Research project energy:shell

Guideline on the integration of energy-producing systems in building shells

Abridged report

Research initiative ZukunftBau

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As part of the research initiative ZukunftBAU of the German Federal Ministry for Traffic, Construction and Urban Development (BMVBS) and the German Federal Ministry for Structural Engineering and Regional Planning (BBR) and with the participation of the Department of Design and Energy-Efficient Construction (ee), Architecture Section, of Darmstadt Technical University (TUD) in the international student competition Solar Decathlon 2007.

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1 Goal of the research assignment

1.1 Guideline on the integration of energy-producing systems in building shells.

Solar systems have been installed on buildings for many years now – elevated on roofs and frames and leaning on facades. Their relationship to the buildings appears arbitrary or provisional. It is more the case that in terms of technology and design integration that creates an impression of permanence is a rare occurrence, yet one that could considerably improve the level of acceptance of these new components.
According to a survey conducted by the German Federal Association for Solar Energy, a mere 1% of installed photovoltaic elements and systems are integrated into building shells. This therefore represents an untapped field that can play a part in increasing system and building efficiency and also provide new design opportunities.

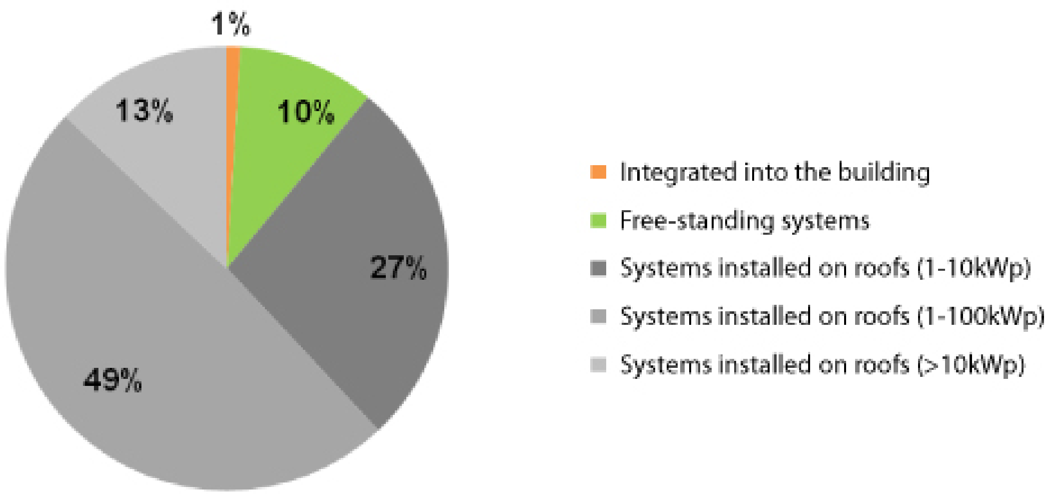


Diagram 2 Market segment of photovoltaic systems in Germany, source: German Federal Association for Solar Energy

In this respect this guideline is intended as a type of planning aid in respect of the integration of photovoltaic and solar thermal energy. Furthermore, it is envisaged that, in combination with a real, small building project, it will assist in developing exemplary opportunities for such integration. The object is therefore to create an understanding of fundamental interrelations, to widen the horizons of practising planners with respect to the possibilities for integration into the building shell. This will demonstrate the advantages of shell integration, and allow the technologies to be better positioned in the market.

To achieve the described goal, basic shell integration was first carried out with regard to the criteria of feasibility, aesthetics and synergies as well as system efficiency, alignment or location circumstances.

In a further research stage, the options with regard to shell were analysed and evaluated in relation to roof and facade integration. It makes sense to integrate solar systems at locations where they can ideally utilise the sun's rays, but where their effects on the utilization are undesirable. This is where energy-producing sunblind systems can create synergies combining protections from the sun with energy production. The use of solar modules as facade elements can also be realized - numerous developments have been made in the area of roof coverings. To illustrate the scope of available options and to demonstrate new avenues in addition to the existing fields of application, the design options for and with photovoltaic and solar thermal energy in general are to be illustrated. These will be documented in the form of a manual.

