

# LESO-PB

**Integration and formal development of  
solar thermal collectors**

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# Integration and formal development of solar thermal collectors.

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**ABSTRACT:** The paper presents selected results of an investigation over possible ways to improve Building Integrated Solar Thermal systems (BIST) on the formal level.

It shows the results of a European survey intended to help defining quality in the architectural integration of BIST. A few criteria of integration are derived and presented as guidelines intended to support architects in their integration design work.

Finally the paper describes a methodology for the formal development of solar thermal collectors responding to both energy and architectural needs.

Conference Topic: 04. Innovative Low Energy Technologies

Keywords: solar, thermal, architecture, integration.

## 1. INTRODUCTION

Solar thermal technologies are not yet playing the important role they deserve in the reduction of building fossil energy consumption and consequent greenhouse gas emissions.

The available optimized technologies and the competitive prices alone are not sufficient to reach the spread solar thermal technologies could expect. As recent developments in Photovoltaics confirm, the formal aspects related to the development of these technologies should be improved to make BIST (Building Integrated Solar Thermal) systems appealing to both users and building designers [1][2][3].

It has to be recognised that building integration of present solar thermal systems is generally characterised by a low level of architectural quality [4][5].

## 2. ARCHITECTURAL INTEGRATION QUALITY

In order to investigate possible ways to enhance the formal quality of BIST, the concept of a formally successful integration had to be explored and described.

For this purpose a survey into the way(s) architects and engineers perceive the integration quality of BIST has been designed and conducted.

### 2.1 The survey.

The survey has been proposed via the web to a large pool of European Architects, Engineers and Façade Manufacturers, equally representing the different European climatic areas (Northern Europe: UK, N, D, NL, B; Central Europe: CH, F, A, and Southern Europe: I, E, P, EL).

Those questioned were asked to rate ten selected examples of existing BIST using a five point scale ( - - ; - ; + - ; + ; + + ).

The examples address both glazed and unglazed solar thermal collectors, with black and coloured

absorbers. Four roof and six facade systems were proposed, comprising a variety of integration levels, building types, materials and colours.

A detailed evaluation of the module sizes, shapes and colours in relation to the integration context was then proposed, to help clarify the bases of the global judgment.

Over 1500 requests were sent out and 170 fully completed questionnaires were collected.

As intended, the majority of responses came from architects, although engineers and façade manufacturers were also an important part of the survey.

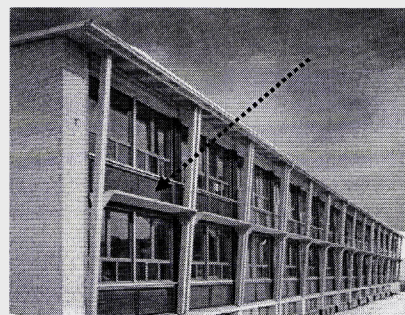
The vast majority (83%) of the respondents had more than five years of professional experience.

### 2.2 Survey results: best to worst.

#### 2.2.1 Facade integrations:

- The best rating was given to the balcony integration presented in Case 6 (Fig.1).

#### 6. Glazed collectors



Upper stage centre in Germany

Figure 1: Existing BIST appreciation - Case 6.



The solar modules occupy the whole parapet area, and are used as parapet external finishing. The size and shape of the modules fit the grid and match the rhythm of the façade. The collector glazing and the black colour of the absorber match the colour and material of the above window openings and are dimensioned to completely cover their area. The collectors appear as an integral part of the building.

- The Solarwall integration into a Canadair Hangar in Canada (Case 8, Fig.2) is considered to be the second best integration.

The unglazed solar system works both as a solar collector and façade cladding. It is placed on the *non-carrying wall*, underlining the structure of the building. The use of the solar system as a solar collector + façade cladding + composition element expressing the structure makes the integration fully successful, although the architecture of the building may not be considered outstanding, and the colour of the absorber is black.

