REPORT WP3.D3, Recommendations for Uniform European Requirements for Building Integration of Solar Thermal Collectors

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1 SUMMARY

This report gives recommendations for uniform European requirements for solar thermal collectors that are integrated into the building envelope. Based on the inventory of existing requirements and guidelines (see deliverable WP3.D2) a survey among architects and planners was carried out to identify gaps in the building standards which are an obstacle for a widespread building integration of solar thermal collectors.

The answers to this survey are summarized in the first part of this report to show which problems occur in the different countries participating in work package 3 of NEGST.

In the second part, a few specific points are mentioned in more detail that were identified to be of interest in most participating countries and where a common European approach is desirable.

No new standards are recommended keeping in mind that standards can also become an obstacle for innovative systems and solutions to enter the market. However, a common approach is necessary to open the European market for national manufacturers.

Roof-integrated solar thermal collectors have been on the market for many years and there are no general problems in terms of European standardization. Façade-integrated collectors are becoming more and more popular. It is important to stress that façade-integrated collectors have to meet the same requirements as other façade components. Therefore a special design of collectors for façade integration is necessary and manufacturers should label their products to show which collectors are suitable for roof mounting and which for façade mounting.

For non-ventilated façade-integrated collectors there is a need for a simple calculation method for humidity transport in the wall behind a collector.

Another topic is to find a way to state the lifetime of a collector as a building component. This would clarify to architects and planners which kind of maintenance or replacement of parts will be necessary during the lifetime of a building.

Finally, labeling of solar thermal collectors with a CE-Mark is an important issue that has to be dealt with on a European level.

2 Introduction

Based on the inventory of existing requirements and guidelines (see deliverable WP3.D2), the goal of this study was to find and describe gaps in the building standards, which cause problems for building integration of solar thermal collectors. The questions to be answered are what is not covered in the existing standards, what are the problems that manufacturers and planners face when integrating solar thermal collectors into façades and roofs. Are new standards necessary or do standards have to be harmonized to facilitate building integration of solar thermal collectors? Where are the barriers to integrating collectors in buildings? Are there situations where a collector integration contradicts or conflicts with standards in force? Can we identify aspects that should be treated in standards to make building integration of solar thermal collectors easier?

The first step was a survey among selected architects and planners in the participating countries that already have experience with building integration. The goal was to identify problems that occur during the planning or installation phase of building integration of solar thermal collectors.

Finally, conclusions from this survey and from the inventory of existing requirements and guidelines will be drawn and areas where common European approaches would be helpful will be identified.

3 Methodology

A questionnaire was created to identify the main problems in each participating country and to define areas where European standards are needed.

The selected architects and planners are all well known in the field of “solar buildings”: architects, planners as well as solar manufacturers and building industry that have experience with façade and/or roof integration of solar thermal collectors. The participating countries were Austria, France, The Netherlands, Portugal, Germany, Sweden and Norway. In total, 25 people were interviewed for this survey.

The survey was sent out by email to the selected persons in most of the countries. They were then called up for an interview. The collected information was made anonymous and the answers were summarized and sorted by the subjects listed below.

Strength of construction

- Has the strength of the construction of the building an influence on the integration of solar thermal collectors in the building envelope?

Fire risk

- Are there problems with the collector insulation, fire classification of collector materials? Is the fire risk a point of discussion when integrating solar thermal collectors in the building envelope?

Noise problems

- Does a collector integration lead to higher noise levels than permitted?

Construction damage

- Does a collector integration weaken a building component or part of the building construction?

Thermal requirements

- Does a collector integration conflict with the standards on energy efficiency of buildings?

Rain and moisture penetration

- Are there any problems with moisture penetration into the building?

Environmentally problematical materials

- Are there problems to meet requirements?

4 Reported Problem Areas

In the following sections, specific problems or general observations regarding the eight thematic areas that were reported during the interviews with planners and architects, are summarized sorted by topic.

4.1 Strength of Construction

Problem A: Loads on collectors, fixing of the glass cover for vertical collector installation

Generally, problems occur mostly for façade-integrated collectors. Especially in tall buildings wind loads may be higher than assumed in the current collector standards.

