“Rethinking collectors from a construction industry perspective”

The trend towards zero-energy and energy-plus buildings has also increased the importance of using roofs and facades for the generation of renewable energy. The TABSOLAR research project has resulted in the development of new thermo-active building systems that are suitable for industrial prefabrication and can be used in a wide range of applications. This concept should allow the construction of solar-active facades that can be fully integrated into facade and building energy management systems. BINE Information Service spoke with the scientist Dr Michael Hermann and the architect Paul-Rouven Denz on the perspectives offered by thermo-active building systems and facade collectors.

BINE Information Service: Are building facades suitable for use as solar-active surfaces in addition to roofs?
Dr. Michael Hermann: Facades are well suited for solar use but present their own special boundary conditions and challenges. One needs to make a distinction between the theoretically possible yields and the actual usable solar yields in a concrete application when comparing roof and facade systems. It is true that roof systems provide higher yields.

However, not every kilowatt hour of generated heat or electricity is usable – for example during low energy requirement phases, when an energy storage system is not possible or in the absence of a grid connection. Thermal facade collectors are especially advantageous when high solar fractions are required, for example in solar active houses. These collectors can make better use of the low-lying winter sun than roof collectors. They also produce less excess heat in summer, which is also beneficial for the solar system.

Paul-Rouven Denz: The factors to be considered are also heavily dependent on each individual project. The roof area of a high-rise building is so small in proportion to the usable floor area and facade area that the roofs do not provide a sufficiently large solar active area. We therefore regard the integration of solar active elements into facades as a necessary measure with a great development potential. We have also noticed a decline in the importance of distinguishing between roof and facade applications in our project business. We therefore now develop complete solutions for the entire building shell, under consideration of all usable vertical, pitched and
horizontal surfaces. Under these circumstances, one would normally think that photovoltaic systems offer better prospects for use as a solar active element of the building shell.

Why should architects and investors choose to use solar collector systems?
Hermann: Buildings usually require both electricity and heat. Both technologies make sense in this respect. A combination of both systems is an interesting and attractive solution for multi-storey buildings. Photovoltaic systems on the roof can provide high yields in the summer, whereas facade-based solar thermal systems can still provide a substantial contribution to heating the building during autumn and winter. Nevertheless, drastic price reductions have now brought photovoltaic systems into direct competition with solar thermal systems, for example in heat pump systems powered by solar electricity.

Regardless of the technology, all and any solar system concepts integrated into the building in general, and the facade in particular, have a much higher architectural relevance than classical collectors mounted on the roof. This presents new technological challenges for photovoltaic and solar thermal systems alike — and innovative products will offer new chances.

Holistic solutions provide more design freedom and economic options

Why have so few solar collectors been integrated into building facades up to now?
Hermann: This question was examined in the Aktifas research project. This identified a significant knowledge deficit across all major project players and a commonly shared supposition of poor economic viability. Market penetration will obviously remain low when good solar thermal facades can only be designed and implemented by a few, well informed specialists. This study also revealed that the multifunctional nature of facade-integrated solar thermal concepts can provide substantial cost benefits. The authors also state a need for research and development of new collector concepts.

Denz: We regard the issue of economic viability as a fundamental problem: What methods should be used for the economic evaluation of facade-integrated collectors during the planning and decision-making process? Facade collectors are often viewed as additional measures for the facade and thus lie in competition with other heating systems instead of other facade solutions. An individual solution is required for each individual project because the facade represents the “face” of the building. They must satisfy the boundary considerations of the construction project, the overall concept of the architects and the wishes of the client. Solutions encompassing the entire building as a whole provide the necessary design freedom and economic options, as is also possible with facade collectors. The planning process should not just view the collectors purely from a heating system or collector technology perspective. The y must also be considered in relation to the special requirements of the building facade.

This has obviously not been the case up to now.
Hermann: A certain number of projects illustrating the architecturally successful integration of solar thermal systems into a building structure already exist. However, these are largely based on classical collector designs. The designs have been somewhat adapted in an attempt to provide at least some of the flexibility desired by the architects. Triangular collectors in the form of a hip roof or gable are an example of these adaptations. In these systems the collector remains primarily a heating system component that is adapted to suit the building.

The solar collector as a facade system

How should this change?
Hermann: We believe that great opportunities lie in rethinking the design and implementation of collectors from a construction industry perspective. This first requires an understanding of the wishes and language of the architects, the building construction processes, the marketing concepts and many other factors. This is the only way of developing new collectors that will be accepted and used by the construction industry. This can only function through an interdisciplinary product development process incorporating all essential elements from the heating, solar thermal and construction sectors.

Denz: A facade collector developed according to these principles also establishes a new fundamental basis for
consideration in the planning process. It no longer represents a heating system component but rather a facade system and can therefore be directly compared with other facade materials and systems. This allows a decision for facade collectors to be made early in the project, during the design process. This is a major opportunity. It also creates a new initial situation when considering costs. For example, natural stone rainscreen cladding is now very cost intensive – but without the added solar value of a collector facade!