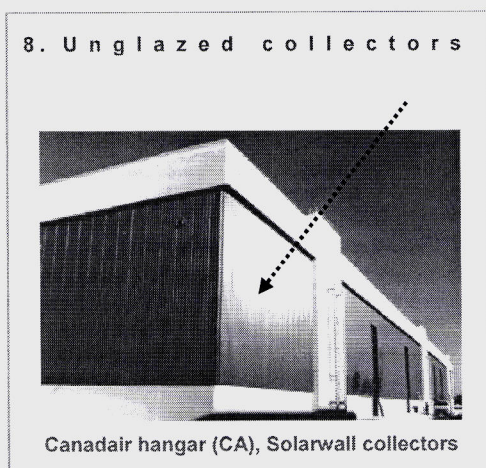


Figure 2: Existing BIST appreciation - Case 8.

- The Canadian school presented in Case 7 (Fig.3) also integrates Solarwall air-collectors into façades. The integration is considered acceptable though definitely not as good as the previous example.

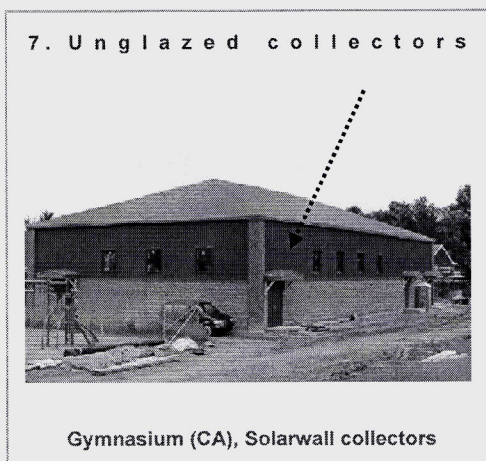


Figure 3: Existing BIST appreciation - Case 7.

The solar collectors are used as façade cladding but the covering rules in relation to the building structure are not as clear as in the Canadair hangar.

The square building symmetry is respected and equal façades are treated equally, but the wall surface of each façade is only covered in the upper part, making the cladding more of a decorative element than the upper layer of the wall system.

The blue colour of the collector does not help the global appreciation and is rated between a bad and a just acceptable choice, while the size and shape of the modules are considered, in accordance with the global appreciation, widely acceptable.

- Case 4 (Fig.4) presents a renovated building with façade integrated glazed collectors. The engineering community considers the architectural quality of the integration good, while for the architects it is just acceptable. The glazed solar modules of the system cover the whole blind wall of the lateral façade, but only that, characterizing and differentiating it from contiguous façades. By contrast, in the original project there was no solution of continuity in the angle between the two façades. In this example the solar system fits the **façade** but is not part of the **building** composition logic. While the size, shape and the colour of the module are considered a good choice by the engineers, they are considered to be acceptable but not good by the architects.

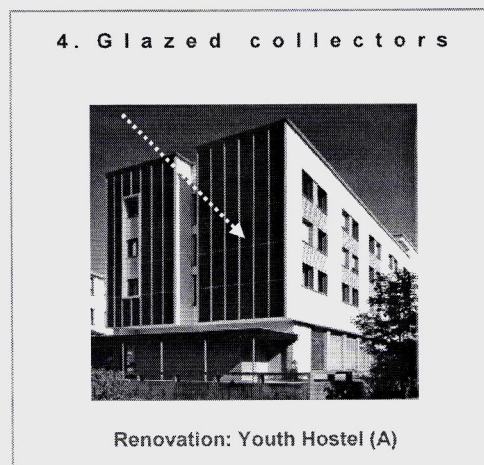


Figure 4: Existing BIST appreciation - Case 4.

- Integrations presented in Cases 3 (Fig.5) and 5 (Fig.6) were considered definitely unsuccessful by the architects, even though the other actors of the construction process were less negative. In both buildings the solar collector is used as an added decorative element applied to the wall without any construction and/or composition logic.

The negative appreciations of Building 5 show how in architects understanding, the use of coloured absorbers is not alone a valuable answer to the integration design problems, considered more complex. On the other hand it is interesting to notice that the same coloured absorbers had a remarkably positive impact on engineers who rated the integration quality as positive.



