The g value of building-integrated solar thermal systems

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Abstract

Innovative building-integrated components provide solar heating, solar control and visual contact to the exterior. However, their contributions to the building are challenging to predict. This paper presents the results of a detailed physical model which show that the g value depends not only on the position of the sun, but also on the collector operation mode. For successful marketing of such innovative components, a new standard would be helpful which clarifies when a detailed model can be considered to be validated by measurements. Customers could then check different applications with easy-to-use models.

Keywords: variable g value, transparent solar thermal collector (TSTC), building-integrated solar thermal systems (BIST), TRNSYS

1. Innovative building-integrated solar thermal systems

Building-integrated solar thermal systems offer the chance to reduce costs compared to building-attached solar thermal systems due to the substitution of conventional façade materials. Especially interesting are products which are not just integrated into the wall, but which actually *are* the wall. For instance, the Austrian project “Multifunctional Plug And Play Façade (MPPF)” [3] developed such façade elements for opaque walls. Even more interesting are semi-transparent façade-integrated collectors which enable visual contact to the exterior. RobinSun [1] is marketing a transparent solar thermal collector (TSTC), with collector fins in an insulating glazing unit. Combined with reflector strips on the inward facing glass pane, such a collector can also provide seasonal shading. Figure 1 presents a schematic drawing of the RobinSun collector.

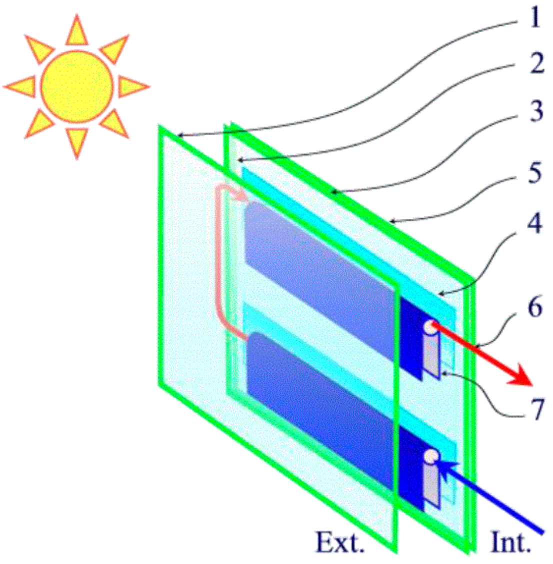

Figure 1: Schematic drawing of the semi-transparent RobinSun collector

(1) extra white external glass pane
(2) argon filling
(3) center glass pane with low-e coating on position 3
(4) aluminum strips with PVD silver coating as reflectors
(5) internal glass pane, glued with the reflectors to the center glass pane
(6) copper serpentine filled with heat transfer fluid
(7) aluminum ∩-shaped profiles with a solar selective absorber coating [1]

Another kind of transparent collector was developed within the European research project "Cost-Effective" [4]. Figure 2 presents a schematic drawing of this collector, which has punched slats creating openings in the absorber.

