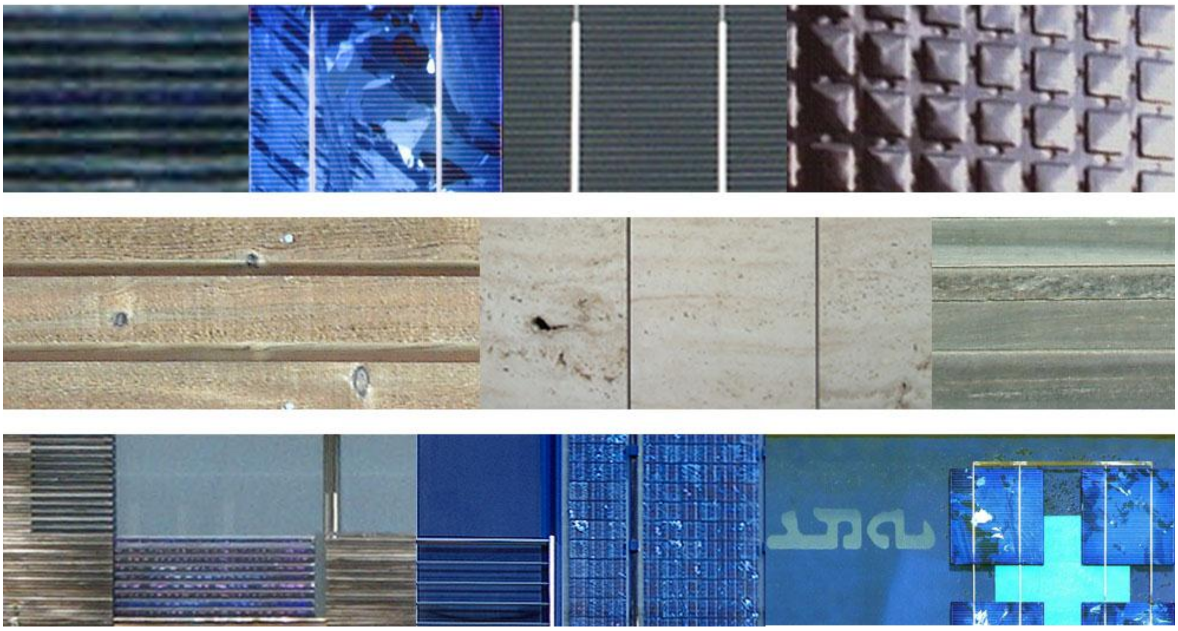
IEA SHC Task 41: Solar Energy and Architecture

Subtask A: Criteria for Architectural Integration



Report T.41.A.1

Building Integration of Solar Thermal and Photovoltaics – Barriers, Needs and Strategies

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SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

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Keywords: solar energy, architectural integration, solar thermal, photovoltaics, utilization, application, barriers, needs, international survey, results

AUTHORS:
Klaudia Farkas (NTNU, Norway)
Miljana Horvat (Ryerson University, Canada)

CONTRIBUTORS TO THE REPORT (in alphabetical order):
Francesco Frontini (SUPSI–ISAAC, Switzerland)
Jouri Kanters (Lund University, Sweden)
Margarethe Korolkow (IBUS - Institut für Bau-, Umwelt- und Solarforschung, Germany)
Marja Lundgren (White Arkitekter, Sweden)
MariaCristina Munari Probst (EPFL-LESO, Switzerland)
Christian Roecker (EPFL-LESO, Switzerland)
Mark Snow (University of New South Wales, Australia)
Maria Wall (Lund University, Sweden)

CONTRIBUTORS TO THE SURVEY (IN ALPHABETICAL ORDER):

Miguel Pires Amado
FCT/UNL
Campus da Caparica
PT-2829-516 Caparica
PORTUGAL
ma@fct.unl.pt

Marius Bjørge
DARK Arkitekter AS
Drammensveien 130
N-0277 Oslo
NORWAY
marius.bjorge@dark.no