In Austria, there are no general guidelines for vertical solar thermal collectors and no normative regulations for integration of solar thermal collectors in façades (for example: mounting in upper floors, with high wind loads).

In Norway, the most critical point with regard to strength is to make sure that the cover sheets sustain wind loads. The same methods and regulations as for green houses and similar installations of twin wall plastic sheets are used.

In a particular project in Portugal, one aspect that was particularly studied, was the fixing of the collector glass cover to the collector box. The fixing of the collector cover was changed in relation to the commercial model of the company as a request from the architects. A mechanical load test was performed, at INETI, in order to determine if the new fixing was secure. The test performed exceeded the pressure values that are established in the EN 12975. The test was performed up to 1800 Pa. This was not a request from regulations but a request from the architect and planner.

In Norway, there are a few examples where sheets have fallen down due to improper mounting. But it’s not a general problem.

In Austria, holding devices for glass building components are available and can be used for solar thermal collectors.

Problem B: Loads on the building structure due to collector integration

When large collector fields are mounted in façades, the weight of collectors and glazing is a major topic in Austria. Therefore specialists must be involved in the design of the construction of large systems: large wingspan of the collector area, overhang of collector over the building envelope. Otherwise, the weight can become a problem (on the contrary light-weight roof constructions can easily be designed). The construction of the wall must be able to hold the additional weight of the collector. This can be a problem in building retrofit. An auxiliary construction must be erected to attach the solar thermal collectors if the existing façade is too weak. For roof-integrated collectors, the weight of the collectors is generally no problem because it is not heavier than typical roofing materials.

In Norway, the absorber and the cover sheets are often made of polymeric materials fixed with aluminum frame profiles. The weight of the collector is low, approx. 6 kg/m^2. This makes the installation and handling quite easy and there are no problems with excessive loads on the building structure.

Problem C: Glass cover of standard collectors does not comply with building regulations

In Austria, glass covers for large façade integrated collectors have to be dimensioned according to building regulations for glass façades. Typically, thicker collector glass covers have to be used than in standard smaller collectors. However, stability of the collector glass can be assured if the glazing of the solar thermal collectors are dimensioned corresponding to the building guidelines. Manufacturers use glass holding devices that can hold thick glass covers.

4.2 Fire Risk

Problem A: Materials used in solar thermal collectors can be in contradiction to building standards

The results from the Austrian study say that there is no risk for the insulation of the collector to catch fire as this is normally made of mineral wool. Further, there is no problem of fire risk in one-storey buildings. The fire risk is a basic problem in multi-storey residential buildings where there is the risk of a flashover of fire if there is a window above a collector in the façade. Problems occur only for façade integration of solar thermal collectors, not in roof integration, where the collectors can be treated like roof windows, which is a well known technology.

In France, the fire risk due to the insulation is evaluated in the technical approval. Effectively, there is no risk if recommendations are met. It’s basically seen as the manufacturer’s responsibility. Additional problems due to large collector areas integrated into the building have not occurred so far.

In the Netherlands, building regulations require that a roof-integrated collector be resistant against burning material landing on it from e.g. a neighboring building. In a test, a metal basket filled with burning material is put on top of the collector and after a certain period, the collector material should not burn. This has proven difficult in some cases for collectors with plastic covers.

In Norway, mostly mineral wool is used as insulation material which is no problem for fire regulations. The polymer sheets used as collector cover are classified differently in different countries with respect to fire risk. Therefore, the manufacturer issues the fire classification valid for the individual countries. In some countries, very tall façade collectors of this construction can be difficult to get approved due to fire regulations.

In Portugal two aspects of the upcoming new buildings regulations can become an obstacle for building-integrated solar thermal collectors:

- Collector insulation materials (especially polyurethane) can be questioned
- Roof area available for collector installation on large buildings (more than 10 storeys). Not more than 25% of the roof area may be occupied by technical equipment like air handling units. But also collectors, piping and storage tanks will fall within this rule.

Problem B: Additional regulations for building materials in contact with solar thermal collectors

According to the Austrian study, building insulation made of polystyrene can be a problem when in contact with solar thermal collectors.

4.3 Noise Problems

No serious problems with noise levels with building integrated collectors have occurred in Austria. Wooden frames of integrated collectors are an advantage because they function as sort of a noise protection.