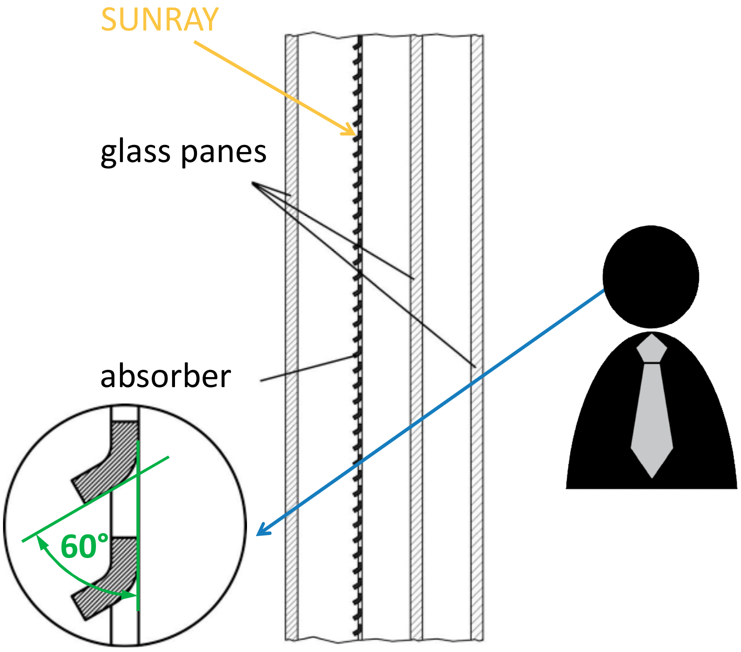

Figure 2: Schematic drawing of the transparent collector of the EU project "Cost-Effective"

Both collectors have two things in common: The solar transmission through the collectors is highly angle-dependent, and prediction of the heat flux to the interior needs a detailed modeling of the collector. Therefore a detailed physical model was developed for the collector of the Cost-Effective project.

2. Variable g value of building-integrated solar thermal systems

Within [5], the detailed physical model of the transparent collector was used to simulate a room with a south façade and various configurations of the façade and the HVAC system at Frankfurt am Main. Figure 3 presents schematic drawings of the different simulated façade configurations. In winter, the collectors were used to supply a thermally-activated building system with water heated to 35°C. In summer, the collectors supplied heat to a desiccant dehumidification system, an absorption chiller, an adsorption chiller or combinations of this equipment. The desiccant system saved the most primary energy.

Regarding the façade configurations, a glazed façade with transparent collectors in the spandrel area needs only half of the primary energy of a fully glazed façade. Compared to a façade with an opaque wall in the spandrel area and glazing above it, the glazed façade with transparent collectors in the spandrel area needs 30% less primary energy.

Furthermore, the g value of the collector proved to depend on the position of the sun as well as on the collector operation mode. Figure 4 presents the g value for each month, once for stagnation conditions (without fluid flow) and once for heating from October to April and desiccant dehumidification from May to September. The stagnation case shows the seasonal shading effect with higher solar gains in winter due to the lower position of the sun. The g value of the collector with fluid flow is lower because heat is extracted from the absorber by the fluid which results in lower absorber temperatures and lower secondary heat gains. In April and October, the collector is operated more often and thus has a lower g value than in January and December. For desiccant dehumidification, the collector is operated at higher temperatures (45°C to 55°C) which cause a higher g value.

Overall, transparent collectors prove to be a promising concept, but their performance is challenging to predict.