Émilie Bouffard
École d'architecture
Université Laval
1, Côte de la Fabrique
Québec,
CANADA
emilie.bouffard.1@ulaval.ca

Marie-Claude Dubois
Subtask co-leader, Subtask B
Formerly of École d'architecture,
Université Laval
1, Côte de la Fabrique
Québec,
CANADA
Marie-Claude.Dubois@ebd.lth.se

Doris Ehrbar
Lucerne University of Applied Sciences and Arts
Dept. of Engineering and Architecture
Technikumstrasse 21
CH-6048 Horw
SWITZERLAND
doris.ehrbar@hslu.ch

Klaudia Farkas
Department of Architectural Design, History, and Technology
Norwegian University of Science and Technology - NTNU
NO-7491 Trondheim
NORWAY
klaudia.farkas@ntnu.no

Alain Filloux
Alphéeis
Espace Beethoven - Bâtiment N°2
1200 Route des Lucioles
F -06560 Valbonne
FRANCE
alain.filloux@alpheeis.com

Francesco Frontini
University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

Institute for Applied Sustainability to the Built Environment (ISAAC)
Campus Trevano
CH - 6952 Canobbio
SWITZERLAND
francesco.frontini@supsi.ch

Shirley Gagnon
École d'architecture,
Université Laval
1, Côte de la Fabrique
Québec,
CANADA
shirley.gagnon.1@ulaval.ca

Susanne Geissler
Formerly of Division Buildings & Heating
Austrian Energy Agency
Mariahilfer Straße 136
A-1150 Vienna
AUSTRIA
office@energyagency.at

Alessia Giovanardi
EURAC research
Viale Druso/Drususallee 1
I-39100 Bolzano/Bozen
ITALY
alessia.giovanardi@eurac.edu

Susanne Gosztonyi
Energy Department
AIT Austrian Institute of Technology
Giefinggasse 2
A-1210 Vienna
AUSTRIA
susanne.gosztonyi@ait.ac.at

Rolf Hagen
Context AS
Rjukan Naeringspark, Bygg 270
N-3660 Rjukan
NORWAY
rolf@context.as

Anne Grete Hestnes
Department of Architectural Design, History and Technology
Norwegian University of Science and Technology - NTNU
NO-7491 Trondheim
NORWAY
annegrete.hestnes@ntnu.no

Gustav Hillmann
IBUS – Institut für Bau-, Umwelt- und Solarforschung
IBUS Architekten und Ingenieure GbR
Alt-Tempelhof 18
D-12099 Berlin
GERMANY
hillmann@ibus-berlin.de

Merete Hoff
DARK Arkitekter AS
Drammensveien 130
N-0277 Oslo
NORWAY
mho@dark.no

Miljana Horvat
Subtask co-leader, Subtask B
Dept. of Architectural Science
Ryerson University
350 Victoria St.
Toronto, ON, M5B 2K3
CANADA
mhorvat@ryerson.ca

Jouri Kanters
Department of Architecture and Built Environment
Energy and Building Design
Lund University
P.O. Box 118
SE-221 00 Lund
SWEDEN
Jouri.Kanters@ebd.lth.se

Karin Kappel
Solar City Copenhagen
Arkitekternes Hus
Strandgade 27A
DK-1401 København K
DENMARK
kk@solarcity.dk

Jun Tae Kim
Department of Architectural Engineering, Kongju National University
275 Budae-Dong
330-717 Chungnam, Cheonan
REPUBLIC OF KOREA
jtkim@kongju.ac.kr

Margarethe Korolkow
IBUS – Institut für Bau-, Umwelt- und Solarforschung GmbH
Alt-Tempelhof 18
D-12099 Berlin
GERMANY
margarethe.korolkow@ibus-berlin.de

Vesna Kosoric
Formerly of: Solar Energy Research Institute of Singapore (SERIS)
National University of Singapore (NUS)
7 Engineering Drive 1
Building E3A, # 06-01
SINGAPORE 117574
seris-info@nus.edu.sg

