EXTRACT FROM

Report T.41.A.2: IEA SHC Task 41 Solar energy and Architecture

SOLAR ENERGY SYSTEMS IN ARCHITECTURE

integration criteria and guidelines

Keywords
Solar energy, architectural integration, solar thermal, photovoltaics, active solar systems, solar buildings, solar architecture, solar products, innovative products, building integrability, integration examples.

Editors MC Munari Probst, C Roecker

8. VI. 2012

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

CONTENTS

1. INTRODUCTION

MC Munari Probst, C Roecker

SOLAR ENERGY

In recent times, the world has fortunately become increasingly cognisant of the significant potential of solar energy as a replacement for non-renewable fossil fuel energy. The sun is a clean, unlimited and almost infinite energy source, providing each hour on earth as much energy as the whole world needs in a year. Proven technologies are able to transform its radiation into heat, electricity and even cold, and are now largely available at affordable prices.

BUILDING ENERGY NEEDS AND AVAILABLE SOLAR TECHNOLOGIES

Solar energy, in its active or passive forms, is able to deliver the entire set of building energy needs: space heating and lighting, domestic hot water (DHW), electricity, and recently also space cooling (fig.1.1) .

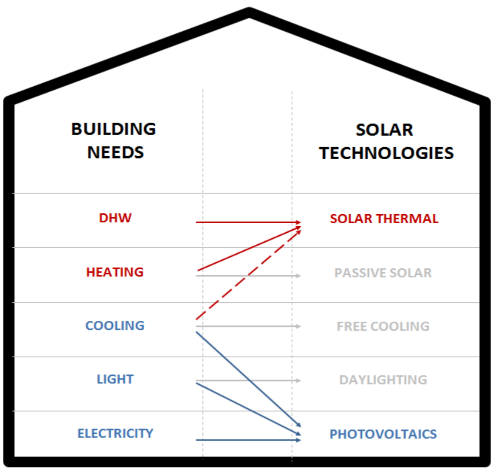

Fig.1.1. : Different solar technologies covering different building energy needs. Credits: EPFL/LESO-PB

- Domestic hot water (DHW) can be produced using active solar thermal collectors;

- Space heating can be easily provided by the direct (passive) solar gains heating the building through the windows (greenhouse effect). The needed heat can also be provided indirectly, by using active solar thermal collectors;

- Electricity for appliances can be produced by photovoltaic modules;

- Space lighting should be provided as far as possible by using passive sun light (day lighting), photovoltaic modules can then provide what is needed for electric lighting;

- Space cooling can be greatly supported by appropriate passive night ventilation (free cooling). Recently solar thermal systems able to transform solar heat into cold have been developed, helping deliver building cooling needs. These systems use standard solar thermal collectors, but are for the moment mostly available as experimental systems for pilot projects.

BUILDING INTEGRATION PROBLEMATIC

It is very important to underline that the different solar technologies presented here above complete each other, rather than being in competition. To reduce to a minimum their fossil energy consumption, low energy buildings will have in most cases to use all of them. Consequently, architects will have to deal with the architectural integration issues they bring.

These issues are more or less complex depending on the maturity of the technology in relation to building use. The passive use of solar gain for space heating or day lighting is somehow part of the architectural design process since ever. Since it does not really bring new elements in the building envelope nor particular integration issues, it will not be further addressed in this document.

We will instead concentrate on the active technologies, bringing in the building envelope new elements not yet metabolized by architecture, i.e. solar thermal collectors and photovoltaic modules.

2. ARCHITECTURAL INTEGRATION QUALITY

MC Munari Probst, C Roecker

2.2 DEFINITION

Architectural integration quality is defined as the result of a controlled and coherent integration of the solar collectors simultaneously from all points of view, functional, constructive, and formal (aesthetic) [2.1]. I.e. when the solar system is integrated in the building envelope (as roof covering, façade cladding, sun shading, balcony fence…), it must properly take over the functions and associated constraints of the envelope elements it is replacing (constructive/functional quality), while preserving the global design quality of the building (formal quality). If the design quality is not preserved (i.e. the system is only constructively/functionally integrated into the building skin without a formal control), we can only call it a building integrated system [2.2] [2.3] [2.4] [2.5] [2.6] [2.7][2.11].

2.3 FUNCTIONAL AND CONSTRUCTIVE ASPECTS

The building envelope has to fulfill a wide and complex set of protection and regulation functions, requiring the use of different structures and components (opaque/transparent elements, monolithic/multilayer structures, composed of fixed/mobile parts,…).
The integration of solar modules in the envelope system should then be studied very carefully, to preserve/ensure the standard envelope functions and the durability of the whole.
The multifunctional use of solar elements taking over one or more envelope functions may require an extra effort to building designers, calling for instance for some modifications in the original design of the collector, in the way it is mounted or by restraining its use in some parts of the building. On the other hand, it brings the major advantages of a global cost reduction and an enhanced architectural quality of the integration.