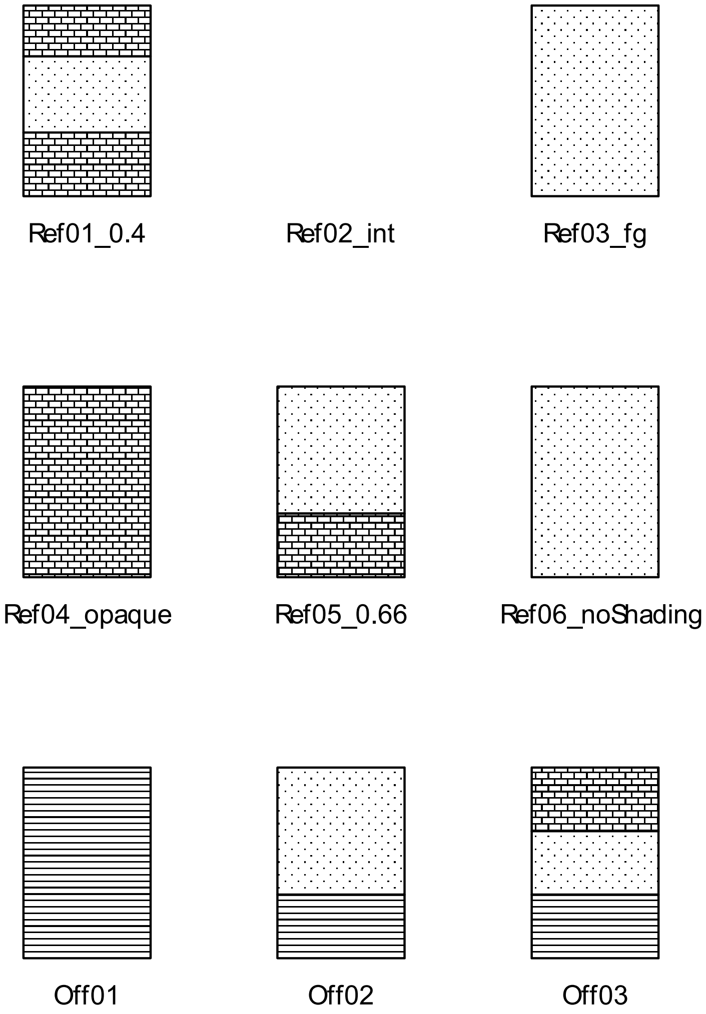

Figure 3: Schematic drawings of the façades of all simulated offices. Dotted areas represent glazing, transparent collectors are indicated by stripes and opaque walls with a brick pattern. [2]

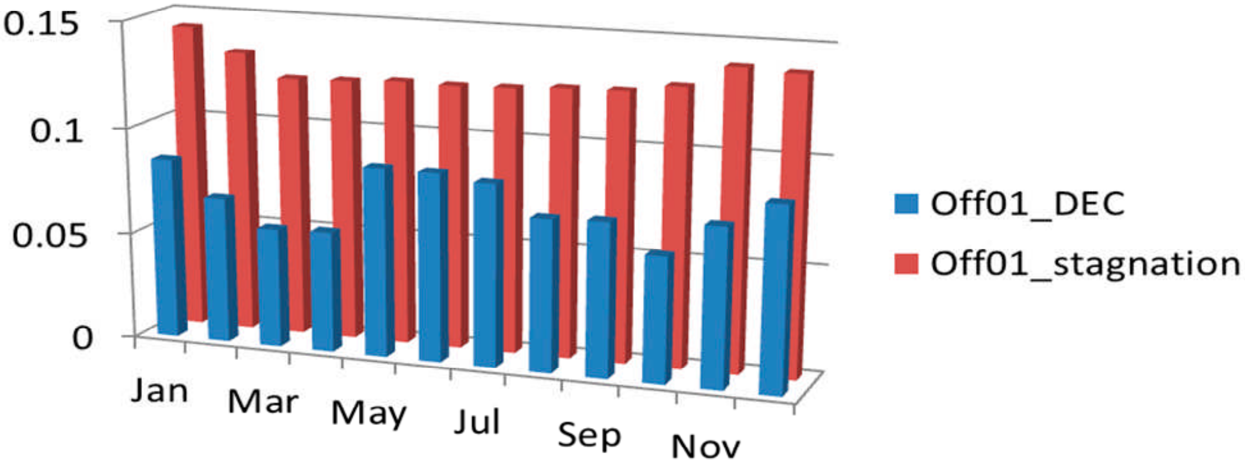

Figure 4: Graph of the g value of the TSTC for each month for stagnation and for operation for heating and desiccant dehumidification for Frankfurt am Main.

3. Solving the complexity of building-integrated solar thermal systems

The detailed physical model uses numerous equations and its own equation solver. Although it is quite complex, it can be compiled in a Dynamic Link Library (DLL) and can be distributed like any other TRNSYS Type with an easy-to-use graphical user interface for the inputs, outputs and parameters. In this way, planners can easily predict the advantages of a transparent collector. Because the code is written in C, the model could be implemented in simulation environments other than TRNSYS, too.

This procedure of encapsulating complex calculations within an easy-to-use graphical user interface would be a promising solution for building-integrated solar thermal systems in general. Future standards could specify when a detailed model is considered to be validated by measurements. The manufacturing companies would then be able to supply customers with the detailed model to enable them to check various operating conditions. On the other hand, without a detailed model innovative components are difficult to market, since their actual contributions to the building are not really clear. This makes it necessary to develop a standard for detailed physical models.

4. References

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