Alissa Laporte
Formerly of Department of Architectural Science
Ryerson University
350 Victoria St.
Toronto, ON, M5B 2K3, CANADA
alissa.laporte@ryerson.ca

Roberto Lollini
EURAC research
Viale Druso/Drususallee 1
I-39100 Bolzano/Bozen
ITALY
roberto.lollini@eurac.edu

Marja Lundgren
White Arkitekter
P.O. Box 4700
Östgötagatan 100
SE-116 92 Stockholm
SWEDEN
marja.lundgren@white.se

Catherine Massart
Architecture et climat
Université Catholique de Louvain, Place du levant, 1
1348 LLN
BELGIUM
catherine.massart@uclouvain.be

Laura Maturi
EURAC research, Institute for Renewable Energy
Universitá degli Studi di Trento
Viale Druso 1, I-39100 Bolzano,
ITALY
laura.maturi@eurac.edu

Ricardo Enriquez Miranda
Energy Efficiency in Building R&D Unit
CIEMAT
Av. Complutense, 22
E-28040 Madrid
SPAIN
ricardo.enriquez@ciemat.es

Maria Cristina Munari Probst
Subtask co-leader, Subtask A
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne
SWITZERLAND
mariacristina.munariprobst@epfl.ch

Kim Nagel
Formerly of SUPSI, Institute for Applied Sustainability to the Built Environment (ISAAC)

Swiss BiPV Centre of competence
Campus Trevano
CH - 6952 Canobbio
SWITZERLAND
info@bipv.ch

Susanne Rexroth
HTW Berlin University of Applied Sciences Renewable Energies
Wilhelminenhofstr. 75A
D-12459 Berlin
GERMANY
susanne.rexroth@htw-berlin.de

Christian Roecker
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne
SWITZERLAND
christian.roecker@epfl.ch

Alessandra Scognamiglio
ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) UTTP Portici
Piazzale E. Fermi 1
I-80055 Portici, NA
ITALY
alessandra.scognamiglio@enea.it

Mark Snow
Faculty of the Built Environment
University of New South Wales
NSW 2052 Sydney
AUSTRALIA
m.snow@unsw.edu.au

Maria Wall
Operating Agent
Energy and Building Design
Lund University
P.O. Box 118
SE-221 00 Lund
SWEDEN
maria.wall@ebd.lth.se

Isa Zanetti
Formerly of SUPSI, Institute for Applied Sustainability to the Built Environment (ISAAC)

Swiss BiPV Centre of competence
Campus Trevano
CH - 6952 Canobbio
SWITZERLAND
info@bipv.ch

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EXECUTIVE SUMMARY

The International Energy Agency (IEA) Solar Heating and Cooling (SHC) Task 41 “Solar Energy and Architecture” has conducted an international survey concerning the integration of solar energy systems and architecture in order to identify barriers that architects are facing when incorporating active solar technologies in their designs.

The survey

The survey aimed to investigate three main issues: the first deals with the use of solar energy in current architectural practice where respondents were asked about the level of importance of using solar energy in architecture, the different utilizations and levels of integration of solar energy in their professional practice. The second part of the survey investigated possible barriers to the uptake of solar thermal and photovoltaics, in order to better understand reasons for architects’ resistance to the implementation of these technologies. Further, it asked about the needs of architects, i.e. what they would like to see being developed for the wider use of solar active systems in the building skin. The third part dealt with the satisfaction level of current market offer of products. All three parts cover both solar thermal and photovoltaics, whilst the first part also discusses the utilisation of passive energy design and daylighting.

Method

The web-based survey was conducted internationally, in 14 participating countries. The questions and layout of the survey were developed during the IEA Task 41 meetings with the collaboration of international experts that include researchers, academics and professional architects. The focus group of this survey consisted mainly of architects and other building practitioners. The survey was launched on the Internet in each country by their national coordinator of IEA Task 41. This involved an indirect way through national architectural organizations, their websites, announcements in magazines and newsletters, or in a direct way by sending e-mails to a list of architects that had been collected from national databases.