Are you researching integrated solutions of this type?
Hermann: Yes, we have already executed various different research projects in this area, in conjunction with industry and specialist planning project partners. Further projects will start in the coming months. A number of different building-integrated solar concepts for high-rise buildings have been developed and implemented in demonstration buildings within the scope of the EU project “Cost-effective”, including components such as a semi-transparent collector, new vacuum tube-air collectors and a plaster-integrated facade collector. In the semi-transparent collector, the absorber is designed with narrow slanted fins allowing light to pass diagonally down through the absorber while also allowing the sun to strike the fins at an optimum angle from above. This results in a multifunctional building component that provides sun protection and partial transparency in conjunction with solar thermal usage.

Are there any other approaches suitable for industrial series production?
Hermann: This is the basic challenge. On the one hand, the desire is to produce collectors that are suitable for highly individual architectural designs, but on the other hand we know that series production of standard products is the key to reducing costs. However, the construction industry has already shown that it is possible to develop individual solutions based on components manufactured in industrial series production. For example, one only needs to consider the modular systems used for sanitary and ventilation systems. Prefabrication allows reduction of costs, even for small component quantities, and this also applies to prefabricated concrete components. This is the focus of our TABSOLAR research project. Together with our industry partners, we have developed ultra-high performance concrete (UHPC) fluid flow-through components as the core technology for new types of facade collectors and thermo-active building systems (TABS).

Concrete facade collectors

Concrete solar collectors: What challenges do these present?
Hermann: Using a membrane vacuum deep-drawing process developed by us and a matching UHPC concrete recipe developed by our project partner G.tecz, we have been able to manufacture a complex, multiply-branched channel network directly from UHPC concrete. Despite the low thermal conductivity of the concrete, we have found a suitable structure that provides very good thermal efficiency of the thermo-active elements and now see great potential in the future development of this technology. In the TABSOLAR project we have already managed to apply a spectrally-selective absorber coating directly onto the concrete. As with metal absorbers commonly available on the market, this coating allows a reduction of thermal losses. A subsequent project TABSOLAR II is planned to start at the end of this year, with the goal of implementing a facade collector based on the technology developed in the TABSOLAR project.

What other innovative approaches for facade collectors exist apart from this?
Hermann: In another project, we intend to develop architecturally integrated facade collectors with heat pipes. The goal is to implement and test two concepts: Firstly, a so-called strip collector with low height and flexible length and positioning features allowing it to be used as a design element in the intermediate spaces between the collectors, in conjunction with a wide range of facade materials such as plaster, wood, stone or metal. Secondly, a solar-thermal blind with rotating and sliding slats that function simultaneously as shade elements and solar absorbers. This allows targeted control of both the daylight entering the building and the solar yield. Both concepts are based on the principle of dry connection via heat pipes. The new heat pipes currently under development and their new type of connection to a header channel will provide the level of flexibility desired by the architects. Economically viable production will be achieved through the use of suitable mass production processes. When this succeeds, we will have achieved our goal: a high
The new heat pipes currently under development and their new type of connection to a header channel will provide the level of flexibility desired by the architects. Economically viable production will be achieved through the use of suitable mass production processes. When this succeeds, we will have achieved our goal: a high degree of customisability using a modular system of low-cost series-manufactured products.

**Would this type of modular system represent a breakthrough for thermal facade collectors?**

Denz: Individual solutions based on certain standard products or processes are a long established practice in the facade sector. Even tailor-made project solutions can pay off for sufficiently large facade areas, also for the manufacturer. We are convinced of the potential of the previously mentioned development approaches and are therefore an active partner as a facade laboratory in these interdisciplinary research projects.

**What will be the future course of development in thermo-active building systems?**

Hermann: This is an interesting topic from several perspectives. Thermo-active components can be used for heating and cooling purposes and allow the implementation of low exergy concepts. These are concepts using low fluid temperatures and large heat exchanger surfaces, which are attractive for use in renewable energy systems. In addition, the TABS elements can also assume a heat storage function in the building. This is equally interesting for direct solar-thermal use and also for cooling concepts using latent heat storage materials for active night-time cooling or for storing excess electricity from regenerative energy sources in the form of heat. This allows these elements to support grid-friendly building operations.

We believe that the core technology developed in the TABSOLAR project is well suited for this. This will allow us to develop attractive components. Together with our project partners, we have decided to initially focus on facade applications in the subsequent TABSOLAR II project. The planned development work will however also benefit thermo-active building systems in general. The aim of the project is to scale up the technology from a laboratory scale to larger components and improve the manufacturing process with a view towards later series production. We aim to present the state of development in a demonstration building by 2018.

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