The Norwegian partners received the answer that the collectors do not increase the noise transmission; they are actually used as an extra noise shielding in some cases. The noise produced by the collector itself occurs in very short periods when water enters the collectors and removes the air (the collectors are of drain-back type). For a couple of minutes during the start-up period sounds like from a distant, lively mountain river can be noticed, but no complains have been addressed due to this.

Noise from the collectors because of bad stagnation behavior of the collectors was mentioned in some of the surveys. However, this problem is not related to building integration but must be solved by optimizing the hydraulics inside and the connections between the collectors.

4.4 Construction Damage

An architect in Austria argued that a solar thermal collector has a shorter lifetime (15-20 years) than the standard façade elements (about 50 years). Therefore, he did not want to install a façade integrated collector, which would decrease the durability of the whole construction.

Long-term tests of solar thermal collectors (in the façade, on the roof) would be necessary to prepare normative documents on the lifetime of a collector. This would be needed for architects and planners to use solar thermal collectors just like other façade components without hesitation.

Also in Norway, the manufacturer of solar thermal collectors cannot guarantee the same long lifetime for the collector as for the conventional building materials which are substituted. Especially the cover sheets are a topic here. That means that the collector has to be made for very easy exchange of the sheet components. The sheets have to be considered as active energy producing element with good pay-back and that exchange after 10-15 years is acceptable.

Also in the Netherlands the lifetime of a collector compared to façade/roof materials is a topic.

4.5 Thermal Requirements

The Austrian, German and Norwegian surveys show that a collector integration is only of advantage since the collector insulation can be used as building insulation. However, the collector insulation is only part of the building insulation, if it is carried out without a ventilation.

In Austria, it was mentioned that thermal bridges are no problem with collectors with a wooden frame. More problematic are collectors with metallic frames. However, collectors have to be installed with metallic frames in some geographical areas; in some cities (for example Vienna) metallic collectors have to be used in multi-storey residential buildings because of fire risk.

In the framework of the Austrian project “Façade integrated solar thermal collectors” the mounting of collectors in a vertical position in the façade of a building has been investigated. Calculations of thermal bridges have been carried out in order to find an optimized construction /Berg02/. The outcome of the investigations have been used to design two test façades in the frame of the project.

The boundary conditions of the calculations have been stationary with fixed temperatures of the collector and fixed room ambient temperatures. The considered constructions are vertical solar thermal collectors mounted in building façades without an air gap for ventilation. Comparisons of collectors with wooden frames and with metallic frames have been carried out. Investigations on light weight constructions and massive building constructions with brick or concrete have been performed.

The output of these calculations have been charts with isotherm lines. The characteristics of the isotherms indicate the thermal bridges and therefore show the quality of a construction. Due to the fact that calculations have been stationary the results of the absolute temperatures must not be taken as a given value but as a qualitative statement.

The calculation of the thermal bridges of collectors with **wooden frames** showed, that the mounting of the collector has no significant influence on the thermal conduction in the wall (see Fig 1).

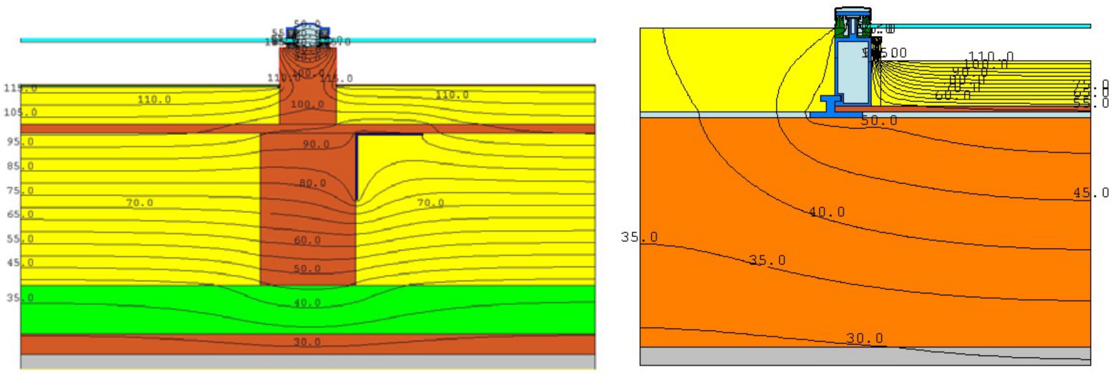

Fig1: Collector temperature = 120 °C, Ambient temperature = +24 °C, room temperature =+20 °C (left: Light weight building construction (Wood), right: massive building construction (bricks)), picture source: Dipl.-Ing. Dr. Karl Höfler, 8200 Gleisdorf, Austria, 2002