Results

Although it is impossible to know how many professionals were actually reached due to the indirect way (announcements on websites and in news latter), the number of completed surveys can be considered satisfactory: a total of 613 surveys were returned, out of which 394 responded all major 6 questions, which is the highest number of responses among similar surveys that have been done in the past as demonstrated in the literature review.

The use of solar energy in current architectural practice – question 1, 2 and 3
The results showed that despite an overwhelming interest in solar technologies and active solar design solutions, with 80% ranking it as important, only very few are applying it in their current architectural practice on a regular basis: from 7% for PVs, 18% for solar thermal (ST) for domestic hot water (DHW), 5% ST for space heating and 2% for space cooling. Passive and daylighting strategies are more commonly used (69% for passive and 79% for daylighting) than active systems.

Regarding the integration level, the results showed that building integration is becoming of increasing interest, especially in Europe, where building integrated and building added systems were given similar importance.

Barriers and needs of using active solar systems in architecture – question 4 and 5
The results of the survey showed that economic issues are the main driving forces equally for solar thermal and photovoltaics: PVs -73%, ST-31% in barriers, PVs-74%, ST-58% in strategies to overcome barriers. Regarding barriers, knowledge of the participants and available information on solar systems were found to have similar importance, while in the case of strategies, economic issues were found to have a much higher impact than other issues, which was expected.

As the survey was conducted in 14 countries around the world (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Norway, Portugal, Spain, South Korea, Sweden, Switzerland), it provides scope to identify possible regional differences in the understanding and acceptance of active solar technologies. Although in some countries, the number of received responses was lower than hoped, still, certain coherence can be observed. Firstly, places where governmental subsidies or feed-in-tariff systems are well established or where the economy is strong, barriers related to knowledge and information become top issues (like Australia compared to Europe in general). Secondly, in certain countries that have either a longer tradition in using solar systems (such as Germany) or a boom due to governmental incentives (like France), product availability becomes more important as a strategy.

The survey results also provide valuable information as a comparative study of the two solar technologies when looking only at issues related to architectural integration potential. The detailed responses on barriers highlighted that for solar thermal, product availability is one of the main issues, preceded only by the lack of interest and knowledge of the client, while this barrier is only at 9th place for PVs. This indicates the need for more development in ST systems to improve their architectural integration potential.

Satisfaction with actual product offers – question 6
Question 6 asked about the level of satisfaction of actual product prices. In summary, the overall results of this survey regarding the current offer of products that are suitable for successful architectural integration reflects the findings from the literature review: that, although considerable advancements have been made in the design, look and efficiency of active solar components, there is still quite a lot of room for improvements, as architects are still finding it difficult to find products on the current market that are visually inspiring and appropriate for integration.

Contribution of IEA SHC Task 41 in removing barriers

The IEA Task 41 focuses on the architects' point of view on factors that create barriers to the use of solar energy in architecture. These have been identified as being: low product availability, low architectural knowledge and lack of simple tools for the early design stage. The survey showed that these factors are important issues and that there is a need for better knowledge dissemination and development in these fields.

The Task is contributing to the removal of these barriers through:
- workshops that are organised both at a national and international level;
- collection of high quality architectural examples and datasheets of products;
- documentation for architects and product developers for both technologies; and
- development of guideline and element libraries for design tools.

The aim of the group of experts in IEA SHC Task 41 is to help remove barriers identified and described in the survey.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Introduction to IEA Task 41: Solar Energy and Architecture

Despite the fact that several parts of the building skin are suitable for the integration of active solar systems, the great potential of utilizing solar energy in architecture in such a way is still untapped. There are several reasons for this situation, spanning from economical, technological and architectural issues. The International Energy Agency (IEA) under the Solar Heating and Cooling (SHC) programme launched Task 41 titled "Solar Energy and Architecture" using researchers and practitioners to develop guidelines for architects and recommendations for manufacturers to help accelerate the widespread use of high quality integrated active solar architecture and efficient solar passive buildings (Wall, Windeleff, & Lien, 2008).