In addition to the functional compatibility, it is important to ensure that the new multifunctional envelope system meets all building construction standards:
- The collector load should be correctly transferred to the load bearing structure through appropriate fixing;
- The collector should withstand fire and weather wear and tear;
- It should resist wind load and impact, and should be safe in case of damage;

- Risks of theft and/or damage related to vandalism should be evaluated and appropriate measures taken;
- The fixing should avoid thermal bridges and the global U value of the wall should not be negatively affected;
- Vapour transfer through the wall should avoid condensation layers, and allow the wall to dry correctly.

Besides these standard building construction constraints, the integration of solar systems implies other issues resulting from specific solar technology attributes, i.e. the presence of a hydraulic system (for ST) or electric cabling (for PV) and the high temperatures of some modules.
- The hydraulic system of ST should be carefully studied to deal with water pressure differences at the different façade levels (heights), should be safely positioned within the envelope structure and should remain accessible; measures to avoid damages resulting from water leakage should also be taken;
- The electric cabling of PV should be studied to avoid shock hazards and short circuits, and measures should be taken to avoid fire.
- Envelope materials in contact with the solar modules should withstand their high working temperature;
- Fixing details and jointing should make collector's materials expansions compatible with those of the other envelope materials;
- Safety issues should be considered for collectors within users' reach to avoid burning or shock hazards (ground floor, window and balcony surrounding...).

As seen, integrating the new function "solar collection" into the building envelope requires an understanding of where (opaque parts, transparent parts, fixed/mobile elements), how, and which collectors can be made compatible with the other envelope elements, materials, and functions.
Each technology or sub-technology has different implementation possibilities in different parts of the envelope. This will be discussed in detail in technologies dedicated sections (ch.3 A.2 for ST and 3.B.2 for PV) [2.8] [2.9] [2.10].

2.4 FORMAL ASPECTS (AESTHETICS)

All the system characteristics affecting building appearance (i.e. system formal characteristics) should be coherent with the overall building design (see also good integration examples in chapter 3-A and 3-B, p.20 to 33 and p.105 to 149):
- The <u>position and dimension of collector field(s)</u> have to be coherent with the architectural composition of the whole building (not just within the related façade)
- Collector <u>visible material(s) surface texture(s) and colour(s)</u> should be compatible with the other building skin materials, colours and textures they are interacting with.
- <u>Module size and shape</u> have to be compatible with the building composition grid and with the various dimensions of the other façade elements.
- <u>Jointing types</u> must be carefully considered while choosing the product, as different jointing types underline differently the modular grid of the system in relation to the building.

Clearly, mastering all characteristics of an integrated solar thermal system in both perspectives of energy production and building design is not an easy task for the architect.
The formal characteristics of the system are strongly dependent on the specific solar technology, which imposes the core components of the solar modules, with their specific shapes and materials.
The more flexibility that can be offered within these imposed forms and materials, the more chances for a successful integration [2.11] [2.12].
The actual flexibility of solar modules (we will call it "integrability") is presently very different in the two fields of ST and PV, as we will see in detail in sections 3A4 and 3B4, making the integration design work either more or less challenging.

References

[2.1] Marcus Vitruvius Pollio, De Architectura, 30-20 bC, Pierre Gros editor, Einaudi, 1997. Also available on-line: www.penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/home.

[2.2] T. Herzog "Solar Design", in Detail n°3/1999, ed. Birkhauser.

[2.3] R. Krippner "Solar Technology – From Innovative Building Skin to Energy-Efficient Renovation", in Solar Architecture, Christian Schittich (Ed.), Birkhauser, Edition Détail 2003.

[2.4] A. G. Hestnes "Building integration of solar energy systems", in Solar Energy vol.67, n.4-6, 2000.

[2.5] A.G. Hestnes "The integration of solar energy systems in architecture", in Proceedings Eurosun 1998

[2.6] I.B. Hagemann "Gebaudeintegrierte Photovoltaik – Architektonische Integration der Photovoltaik in die Gebäudehülle", Ed. Rudolf Müller 2002.

[2.7] T. Reijenga "What do architects need?", Proceedings of the IEA PVPS Task 7, 2000.

[2.8] R. Krippner "L'enveloppe productrice de chaleur et génératrice d'électricité", in Enveloppes - Concepts, Peaux, Matériaux. Sous la direction de Christian Schittich. Birkhauser, Edition Détail 2003.

[2.9] T. Herzog, R. Krippner, W. Lang, Façade construction manual, Birkhauser, edition Detail, 2004.

[2.10] C. Schittich, Enveloppes - Concepts, peaux, matériaux, Editor Christian Schittich. Birkhauser, Edition Détail 2003.

[2.11] MC Munari Probst, C Roecker, Architectural integration and design of solar thermal systems, PPUR -Routledge, Taylor&Francis, 2011

[2.12] MC.Munari Probst, C.Roecker, Towards an improved architectural quality of building integrated solar thermal systems (BIST), in Solar Energy (2007), doi:10.1016/j.solener.2007.02.009.