Zukunft Bau

REPORT

title

benefit E2
building-integrated solar-active strategies: Analytical evaluation and development of building-integrated solar active systems

starting point

The rapidly growing expansion of building-related solar energy usage offers the opportunity to become an essential part of a renewable energy based supply. At the same time, different reservations regarding the use of applied technical solar systems had been expressed by several building experts. For the further successful expansion of building-related solar energy usage it is necessary to require adaptive and systematic high-quality solutions that are as well economically usable.

subject of the research project

The presented research project is based on the qualitative interview research of the previous project „benefit E“ (AZ: SWD-10.08.18.7-13.47) identifying barriers in the integration of building-related solar-active systems and is developing strategies and concepts for a perspective use of solar-adaptive building envelopes.

The term "solar-adaptive" is meant as a principle that enables as well a passive and active usage of solar energy within an architectural design. At the same time the facades shall have the ability to react to specific energetic, constructive or creative concerns. An important aspect here is the consideration of thermodynamic effects of volatile solar gains. Phase shifts and load controls are essential basic properties of solar-adaptive behaviors. In particular, solar heat and exhaust heat from solar power production can be utilized in different ways. At the same time, solar-adaptive building envelopes must fulfil the same economic requirements that are imposed on "standard systems" without a solar functionality.

The aim of the project was to analyse decidedly areas for using solar energy in different buildings types, the design of a solar-adaptive principal, taking energetic, constructive and economic conditions as well as to present its creative bandwidth into account. Methodically the four levels – building, building-shell with it’s constructive component structure, building process and usage – have been edited.

Simulations were used to generate specific solar radiation profiles for common building types thus as point shaped buildings, skyscrapers, row buildings, yard-shaped buildings and halls. Determined energy and building structure related characteristics had been included in a typology catalogue. Parallel to the determination of radiation potentials on typical buildings, these were quantified in terms of number and share of the total building stock.

In a second step, a solar-adaptive façade principle was designed. It is composed of a finely structured, curtain wall "façade grid", which can be prefabricated to a great extent and whose structure allows a maximum design freedom and energetic usability. The "grid" is a supporting structure for an outer and inner layer assume that each has it’s different constructive, energetic and design related tasks. The outer layer is used for weather protection, solar energy gaining (active and passive) as well as for individual architectural expressions. The inner layer forms the visual and constructive surface. It can consist of opaque isolating panels, fixed glazing or openable window elements depending on the architectural conception. Depending on the energetic goal, the air in between the "grid" can be encapsulated or air-flowed. An encapsulated air layer serves to store solar heat as well as wasted heat from active solar power productions. A air-flow layer, however, allows the removal of solar heat loads from the inner facade.

Depending on the configuration, various thermodynamic behaviours could be achieved for summer and winter situations. Therefore, dynamic simulations of different component structures were carried out to determine meaningful layer combinations. In addition to a series of varying solar-adaptive poly-functional facade components, also common "standard" component structures were simulated. The results were extracted in the component catalog of the poly-functional façade principle and also included in the following described building energy model for further evaluation.

In a third step, a building energy model was developed for the energetic, ecological and monetary assessment of integration possibilities for thermal and electrical solar energy gaining systems. It displays all significant energy flows, including the buildings technology. The different configurations could therefore also be rated in terms of their demands on end energy and the resulting CO2 emissions. Based on the results of the building energy model, the financial effects of the developed system were analysed

using the example of an office building. For this analysis, an interface had been developed, which made it possible to carry out a cost-effectiveness analysis of solar-adaptive facades. A particular feature is that the financial effects of solar-active facade elements are modelled on the basis of complete financial plans, taking into account the reciprocal influences on owners and tenants.

conclusion

The extensive analysis has identified large fields for an application of solar-adaptive building envelopes in stock. The new polyfunctional façade principle proves to be flexibly applicable in terms of energy and design. By buffering solar heat and wasted heat from active systems, the heating energy consumption can be reduced equivalent to the insulation measures. The " sensitivity" of solar buffer zones for summer overheating effects can be largely eliminated by controlled air-flows.
The results of the analyzes also show that solar-active façade elements can be economical for owners as well as for tenants. It makes a contribution to the implementation of the heat and energy transition in the building sector. Overall, the hybrid use of solar energy, especially in the façade sector, has great potential for regenerative energy production.

basic information

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Images/pictures:

fig 1: bE2-Abb1-AnsichtPolyfassade.pdf
caption: Solaradaptives polyfunktionales Fassadenprinzip

fig 2: bE2-Abb2-Methodik.pdf
caption: Methodik und Untersuchungsaufbau

fig 3: bE2-Abb3-Rahmenkonstruktion.pdf
caption: Konstruktionsprinzip des polyfunktionalen Fassadenprinzips

fig 4: bE2-Abb4-Fertigungsprozess.pdf
caption: Fertigungsprozess mit den Schritten der Planung, Fertigung, Transport und Einbau

fig 5: bE2-Abb5-Gestaltungsvielfalt.pdf
caption: Flexibles System als Basis vielfältiger Gestaltungsmöglichkeiten