To achieve these goals, IEA SHC Task 41 is organised in three subtasks:

Subtask A: Architectural quality criteria; guidelines for architects and product developers by technology and application for new product development.

Subtask B: Guidelines for the development of methods and tools focusing on tools for EDP and tools for the evaluation of integration quality of various solar technologies.

Subtask C: Integration concepts and examples, and derived guidelines for architects.

1.1.2. Subtask A – Description and objectives

This Subtask focuses on architectural integration of active solar energy products and systems since these are the least developed products for building envelope integration. As stated in the Task 41 Annex plan (Ibid.), the objectives of this Subtask are:

- Help improve the architectural integration quality and flexibility of active solar products and systems (integrability);
- Bring together architects and product/system developers to understand each other's needs. Develop criteria for products and systems, aiming at integrating solar energy systems in high quality architecture. Give recommendations to the industry;
- Focus on products/systems that offer an important potential of increasing quality regarding architectural integration. Examples of products/systems are: solar thermal systems, PV systems and systems combining functions;
- Educate/inform architects on integration characteristics for various technologies and on state of the art of innovative products.

The Participants shall achieve this objective by:

- Identifying and differentiating between the technologies already mature or needing new developments;
- Identifying the need for product development;
- Industry workshops with architects and manufacturers presentations, as a basis for discussion. Through the workshops and interviews, identify barriers and define key factors for successful component and system integration;
- Collaborating with architects, engineers and product developers to specify key issues and develop criteria for products and systems;
- Studying and documenting good examples of products and systems.

1.2. Background/Literature review

Buildings in our urban ecosystems must carry out a similar function to trees in the woods. This way, a building would collect energy in its outer surface and be able to conveniently transform and accumulate it to be used for its own needs.

This intriguing comparison between built environment and natural ecosystems was made by Serra i Florensa & Leal Cueva (2003), the authors of the chapters that talks about architectural integration of PVs in the book *Practical Handbook of Photovoltaics - Fundamentals and Application.* Although the authors, in this particular case, refer exclusively to PVs, the analogy is clearly applicable to all active and passive solar strategies.

For many, active solar technologies are still being considered as just another mechanical system of the building, similar to HVAC or plumbing system – something that serves a purpose and needs to be as efficient as possible. However, as both solar thermal and PVs need to be entirely exposed to rays of sun in order to be efficient, they obviously should occupy some of the most prominent portions of the building: roofs and, even more importantly, façades. In addition to their traditional role as separators between comfortable, controlled indoors and often not so comfortable outdoors, and sometimes a structural and form giving element of the building, façades are acquiring another function: energy harvesting and electricity generation. As façades are being the front, the face, the expression of the building to the outside world, the consequences of these new functions greatly influence their appearance and make them completely exposed to aesthetics' judgement both by professionals and general population.

Needless to say, the responsibility of the designer is enormous. For a long time, active systems had been considered as components that should be hidden from view. These "camouflages" did not always work and often resulted in less than acceptable architectural expression (Serra i Florensa & Leal Cueva, 2003). In addition, too often in architecture, buildings and solar technologies are still seen as two separate components. For a successful application and wide use, it is of utmost importance that solar technologies stop being considered as something that is 'applied' as an afterthought, but rather as another component on the architect's palette (Clesle, 2010). Furthermore, as architect and researcher Anne Grete Hestnes argues, words such passive and active does not make sense any more as both are inseparable: newly designed buildings usually combine both aspects, i.e. *they are simply solar buildings* (Hestnes, 1999).