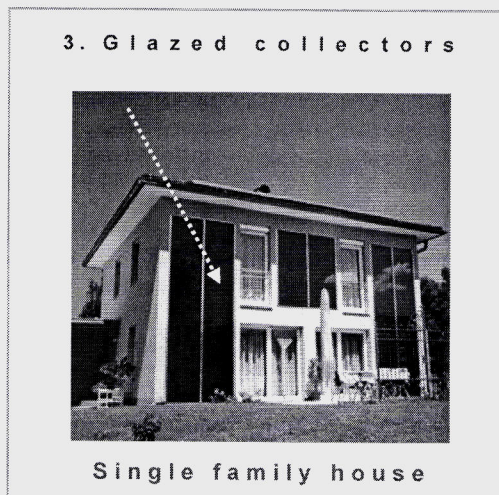


Figure 5: Existing BIST appreciation - Case 3.



Figure 6: Existing BIST appreciation - Case 5.

### 2.2.2 Roof integrated systems:

The appreciation of roof integration examples is consistent with the façade integration judgements.

- The most appreciated integrations were the roof integrated unglazed solar collector systems presented in Ex. 9 (Fig.8) and 10 (Fig.7), both judged very good. In these examples the collector occupies the whole roof area and has the double function of solar absorber and upper layer of the covering system. The size and shape of the collector as well as its black colour are considered to be a good choice.

The visible piping of Example 9 seems to disturb engineers more(!) than architects, who appreciate the controlled design of the technical elements, conceived as integral part of the building design.

- The integration presented in Case 2 (Fig.9) is considered positive by the architects, and is even more appreciated by the engineers.

Like in the previous examples, the solar system occupies the whole roof surface of the building and has the double function of solar absorber and upper

layer of the roof system, but in this case the collectors are glazed and "framed".

The size of these glazed collectors is considered acceptable, but not good; the blue colour is considered to be less appropriate than the black colour of the previous examples.

- The classic roof integration of Case 1 (Fig.10) is considered to be a failure. The approach reminds of the façade integration of Example 3: the collector is used only in its primary function, and is added to the building as an independent technical element.

As can be seen in the diagram of Fig. 11, the three geographical groups of architects (first three bars, left) consistently agreed on the value of the integration quality of the objects, be it good or bad, with only minor differences in the intensity. Façade manufacturers and engineers, on the other hand, are generally less demanding toward integration quality. Their responses tend to differ in intensity, but also radically in the judgement of two examples (3 & 5).

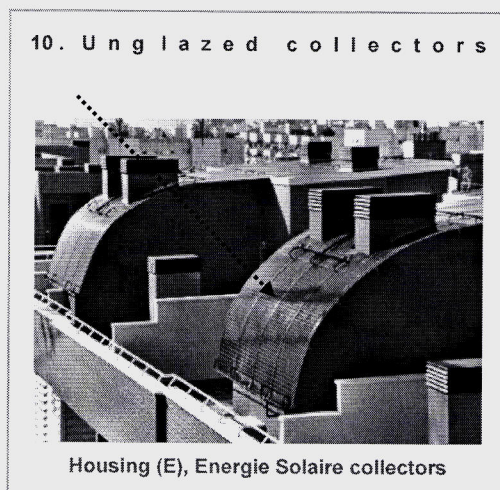


Figure 7: Existing BIST appreciation - Case 10.

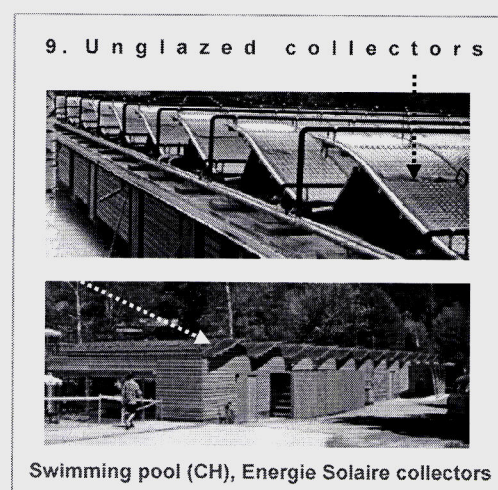


Figure 8: Existing BIST appreciation - Case 9.





Figure 9: Existing BIST appreciation - Case 2.

