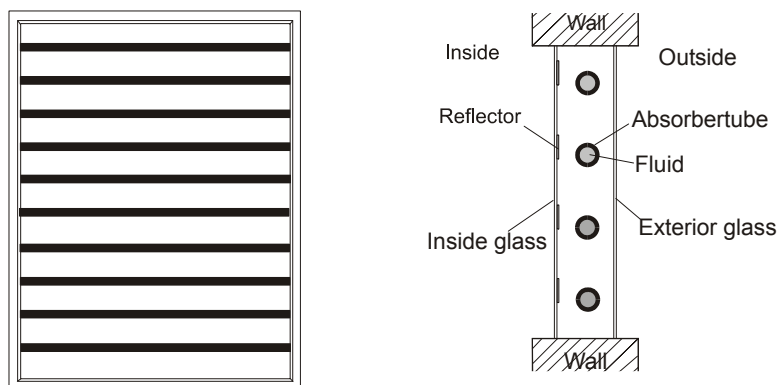
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## 1. Introduction

The use of solar thermal systems for hot water preparation and space heating in single family houses is the state of art. For further dissemination of solar thermal energy multi family houses and industrial- as well as business-buildings promise great potential. For such buildings solar cooling can also assume importance. In contrast to single-family houses the ratio of roof area to heated space is much smaller for these buildings. For bridging this gap solar active facades are suitable. It is expected that these components will take their part in the future solar market.

In this article the investigation of a solar active glass facade is described. This facade consists of a solar collector integrated into a conventional double-glassed window. To improve the collector efficiency reflector stripes are properly arranged as shown in the figure1. One half of the window area is covered by absorber and therefore diffuse and direct irradiation can still enter a room behind the facade.



**Fig. 1:** Front view and cross section of the window collector

Technical advantages of the solar activated glass facade are:

- the use of solar thermal energy,
- controlled room illumination,
- prevention of overheating.

In this project theoretical and practical investigations of the glass facade will be carried out to analyse the thermal behaviour under realistic outdoor conditions.

From an architectural point of view these technical advantages will have to be combined with the aesthetic appearance. This new device fulfils both.

To establish this new technology outdoor measurements under realistic conditions are necessary.

## 2. State of investigations

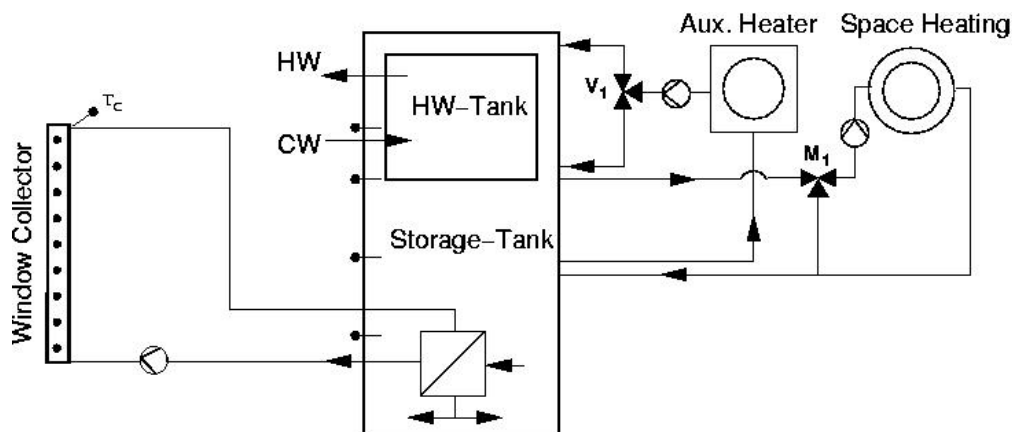
The concept of the window collector was setup by *J.M. Robin et. Al.* In [1] an overview of the state of art is given.

To evaluate the thermal performance of the window collector, a numerical investigation is made. A simple model describing the thermal behaviour of the system is implemented under the TRNSYS environment. The model takes both passive and active solar gains of the window collector into consideration. A dynamic building simulation was carried out with a solar combi system for space heating and domestic hot water preparation. The goals of the simulation are the estimation of the possible yearly energy saving and its influence on the room temperature behind the collector.

The necessary collector parameters for this simulation are obtained from a collector test in accordance to EN 12975-2. The collector testing was performed with a first prototype of the window collector. For this testing the collector was treated like a conventional collector. The thermal efficiency of the window collector is of course the efficiency of a typical flat plate collector due to the fact that only half of the aperture area is covered by the absorber. The k-value obtained from this test method is over predicted and therefore not suitable for the window collector.

Under realistic conditions with the window collector integrated into a wall the heat losses will be much smaller than the calculated one taking the above mentioned k-value into account.

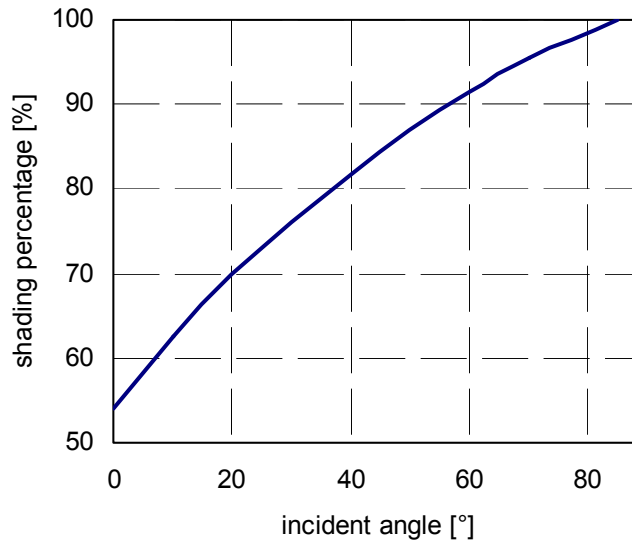
A one-family house at Würzburg with a yearly energy demand of 12674 kWh served as a reference. A schematic description of the solar combi system with 750 litres of tank-in-tank storage is given below (Fig 2).