Buildings with active solar electricity production technologies (PVs) have been around since 1970s, and the simple solar water heaters have been installed on roofs in some parts of the world since early 20th century. However, the particular issue of *architectural integration* of active solar technologies is has been the topic of investigation for researchers since early 1990s, as Roecker et al. point out in 1995, and this brief literature survey demonstrates that it has been and still is very actual. Apart from the issues of technical and economical nature (i.e. efficiency and financial justification), according to the reviewed publications, the obstacles for broader and better integration of active solar technologies may be grouped in three main categories: issues related to actual components, to design process and to knowledge and education. It is interesting to note that although some studies focused exclusively to PVs and others on solar thermal (ST), the identified barriers appear identical for both groups of technologies.

<u>Suitability of active solar components on the current market for successful architectural integration</u> seems to be the most recurring matter raised in almost all reviewed reports, published from 1994-2011. In already mentioned paper by Roecker et al., (1995), authors warn that if the technology for architectural PV integration is not ready by the time PVs become widely

available due to diminished price and increased efficiency, the use of this resource may become restricted due to the lack of suitable space or due to opposition for aesthetic reasons (Ibid.). Although the authors focussed their study on PVs, the same analogy can easily be drawn to solar thermal (ST). Ten years later, another study done at the same institution, this time focussed on ST, concludes that it is difficult to achieve a successful integration with the assortment of products available on today's market (Munari Probst & Roecker, 2005).

In a more recent paper, the same authors re-introduced the aspect of architectural integration discussing that improved technical performance and reduced prices of active solar technologies (in this case, solar thermal) are not sufficient for increasing acceptance and wider use of these systems. The formal aspects, they argue, related to the technology need to be *carefully treated to make solar systems appealing to both users and building designers* (Munari Probst & Roecker, 2007). Their findings are based on a survey of architects, engineers and façade manufacturers equally representing main European climatic zones, whose purpose was to identify how architects and engineers perceive the integration quality of building integrated solar thermal (BIST). The most thorough up-to-date survey at the time (that we know of) with 170 responses plus additional detailed one-on-one interviews with selected architects helped developing integration guidelines whose main premise is that successful integration needs to be coherent with the global building design logic (Munari Probst & Roecker, 2007).

This survey was not the only occasion that architects were asked to voice their point of view on barriers to wider application of active solar technologies: in the IEA-PVPS Task VII Workshop held in Lausanne, Switzerland in 1999, Tjerk Reijenga of BEAR Architecten in a very short and concise section titled *What do architects need?* listed the set of needs in five different categories; issues related to architectural quality and criteria of integration are at the top of each category (Knight & Rudkin, 2000). A literature survey done for Task VII also revealed architects' concerns with the aesthetics of PV systems, from the way they are mounted (e.g. aluminium profiles in contrast with high-tech looking PV modules) to the limited assortment of colours and sizes that prevent successful integration (van Mierlo & Oudshoff, 1999).

Another survey of architects' needs was done in Austria in order to identify what the priorities are for architects and town planners regarding (ST) collectors and their better integration ability (Kovács, Weiss, Bergmann, Meir, & Rekstad, 2003), (Bergmann, 2002). Although they do not present the method that survey was conducted nor the number of respondents, the authors do report that overwhelmingly (85%) architects desire more freedom in design with the regard of the colour and shape of the ST absorbers (more colours, flexibility in sizes).

Mismatched potentials, i.e. between architectural design specifications and PV characteristics, between aesthetics of the PV system and aesthetics of the building and surroundings, are also identified in the study by Sozer & Elnimeiri (2003). In the analysis of the factors that influence design and visual appeal of PVs, such as size, shape, colour, texture, translucency, Serra i Florensa & Leal Cueva (2003) also identify a "point of view" as one of the important and often neglected aspect: the distance and angle from where (PVs) are seen from is a determinant factor for the visual impact they produce (Ibid.).