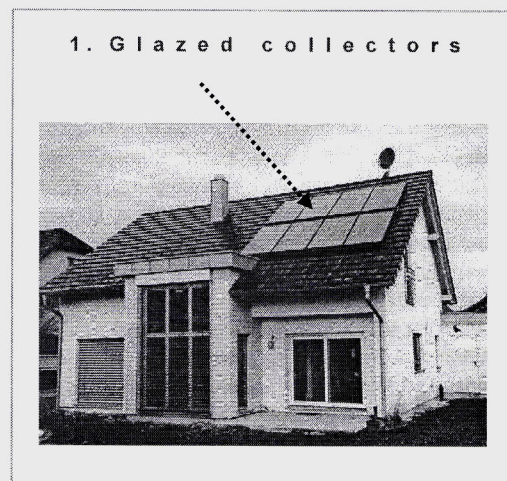


Figure 10: Existing BIST appreciation - Case 1

### 3. INTEGRATION CRITERIA.

The consistency of the architects' votes confirmed the existence of general criteria, not necessarily appreciated by some engineers, defining quality in architectural integration of BIST.

The appreciation results have highlighted how system size and position, module size and shape, jointing type, collector surface texture and material characterize integrations as much as does the absorber colour.

Each of these characteristics has to be coherent with the building design logic for the integration to be considered successful.

The following integration guidelines synthesize the criteria highlighted by the survey results, and are intended to support the integration design work.

#### 3.3 Integration guidelines

Solar systems should be integrated within the composition logic that regulates the design of the

whole building:

1- The positioning and the dimensioning of the system should be defined considering the building as a whole (not just within a façade or the roof):

Energy production goals, formal integration needs and solar thermal technology choice are all parameters to play/work with in defining a suitable system dimension and position.

To widen the range of possible solutions, the option to use dummy elements should also be taken into consideration.

2- The colours and materials of the system should be thought together with the colours and materials characterizing the building and the context.

The initial choice of technology is fundamental, as the material of the external (visible) system layer (glass, metal, plastic...) will depend on it.

Within the chosen technology, the available material treatment (surface colour and texture) offered by various available products can then be considered.

3- Module size and shape should be chosen considering the grids on which the design of the

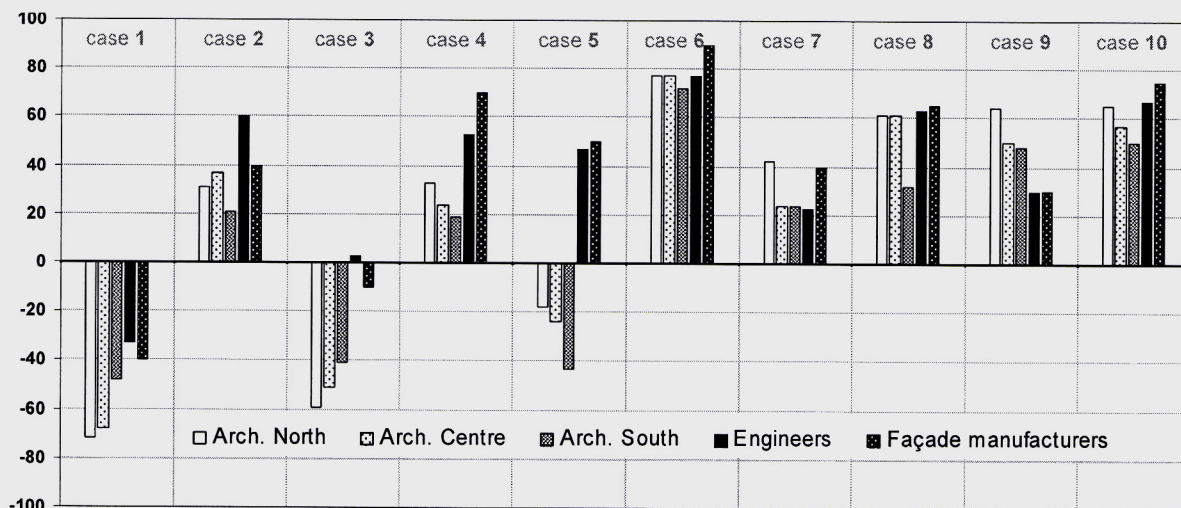


Figure 11: Comparison of appreciation results

(Results reported in a -100 to +100 scale)



building and the design of the façades/roof are based (or vice versa...).