The calculation of collectors with **metallic frames** led to the result, that thermal insulation of the glass cover strip and the building fixation is necessary to minimize the heat loss. Moreover the utilization of a wooden back wall of the collector is to be preferred in the case of a direct integration of the collector without ventilation (see Fig 2).

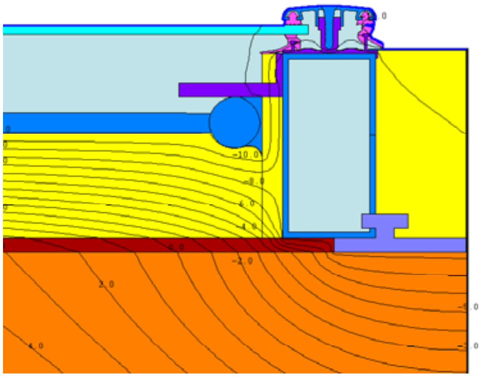

Fig 2: Wooden back wall of the collector, thermal insulation of the glass cover strip, ambient temperature = -12 °C, room temperature =+20 °C, brick wall= 25 cm massive building construction (bricks), picture source: Dipl.-Ing. Dr. Karl Höfler, 8200 Gleisdorf, Austria, 2002

4.6 Rain and Moisture Penetration

Problem A: Rain

The asked Austrian architects know the issue of tightness against rain from roof windows, and this applies for solar collectors also. There is no difference to other parts in façades with panel covering.

Further, since the integration results in a discontinuity of the upper water proofing layer (roof), a leakage can occur at the interface between collector and roof material, if the mounting was not carried out properly. It is therefore important to apply a second water proofing layer under the collector (cold roof construction).

Tightness of roof-integrated collectors are problematic in countries, where the double water-proof roof insulation is not mandatory. Materials should be selected to avoid premature erosion causing moisture penetration and welding spots should be controlled when applicable.

A weak point is the durability of the sealings (EPDM), according to the German experts.

In Norway, water tightness of collectors or building integration of collectors has not been a problem.

In France, there is no problem with moisture penetration because there is no difference to other parts in façades with panel covering because the product has to be technically approved.

Problem B: Moisture penetration for non-ventilated façade integration

Regarding vapor diffusion: architects and planners would prefer expert opinions from building physicists. The construction can only be implemented with integrated façade collectors without air gap for ventilation if it is documented, that the construction is correctly planned. The planner can be made liable for the construction for 30 years in Austria and therefore, in some cases constructions with air gap are carried out instead.

The time of the year of the installation of the façade collectors is important, because an installation is more problematic during the humid season. Humidity, which is in the construction from the beginning slowly diffuses to the inside of the building during the operation of the systems.

Sweden reports that building integrated systems show problems with moisture interference and that problems with the drain issues must be considered.

Problem C: Organic materials, insects etc.

In Norway, moisture, particularly in the form of organic materials, insects etc. can in some cases be trapped and found inside the channels of polycarbonate twin-wall cover sheets. It is important to carefully block these channels, and still enable diffusion or removal of water vapor. The problem is considered to be a serious obstacle.

4.7 Environmentally Problematical Materials

All of the questioned planners and architects in Austria assured that there are no environmentally problematical materials.

In France, CFC is forbidden in the insulation and collector coating must not contain chrome 6 or cadmium element, in order to be environmentally friendly. All components, except the absorber selective coating have to be validated.

Isocyanates, used as binding agents in polyurethane foam is not stable at high temperatures and can thereby emit poisonous (carcinogen) gases, according to the report from Sweden. However, there are no specific restrictions regarding this compound.

