ARCHITECTURAL ASPECTS OF SOLAR TECHNIQUES.
STUDIES ON THE INTEGRATION OF SOLAR ENERGY SYSTEMS
INTO THE BUILDING SKIN

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Abstract – The integration of solar energy systems should be coherent with the design of the roof and facade of a building - it is supposed to complete and support it. These studies were made from an architectural point of view and generally based on the tasks of development of components. It was basically done in two steps. First the study of various types of building skin, and secondly an analysis of various exterior wall constructions (in different scales).

First of all a morphology on typical aspects of roofs and facades was created. This was followed by studies to locate possible spaces for solar systems of selected types of roofs and facades. To analyse the situation concerning where and how the elements should be installed was another important instrument to look where existing systems could be improved and to enlarge the applicability of solar systems.

Looking at architecture in such a specialised way, one should not forget that the decision how to design a component depends on the design as well of the facade, as the roof - and finally on the design of the building itself. The integration of solar energy systems in the design of buildings depends largely on the possibility to modulate the components for their specific use. For this kind of work these studies provide concepts and instrumental methods as a means of rating solar energy systems.

1. PRELIMINARY REMARKS

In the combination between architecture and solar technique there are still enormous deficits in the creation of new and coherent designs.

With the increasing possibilities of the use of environmental energy in building construction there is a high importance in the connection of architecture and solar techniques. The integration of solar energy systems cannot be seen separately of the building design. Even if solar energy systems and components of high efficiency are available there is a lack of "Solar Design". One reason may be that the work on planning and realisation of buildings is done separately from research and development of components. This may be due to the different approaches from the architect’s point of view who designs and constructs buildings and the engineer’s who develops components for construction. (Fig. 1)

In developing a component there is mostly a focus on technical questions and not on the tasks of design. It is our understanding that architecture integrates a multiplicity of participants and information, the complexity of technique, as well as cultural aspects - it includes the process of planning, as well as, the completed building. Therefore, we started at the Technische Universität, chair of Prof. Herzog, to work on methods for locating and configuring, as well as integrating solar energy systems into building roof and facade systems. It is our goal to offer tools and methods that the specific demands of the building skin, as well as, the design of the building itself will have a stronger impact in research and development of solar components.

2. ARCHITECTURAL ASPECTS OF SOLAR TECHNIQUES

Solar energy systems are building elements that have to fulfill the various demands of roofs and exterior wall systems and have to be integrated into the overall concept with the building design. They enlarge the spectrum of materials and components that may be used in building construction. Therefore architects have to deal with an increasing number of technical possibilities. Working with solar components requires a wider knowledge of design, construction and physical demands on the building skin.

The building skin is the most important subsystem to the energy balance of houses. Practical experience shows that it does not suffice if the integration of solar components only fulfills functional and constructive aspects - one must also consider a multiplicity of design aspects. There is also an impact from the structure of the building, the

1 See: Herzog, 3/1999

2 The studies were part of the R&D-Project: SOLEG – Solar Assisted Energy Supply for Buildings, 8/1996-7/1999, Project-Coordination by Bavarian Center for Applied Research
floor plans, the number of floors, its exposition, the structure, the construction of the walls and the design of the facades. New solar components require new demands for the design of roofs and facades in matter of proportion and structure and the arrangement of transparent, translucent and opaque surfaces, the material of the building skin and the design of the surfaces.

3. INTEGRATION IN THE BUILDING SKIN

If you look at existing examples of integration of solar energy systems in buildings you may notice a missing sensibility and/or understanding about the character of the building. Usually there is little adjustment made to the general structure. The main obstacle of a coherent design with an integrated solar energy systems may be that design is based on conventional standards. But these standards are solutions for other problems in another generation of buildings - we will not be successful in creating a "Solar Design" if we just add a new technology to this existing type of buildings. Furthermore, design aspects in the past were less important for the issue of integration than technical requirements. Therefore, it seemed necessary to us to treat the design of the building with its aesthetic aspects and the integration in the building skin with its constructive and physical aspects separately. Separate approaches to locate solar systems at roofs and facades were also determined. To make up a typology of facades proved to be more difficult than to do the same for roofs. Looking at roofs (neglecting built-on or built-in elements) it is sufficient to study one layer. Looking at facades three layers of consideration were originated. (Abb. 2)

4. INTEGRATION IN THE DESIGN CONCEPT

To integrate solar energy systems means basically to insert a technical element in a new or existing roof or exterior wall system. Roofs and facades require different demands for the integration of solar energy systems in architectural concepts.

Not only in the past design aspects have been neglected in existing concepts and build examples.\(^3\) In general one can distinguish from three concepts how solar components are integrated in buildings. The first scheme is without attracting attention, the second is an appropriate appearance, the third is to distinguish the component from the building design. Design aspects such as dimensions, proportions, the structure of the surface and colour are not respected in these strategies. Another important factor for integration is the target factor of saturation for solar energy and the resulting size of the unit. The necessary size has a great impact on how it affects the appearance of the house. It has to be reconciled with the surface of roof and facade. Looking at the surface of solar components they are usually flat and shining faces made from metal and glass (for example flat plate collectors and pv-modules). On the other hand, most of the roofing-materials and materials used for facades show rough surfaces and warm colours. This very brief reflection already shows the necessity of a conceptional and methodical approach to point out the coherency of form, function and design. In this study of solar energy systems include mainly examples of flat plate collectors and pv-modules.