**Fig. 2:** schematic draw of the solar combi system

Comparison is done for the energy savings due to a wall-mounted conventional flat plate collector of 15 m<sup>2</sup> and the window collector of the same area. The yearly energy saving was calculated as 22.2% for the flat plate collector and 19.2% for the window collector. This is a remarkable result given that the absorber area of the window collector is only half that of the flat plate collector. The primary reason for this better performance of the window collector is its optically optimised design (distance of absorber tubes, reflector arrangement) under the prevailing irradiance condition on a vertical wall and the secondary reason is an additional passiv solar gain. On account of the special optical

property of the window collector this passive solar gain is dependent on the incident angle (IAM). Corresponding the IAM the collector shades the room located adjacent behind the window collector depending on the position of the sun. Ray-tracing studies are undertaken to evaluate this. The results of this study are depicted in Fig. 3.



**Fig.3:** shading percentage as a function of incidence angle

The TRNSYS simulation described is not detailed enough to capture the interaction of the window collector and the room behind to calculate the influence on the indoor climate and comfort. The simulation results showed that even in summertime the room temperature may not rise above 25°C due to the shading effect of the window collector where as an ordinary window of the same size yields a temperature of 35°C.

A more detailed description of the simulation results is given in /1/

Despite the availability of the room temperature through TRNSYS simulation the comfort level inside the room is not fully discovered. The comfort level might be influenced by the possible high temperatures at the window collector. First measurements using infra-red camera showed temperatures of the inside glass surface up to 55° under stagnation condition corresponding to maximum a temperature at the absorber of 102°C. The effect of the window collector on the room climate still has to be investigated.

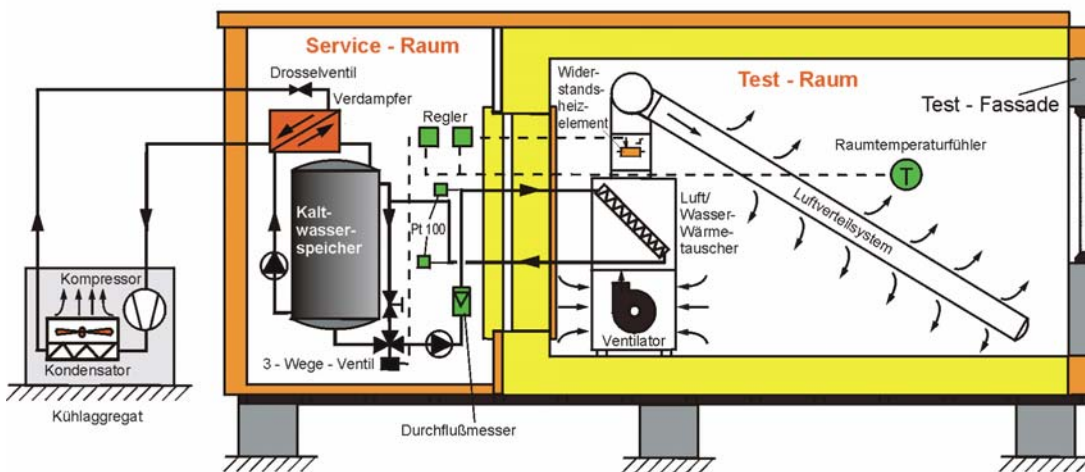
### 3. The PASSYS Test Procedure

To get an impression of the comfort level inside the room behind window collectors outdoor measurements under realistic weather and building conditions has to be carried out. To improve the simulation model realistic values of the important parameters like k and g-values should be measured.

For this purpose a test facility developed in the frame of the European project “ Passive Solar System and Component Testing” (PASSYS) is used.



**Fig. 4:** South View PASSYS Test Facility at ITW



**Fig. 5:** Construction of a PASSYS Cell with Test and Service Room

The PASSYS cell consists of a test room of a volume of  $38 \text{ m}^3$  and floor area of  $13.8 \text{ m}^2$ . The south oriented wall is removable a solar activated glass facade up to an area of  $7.6 \text{ m}^2$  can be integrated. The facade is connected to an acclimatised room. Computer controlled heating and cooling systems allows a wide range of control strategies. Using heat flux plates we are able to measure in and outgoing heat fluxes. The principle of the PASSYS procedure consists of an energy balance over the whole test room. All heat fluxes over the cell walls are known except the one over the test façade, which can be described using a RC-model containing the unknown k- and g-Values. The unknown k- and g-values are determined using parameter identification. The comfort level can also be monitored by the measurement of room temperature, surface temperatures and humidity.

## 4. Conclusion

A collector test in accordance with EN 12975-2 is carried out for a new window collector. The collector parameters were used in simulations to calculate the yearly energy savings for a typical one-family house in Germany.

Considerable energy savings are calculated for the configuration of conventional flat plate collectors mounted on a vertical wall. Further investigations are necessary to improve the numerical model and to adapt it to the real working conditions. Outdoor measurements under realistic conditions are necessary to investigate and to ensure the comfort level in the room behind.

## References

/1/ J.M. Robin, B. Flament, C. Vasile, *A new solution for the architectural integration*, Eurosun 2004,

/2/ H. Kerskes, H. Müller-Steinhagen, *Nutzung passiver Effekte bei der aktiven solaren Gebäudeheizung*, Tagungsband Solares Heizen, Intersolar 2002, Freiburg