The applicant was the sole German university granted permission to take part in the international university competition Solar Decathlon 2007. The overriding goal of the competition is the development and realization of a prototype for a plus-energy building that can be ready to be marketed by 2015. The contribution made by applicant's team demonstrates several new approaches in its use of innovative technologies and materials and the integration of new systems, for which the research described above provided extremely useful groundwork. The combination of guidelines and real implementation as part of the pilot project Solar Decathlon is intended to highlight the manageability and the capability for immediate implementation and to provide suggestions for further development.

2 Implementing the research assignment

2.1 Research and systematic analysis and documentation of the systems in place in the market. Documentation in the form of a guideline.

First of all different strategies for combining energy-producing systems with building shells were examined. These can be independent elements, can be integrated into a building shell or, as synergies, can assume many additional functions of the building shell.

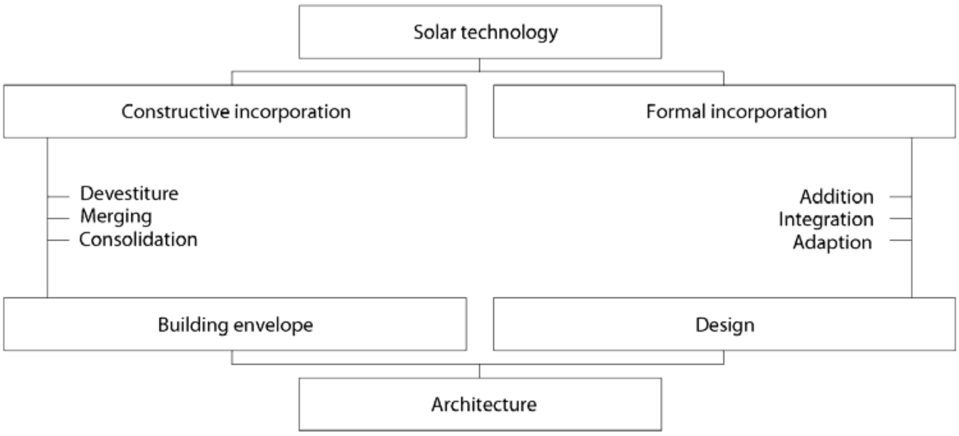
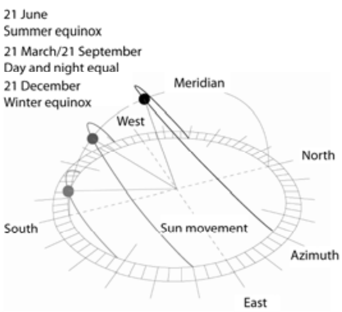


Diagram 1 Construction and draft strategy with active solar technology, source: Energieatlas Hegger et al, page 109

It is envisaged that this study provide planners and building contractors with an appropriate overview of the current status of technology and the potential of photovoltaic and solar thermal systems combined with building shells. Parameters were drawn up that represent meaningful building integration and that can be considered a guarantee of efficiency and sustainability. Basic catalogues were created for photovoltaic and solar thermal systems with a view to integrating energy-producing systems into building shells.



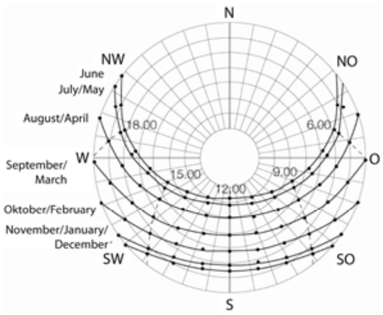


Diagram 2 Annual sun movement in the northern hemisphere, source: Hegger et al. 2007, S. 54 (links)
Diagram 3 Sun status diagram for 51° north latitude (in each case on 21st day of each month), source: Hegger et al. 2007, p. 54 (right)

Critical consideration and evaluation of examples has produced a collection that gives planners and building contractors an overview of the current state of development and its potentials.