The Netherlands report that the polymer materials used are not considered as environmentally harmful and they are recyclable. Comprehensive life cycle assessments have been carried out and show that the polymer collectors are much better in terms of environmental factor than e.g. metal-based collectors or even some of the building materials they may substitute by integration.

4.8 Additional Topics

The questioned planers and architects also had the possibility to add further points that have not been listed in the questionnaire.

The Netherlands report that the standards for solar collectors and solar domestic hot water systems sometimes conflict with the demanded freedom for proper building integration. A major aspect is that the product standards deliver performance figures for one design and not for a whole range of products with different sizes. From an architectural and esthetical point of view, there is a strong wish for freedom in sizing. Hence, it is recommended to adapt EN 12975 and EN 12976 in such sense that performance is presented as function of collector (and maybe heat store) size. The EIE Solar Keymark project is taking care of this aspect. European standardization should include it in their work, too.

Failures often occur at the interface of different working areas such as the roofer's work for the collector and the installer's work inside the house. A well-known problem is condensation inside the collector caused by un-insulated piping and an open connection between attic and inner collector casing.

The Portuguese partners report that in their opinion the reason for the few examples of building integration in Portugal is not that building standards constitute barriers to the application of collectors in the façades, but mainly because there is not enough knowledge among architects of the possibilities to integrate the collectors in building façades. Also the companies that commercialize and install collectors do not offer solutions with integration.

There are difficulties caused by the diversity of the roof tiles between countries and even great differences inside the same country. Consequence for this is the complexity of the in-roof integration solutions and the diversity of the product ranges, according to the German partners.

The biggest barrier is the aesthetic acceptance and the limitation of the collector installation due to the proximity of historical buildings in some countries (in some areas, it is forbidden to make any single change on the building / house roof).

A lot of administrative requirements are needed in France. It seems for professionals, probably the first barrier for projects realizations. The success of solar projects are limited: depends on a lot of political authorizations and the slowness of administrative requirements.

Further was the problematic addressed in Austria that the collector-mounting in the building façade leads to very thick walls. This decreases the living area and therefore makes the m^2 of living area more expensive.

4.9 Dutch Pre-Standard NVN 7250 (en) 'Solar Energy Systems – Integration in Roofs and Façades – Constructional Aspects'

The Netherlands is the only country participating in this study that has a pre-standard that deals particularly with integration of solar energy systems in roofs and façades. This includes solar thermal systems.

This pre-standard deals with:

- Constructional requirements (fundamental load combinations, special load combinations, interstitial condensation and influence of temperature)
- Requirements regarding fire safety (restricting the occurrence of a flammable situation, restricting the development of fire, restricting the spread of fire, protection against lightning)
- Requirement regarding noise (protection against outdoor noise, noise control between rooms)
- Requirements regarding damp-proofing (moisture control from outside damp, moisture control against inside damp)
- Requirements against thermal insulation (thermal resistance, restricting air permeability)
- Requirements on materials used (dangerous substances, anti-corrosion, sealing materials, resistance to hail)
- Determination methods (wind resistance, interstitial condensation, resistance to temperature changes, frost resistance, wind-spread fire test, water tightness, resistance to hail).

The pre-standard both covers both solar thermal and PV systems, flat and tilted roofs and is coupled to the Dutch building situation. The present pre-standard can be ordered from NEN, PO Box 5059, 2600 GB Delft, The Netherlands.

5 Conclusions and Recommendations

5.1 Roof Integration

In general, roof integration has been done successfully for many years. There are no additional standards necessary. However, some problems occur in countries with smaller solar thermal markets. Some of these problems have been reported in our survey and the majority is in connection to the construction and installation of collectors. These problems can be solved by adopting solutions from other European countries.

5.2 Façade Integration

Façade integration of solar thermal collectors is much less common than roof integration. In recent years, a number of systems has been installed with good success regarding the thermal and energetic performance. However, in most cases collectors that were developed for roof integration or on-roof installation, have simply been mounted to façades. This led to problems regarding the glass cover supports and other problems that are due to the mounting orientation and do not occur when the same collector is installed on the roof.