4.1 Roof

The roof is the part of the building with a high potential of possibilities for integration of solar systems. This potential depends on the geometry of the roof, which normally gives wide and homogenous spaces tiled by small sized roofing materials. There is also a great impact of regional differences depending on climate and the used materials. Roofs naturally have a big influence in the appearance of towns and villages. In this context the roof is an extremely sensitive part of the building. From an architect’s point of view the most common reasons for unacceptable roof top solar energy systems are the disharmony with the geometry of the roof or the placement of components without any context to the roofs scale that lead to a fragmentation of homogenous spaces. Therefore it is important to reconcile the size of the components with the mostly small-sized roofing

\(^3\) See: Krippner, 4/1999
materials. On the other hand there is a disproportion between the necessary size of the collector units and the size of the roof – more often it is difficult to integrate a small sized unit into an expansive roof. Starting with the documentation of the different types of roofs the study was continued by various possibilities to locate solar components without specifying any particular roofing materials.

The first results showed that there are not more possibilities of integration of orthogonal shapes as ‘single pitched roofs’ and ‘saddle back roofs’ but more coherent ones than in tests made on hipped or mansard roofs. These type of roofs, due to the numerous ridges, provide little rectangular space for the components. Furthermore attention must be given to the ‘flat windows on pitched roofs’ as well as to dormers. (Fig. 3-5)

4.2 Facade

Facades are the "face" - the expression of the building. On one hand they are a mirror of the functional structures of the inside, on the other hand they are influenced by proportion, size of doors and windows, and material. The design of facades, as well as their construction, is more complex than the design and construction of roofs. At facades the efficiency of solar components is more limited and also there is also a greater possibility of shading.

More so than roofs, facades have to fulfill a number of additional tasks. Components which are installed, for example, at balconies or apertures, demand more attention to details because they are much closer to the observer. At facades there are various overlaid principals of structure including size, proportion and rhythm of a structural grid, as well as, principles of building construction. The result is a large variety also determined
by the building material and the age the building was erected. Looking at the facade as three layers of design (the whole facade, individual parts of the facade, and apertures) principles of structures were described and general possibilities of configurations were located. Firstly, concepts were made for orthogonal facades with an even surface without specifying on particular materials.

To achieve a coherent design solution there has to be also a focus on surfaces and colours. Therefore, not every part of the facade, which is exposed in a more or less perfect angel to the sun, can be used for the integration of solar components in the meaning of “Solar Design”, but the chances are much better for new than for existing buildings. (Fig. 6-8)

5. INTEGRATION IN THE CONSTRUCTION OF THE BUILDING SKIN

The integration in the building skin means the application of solar components to roofs and facades respecting aspects of construction and physics related to construction. This subject is very popular in architecture and is becoming even more important with the use of environmental energy in building construction. On the one hand, integration means the installation of technical elements and components in the building itself - or mostly the building skin - on the other hand, it is the combination of several functions as protection, support, as well as, energy-control. Components can be used as an element of the building or substitute one.

In a first step there different principles of integration of solar components in roofs and facades were named. A difference was made concerning the position of the solar components whether it is placed under, in or on top of the ‘draining layer’. 4 (Fig. 9)

5.1 Examples of buildings

In a second step there were two types of solar-collectors selected and integrated in a building context in scale 1:25. Three different types of roofs and nine common variations of exterior wall systems were selected. Differences concerning load bearing (load bearing or no load bearing), number of layers (one or multi-layers) as well as the sequence of layers were made. 5 One example was the integration of a Ti-Collector in roofs - its connections to the materials next to it and the load bearing construction. (Fig. 10) Numerous techniques exist, which are tried, and tested since years for an installation at the roof, but the main problem still is the integration in the design concept.

Looking at facades there was a focus on the position of the solar-collector to the layers with specific functions as the heat insulation. (Fig. 11) A point of major interest was the influence on the isotherm, as well as, the co-action of width of collector and exterior wall. To rate the results of the tests there had to be an evaluation from the inside of the building, as well as from the outside.

The integration of solar components in roofs and facades has to be modulated with the overall design of the building, and it depends largely upon the possibility to adapt components for their specific use.

5.2 Details

Regarding the components there have been studies on the structure of joints and the connection to elements of the building construction in scale 1 : 5. There also have been examples for the connection to the exterior wall and connections from the inside to walls, floors and ceilings. Furthermore, the size of the section and the possibilities to minimize the screen was scanned in alternatives.

4 See: Hullmann, 1977

5 See: Herzog/Krippner, 1999
6. CONCLUSIONS

Looking at studies on the subject of the integration of solar components in the design and construction of buildings - mostly a methodical approach is missing. Even if this kind of work is highly important for existing buildings it could be a valuable tool to the planning of buildings as well. Because of these studies some concepts were elaborated which will be tested and improved in research and development projects at our chair. Because of the variety of facades, constructions and materials it was not intended to work out a catalogue of examples. It will depend on the building design and the concept for energy use which scheme will be the most promising. Therefore there has been no proposal for a particular solution - primarily this study should give a strategy on how to deal with the design, constructive and technical aspects and aims to develop components which are extremely flexible. They give an initial concept for different phases of planning (preliminary design through construction documents) and are made, as well for the planning of buildings, as for research and development of solar components. They are intended as a pool of information and provide concepts and instrumental methods as a means of rating solar energy systems. The integration of solar techniques should be coherent with design and function of the roof and facade. It is supposed to complete and encourage the architecture. Only if there is also a focus on the aesthetic design aspects the use of solar components at buildings will create a positive impact on the design of our built environment.

REFERENCES