Proposed jointing types should also be carefully considered while choosing the product, as different jointing types differently underline the modular grid of the system in relation to the building.

4- The use of a solar energy system as construction element (façade cladding, roof covering etc...) greatly eases the integration design work: building design logic is easier to follow while the architect has to balance fewer elements fulfilling more functions [6].

#### 4. COLLECTOR DESIGN.

The described criteria highlight how much the choice of a suitable product within the technology type is fundamental for the integration to be successful.

Unfortunately, the collector designs currently available in the market are generally not well suited to meet integration requirements, being developed with insufficient awareness of the buildings' formal needs.

##### 4.1 Methodology.

Novel collectors should be developed to respond to the defined building needs and to support the

designers' integration efforts.

Developers will have to deal with the formal limits imposed by the different solar thermal technology types (evacuated tube/ glazed collector/ unglazed metal collector/ unglazed plastic collector; air collector/hydraulic collector...), which impose both, the **material** of collectors' external layer and the **basic form** of collector modules (glazed tubes for vacuum collectors, metal sheet for unglazed flat plate collectors, etc...).

Nevertheless, new attractive and performing designs can be defined making the most of the formal possibilities offered by those imposed **materials** and **basic module forms**:

- The possible options offered by the **material** will have to be specified in terms of textures, finishing and colours.

- The possible options offered by the **module type** will have to be specified in terms of module shapes, sizes and jointing.

The specified options will have to be evaluated in terms of:

- Building needs (integration criteria);
- Users' required freedom and aesthetic preferences;
- Production feasibility and standardisation;
- Energy performances.