Example project for the integration of photovoltaics

2.1.1.1 Day nursery and youth leisure centre, Munich, 2007

Architect’s office Ebe + Ebe, Munich

Facade made of polycrystalline silicon cells



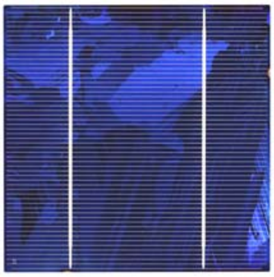


Diagram 4 South facade of day nursery and youth leisure centre in Munich, source: www.baunetz.de
Diagram 5 Day nursery and youth leisure centre in Munich, source: www.baunetz.de
Diagram 6 Polycrystalline silicon cell, source: www.energie.at

Description

The two independent facilities of day nursery and youth leisure centre have different coloured wall coverings in the ground floor. However, the building's external appearance is characterised by an approx. 80m² facade photovoltaic system above the entrance.

Integration

The photovoltaic system has been fully integrated into the south facade and also identifies the location of a large hall located behind it. The 51 frameless polycrystalline modules were developed as a pre-hanged, back-ventilated facade and are assembled on a point-fitting basis.

Photovoltaic			
Annex			
Total yield Solar active Area Yield/m²	6,300 kWh/a 80 m² 78.75 kWh/am²	Yield Performance/total Performance/m²	630kWh/kWp 10.00 kWp 0.13 kWp
Module			
Measurements Points Manufacturer	 > 95% (point holder) 3S – Swiss Solar Systems	Performance	0.19 kWp

Constructive incorporation			Formal incorporation		
Disentanglement	Interlacing	Blending	Addition	Integration	Adaptation

2.2 Methodological analyses of existing solar calculators and feasibility study for a calculation tool for the integration of solar systems into residential housing construction (solar integrator).

In a further step the way was paved for a so-called "solar integrator". The solar integrator is an interactive planning and communication tool for architects, planners and building contractors, aimed at providing details on the efficiency of solar systems and their integration into building structures. In addition it is envisaged that the solar integrator should provide support as a communications instrument at the draft planning stage by way of illustrating already-realized projects or by developing an ideal solution in tandem with a project.