Solar thermal collectors for façade integration have to comply with building standards that are valid for façade components. It does not make sense to create new standards for this type of collectors but collectors have to be designed especially to meet all the requirements of a façade component. The manufacturer of a collector has to label its products to show which collectors are suitable for roof or façade integration respectively. This way, planners and architects would be sure that a collector complies with all the requirements for façade integration.

5.3 Calculation Method for Non-Ventilated Façade-Integrated Collectors

A special case are solar thermal collectors that are attached directly to the wall of a building and where the collector insulation is at the same time the building insulation. It has been shown in several research projects (see /Berg02/ and /Col04/) that this type of integration has many advantages because the collector reduces the heat losses from the house during the day even if there is not enough radiation to operate the system. The temperature of the absorber will often still be higher than the ambient temperature.

However, there is some insecurity among planners and architects about the moisture transport within the wall behind such a collector. This uncertainty leads to the implementation of constructions with ventilation and the ventilated construction parts can not benefit from the thermal insulation effect of an integrated collector. Therefore it would be helpful to have a European Standard that provides a simple (rule of thumb) calculation method that allows to judge which type of wall construction is suitable for direct integration of solar thermal collectors. This document should also include recommendations on good design including the thermal advantages of direct integration and how to avoid problems (summer overheating).

5.4 Lifetime of Solar Thermal Collectors

An important topic for building integration of solar thermal collectors is the lifetime of a collector. If solar thermal collectors are used as building components, it is important to know how their lifetime compares with that of other building components.

The assessment of the lifetime of collectors with regard to the lifetime of other building components is quite difficult, since for typical building components that are offered on the market information about the expected lifetime is mostly not available. This is due to the reason that there is a leak of test procedures for the determination of the lifetime of building components exposed to outdoor conditions.

The lifetime of a solar collector is very likely to be smaller than that of other building components that are usually designed for a lifetime of 50 years or so. That means that the collector or parts of it will have to be replaced during the lifetime of a building façade or roof. The replacement of the collector or parts of it can be seen as maintenance of the collectors. The necessary maintenance interval and what kind of maintenance will be needed is a piece of information that the manufacturer of the collector should provide to the architect or planner just like maintenance intervals for other façades (e.g. wooden buildings) are known.

A method to obtain this information would be to conduct accelerated ageing tests. Standard building elements have to comply with harmonized standards on a European level or European technical approvals. There are different standards and guidelines for approval for each type of building element. However, some building components have similarities with solar thermal collectors and these requirements could be used to establish a testing procedure for solar thermal collectors. An example of such a guideline for technical approval is the one for Structural Sealant Glazing Systems (SSGS) /ETAG002/.

A method for a theoretical analysis of material degradation and its effect on the functioning of solar thermal collectors has been developed by CSTB. The method is called Failure Modes and Effects Analysis (FMEA). This could also be an interesting tool for manufacturers to define the lifetime of their products and possible improvements /Lai03a and Lai03b/.

Another aspect is that the replacement of a collector or parts of it has to be seen with regard to the payback time of a system or solar collector respectively. If the collector reaches the end of its lifetime and it can be retrofitted by just exchanging some components this can result in a substantial reduction of the energy payback time, compared to the installation of a complete new collector.

5.5 CE-Marking

Within Europe a large range of building products (e. g. windows, roof bricks) are within the scope of the Construction Product Directive (Council Directive 89/106/EEC). As a consequence, these products have to fulfil the requirements specified or resulting from this directive. The fact that a specific product fulfils the related requirements is expressed by the CE-Mark (see Figure 3). Since in general the CE-Mark can be based on several directives the documentation delivered with the product has to include a so called "declaration of conformity" providing information on the basis of which directive the CE-Mark is issued. Only products fulfilling the relevant European directives are allowed to be sold on the European market.

Fig. 3: CE-Mark

Up to now (Summer 2006) solar thermal collectors are not within the scope of the Construction Product Directive (Council Directive 89/106/EEC). Therefore CE-Marking of solar thermal collectors based on that directive is not possible. However, there are ongoing discussions whether collectors should be included in the scope of the Construction Product Directive.

Today there are already collectors on the market, that are labeled with a CE-Mark. In this case the CE-mark is issued on the basis of the Pressure Equipment Directive (Council Directive 97/23/EC). Whether CE-marking in the basis of this directive is allowed or even required is still under discussion.

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