The careful balancing between all these needs will

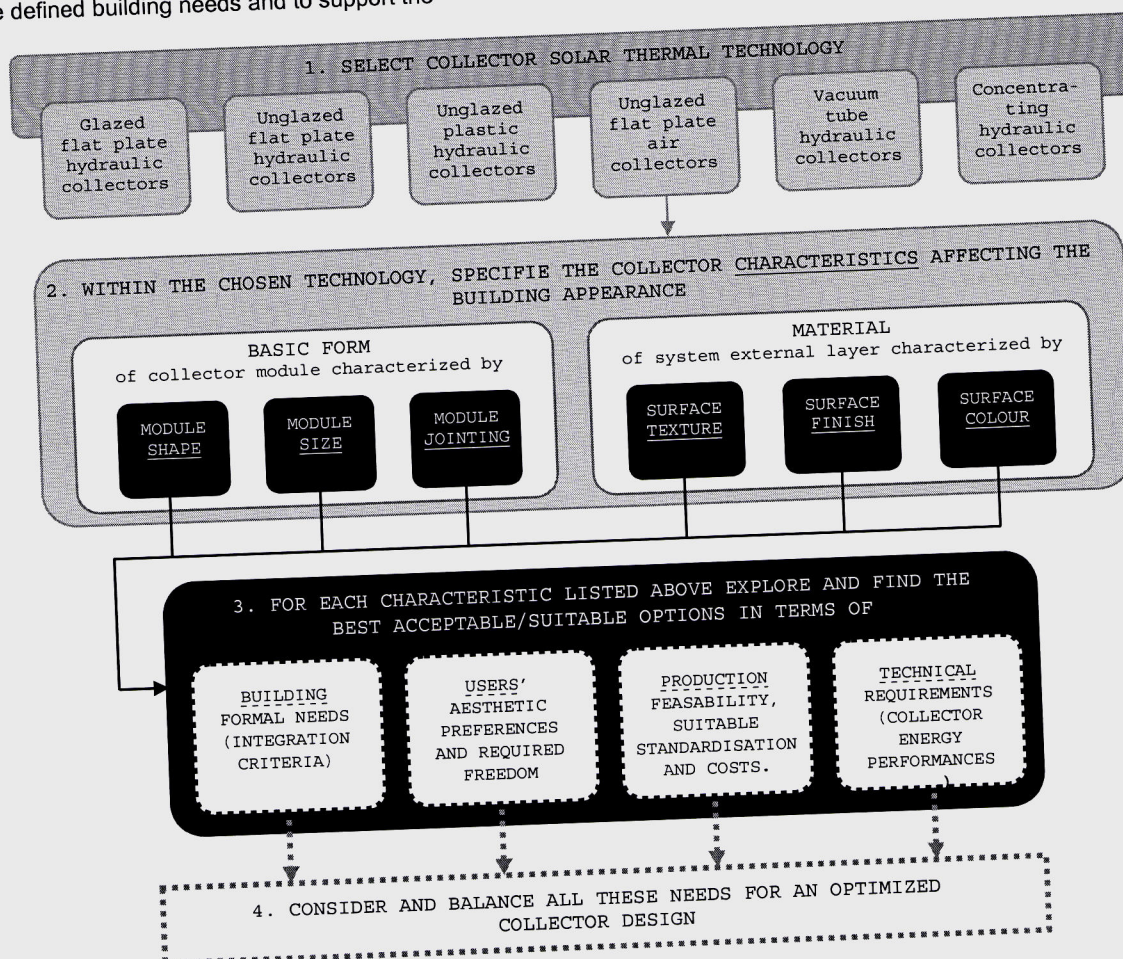


Figure 12: Collector design process.



lead to a formally optimized design.

Fig.12 summarises the whole suggested process of design work.

The described methodology and design process are currently used as a base for the development of a novel unglazed solar thermal collector conceived for facades and resorting to coloured selective coatings on steel material (EU project SOLABS) [7].

The SOLABS project team includes both engineers and designers, who jointly bring in all the competences needed to balance energy production, durability and design.

All the collector characteristics affecting building appearance have been evaluated within the team and suitable developments have been established in the light of the defined building integration criteria.

To ease the integration design work, the decision was made to conceive the new solar collector as a multifunctional construction element.

As de facto unglazed thermal collectors for façades are façade metal cladding, possible formal collector developments were directly inspired by existing façade metal claddings (already developed to respond to building needs), rather than from existing solar collectors.

A specific questionnaire was then designed to explore users' statistical preferences with respect to collector appearance (mainly architects, but also engineers and façade manufacturers).

Each collector characteristic was described and the preferences investigated in terms of suitable freedom/acceptable standardization and aesthetic preference, through specific multiple choice questions [8].

Then the balancing work between defined users' wishes (aesthetic preferences, need for freedom) and production feasibility, cost requirements and energy performances was conducted.

The joint efforts of engineers and architects and the clear identifying of the problems to be solved made the construction of a first performing prototype possible, prototype responding to building needs and to recorded users' wishes.

The new approach was received with clear enthusiasm by the contacted architects and building professionals.

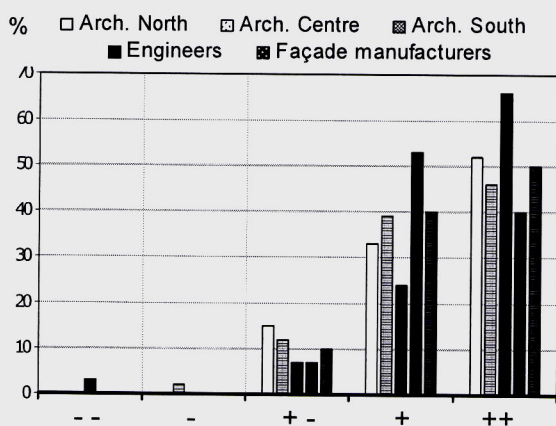


Figure 13: Interviewed interest in the SOLABS project.

## 5. CONCLUSIONS

The remarkable consistency of architects' votes in the appreciation of the proposed existing BIST has confirmed the existence of common criteria used as a basis to judge integration quality.

The understanding of those criteria led to the fundamental identification of the solar system characteristics that, having an impact on building appearance, affect integration quality: jointing type, module size and shape, collector material, surface texture, finishing and colour (i.e. formal characteristics).

To reach BIST quality the designer's complex task is to control and define all these characteristics within a clear whole building design logic.

On the other hand the true comprehension of the formal characteristics' impact should also induce/help developers to provide novel collector designs finally conscious of building needs, and targeted to ease the integration design work.

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