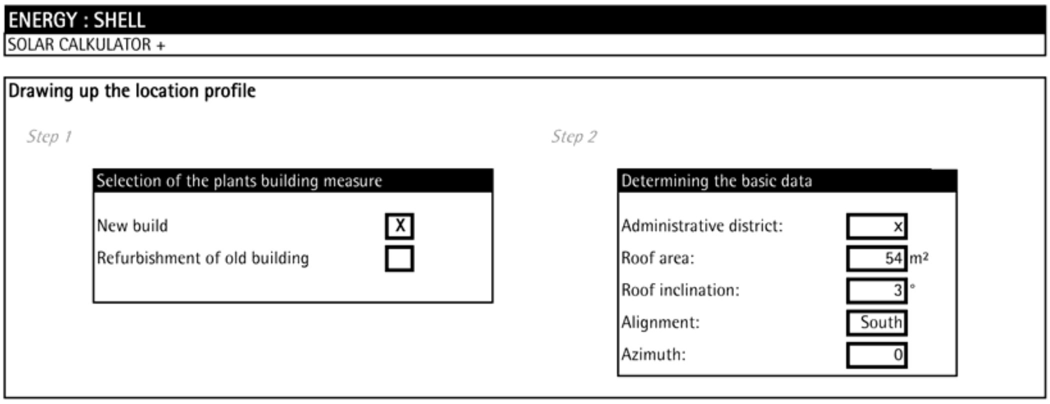


Diagram 147 Drawing up the location profile, source FG_ee

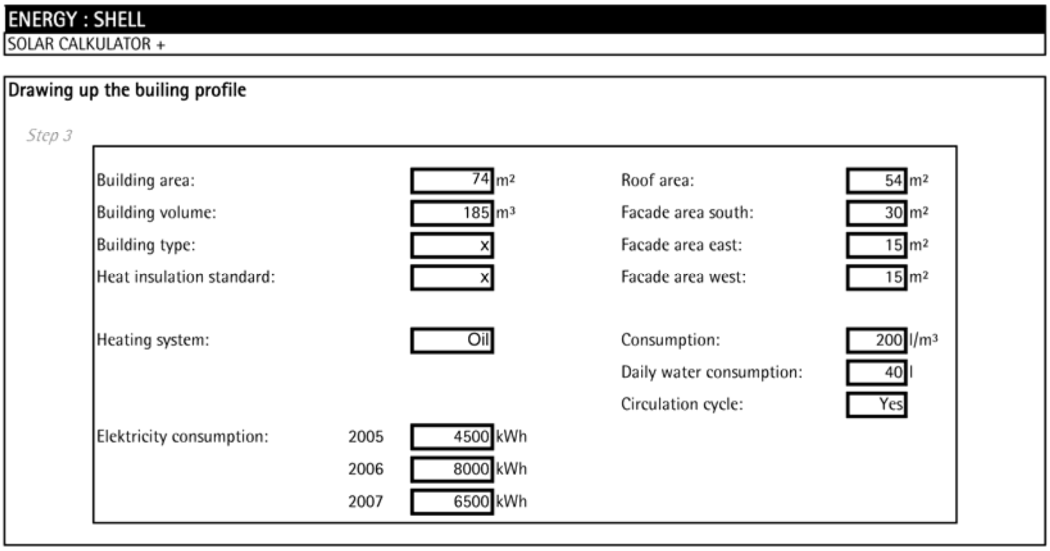


Diagram 8 Drawing up the building profile, source: GF_ee

As the tool is to be built such that is it comprehensible for non-specialists in particular, it is closely linked with the explanatory guideline. Furthermore the entries required were kept to a minimum without diluting the reliability of the results, which will be beneficial to both planners and non-specialists in respect of the draft and implementation planning.

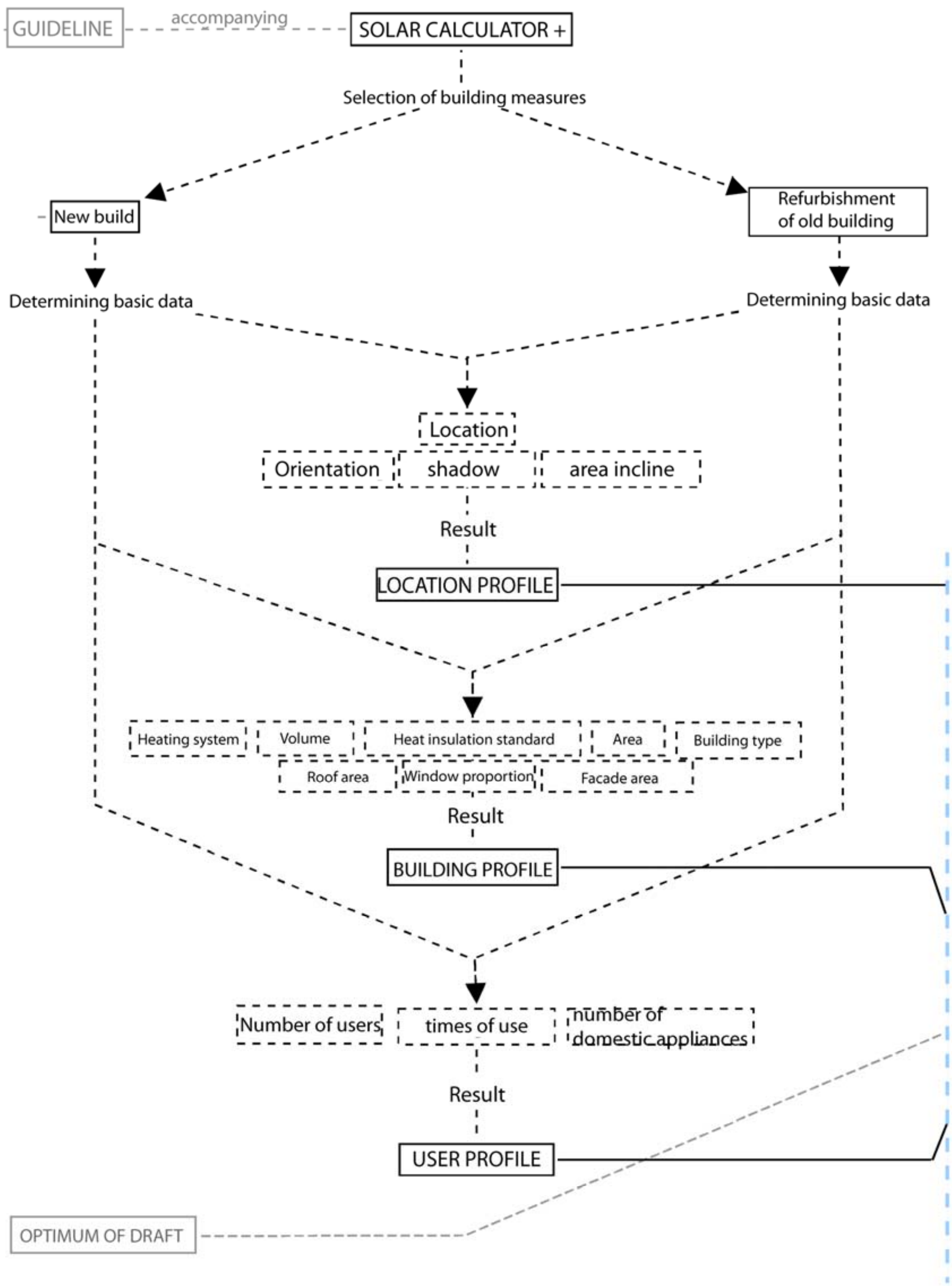


Diagram 9 Detail of Structure programme of the solar integrator, source: FG_ee

2.3 Product development, prototype construction and tests for the slatted facade.

The photovoltaic sun-protection slatted façade was devised as an idea for a building component that combines protection from the sun, an anti-glare device and energy production and maximises the surface of the building shell that can be used for energy production. The classic functions of slats such as protection against overheating and protection from glare and weather can be supplemented by an energetic component. During the course of component planning, different variants of slatted façade were examined – sliding, folding, collapsible and rotating. The horizontal rotating slats were developed subject to these requirements in a vertical folding frame.

Diagram 10 Façade section of the lamella facade, source: FG_ee

The individual planning levels were implemented as prototypes. They were used to test and to modify the requirements for the product . The knowledge gained from these prototypes was incorporated in the planning process, and allowed for optimisation up to the stage of series production in the workshop. This was supplemented by interdisciplinary collaboration in the areas of controlling, tracking and switching.

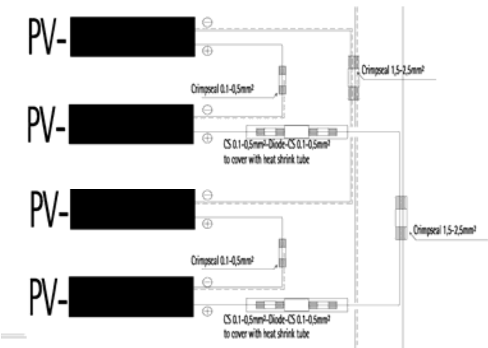


Diagram 11 Plan section of the caballing system, source: FG_ee

On the basis of the first small series, which is installed in the building of the competition entry for Solar Decathlon 2007, further tests were and continue to be carried out in relation to energy production, material wear-and-tear, mechanical functionality, tracking and controlling. The experience gained will be incorporated into further product development.

3 Future Prospects

3.1 Guideline on the integration of energy-producing systems in building shells.

The integration of energy-producing systems into building shells is becoming an ever more important aspect in the application of such components. The guideline is intended to draw the users' attention at an early stage to the potentials for integration, so that they need not be assembled afterwards as additive elements on roof coverings or façades.

The timely incorporation of these planning components will save building contractors time and money. This guideline provides planners with an overview of this area. It can therefore provide building contractors with sound basic information in the draft phase as to how energy-producing systems can be effectively included in the planning in respect of design.
In addition, planners can expand their working fields on the basis of the knowledge gained and as a result improve their market chances.

3.2 Solar integrator

The solar integrator could enable planners to review and, where applicable, correct active solar systems as early as the draft phase. By way of a few basic entries, data can be obtained on the use and effects of solar systems. The development of the solar integrator in conjunction with the guideline would create an effective tool for planners with which they could provide building contractors with professional information that is already supported by data. We see the development of a marketable solar integrator as a worthwhile development because it would give users the opportunity to swiftly obtain relatively precise information about the size and orientation of the desired systems by way of entering building data and user behaviour.

3.3 Product development

The positive feedback in relation to the developed photovoltaic wooden slats during the Solar Decathlon 2007 competition in Washington, USA, and as part of further events in Germany, point to a marketable opportunity for this system. The further development of the photovoltaic wooden slats to create a product ready for series production would be a positive contribution to the use of solar active systems in building shells or their components.