Successful integration as a design issue. The integration of solar energy systems cannot be seen separately from the building design (Krippner & Herzog, 2000). Furthermore, another study proposes the need for early involvement of architects and city planners at the stage of the city planning in order to achieve successful integration (van Mierlo & Oudshoff, 1999). Coming back to the scale of a building, according to Krippner & Herzog (2000) the problem may lay in different approaches: architects' point of view who design and construct buildings and the engineers' who develop components for construction. The missing link between engineers and architects as well as perception barriers, such as: limited knowledge of solar technologies (in this case BIPVs) by planners, developers and architects and perceived unattractiveness of BIPVs by some architects are also identified by Montoro et al. in two studies (2008a) and (2008b) in the SUNRISE project in the European Union. Both studies also stated as a limitation a lack of standardised sizes (for PVs) that would correspond with architectural design modularity.

In their annotated bibliography of non-technical barriers to solar energy use, Margolis & Zuboy (2006) quote Sozer & Elnimeiri (2003) who also looked at BIPVs. Among other issues, as main barriers they list the lack of integration with the typical building process: including lack of integration with common building materials, building design process, the organizational structure (i.e. lack of awareness by architects, engineers, contractors, facility managers and owners). Furthermore, they claim, the lack of common language between various building professionals creates a gap between solar technologies and architectural design process (Ibid.).

This last statement brings us to *Issues related to knowledge and education.* Expectations for architects to recognise the importance of active solar technologies and to encourage various possibilities to make them well integrated into architectural design was recognised almost twenty years ago (Kimura, 1994). Still, some architects even today fear that including decisions related to solar design at the building massing stage can significantly constrain the range of forms available to the designer (Otis, 2011). In her presentation titled *Is Solar Design a Straightjacket for Architecture?* at PLEA 2011 conference, Otis demonstrated that, in fact, the case can be quite the opposite and that this can broaden architectural expression and enrich the design.

Another study, by (van Mierlo & Oudshoff, 1999) revealed other barriers, such as acceptance by occupants and / or clients (in case they are not the same) on the merits of aesthetic. It is expected, however, that this barrier can diminish over time, as active solar technologies become more present in our surroundings and as awareness of their benefits is raised among general public.

In summary, the literature reviewed spanning from 1994-2011 revealed that although significant improvements have been made regarding increasing efficiency and reducing cost of active solar technologies, one of the main barriers for wider implementation still remains in the sector of architectural integrability and formal expression of these components. Interestingly, as many architects worldwide stated this as an obstacle, there has not been that much work done on systematically categorising and analysing what would be included in the list appropriate criteria for successful integration until doctoral dissertation by Munari Probst (2008). Here, the author attempts quite successfully to define formal criteria related to architectural expression and apply developed methodology on several models. This work, developed further, has also been recently published as a book that can provide a valuable help to both architects and component manufacturers in improving their design (Munari Probst & Roecker, 2011).

2. ARCHITECTS' VIEW ON BARRIERS AND STRATEGIES FOR SUCCESSFUL INTEGRATION OF SOLAR TECHNOLOGIES - INTERNATIONAL SURVEY

2.1. The content of the survey

Recently, an international survey of architects was carried out within IEA SHC Task 41, Subtasks A and B in order to find out what are the barriers that prevent architects implement solar strategies in their design, with regards to architectural integration of solar technologies, and methods and tools available for solar design. This report only focuses on the results of Subtask A: Identifying the barriers of using active solar systems and the needs of architects for a wider use of solar systems in their architectural practice.

The survey covered the following topics:

- perception of importance of using solar energy systems in architecture;
- utilization of active solar systems in current architectural practice;
- integration of active solar systems in current architectural practice;
- identifying barriers against using solar thermal and photovoltaics;
- identifying strategies needed to encourage the use of solar thermal and photovoltaics; and
- level of satisfaction with available products in the market regarding architectural integration potential.

2.2. The survey method

The web-based survey was conducted internationally, in 14 participating countries (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, South Korea, Norway, Portugal, Spain, Sweden and Switzerland) and was translated into 10 languages. The questions and layout of the survey were developed during the IEA Task 41 meetings with the collaboration of international experts that involved researchers, educators, academics and professional architects. For each country a list of architects was collected. The survey was launched on the internet by national experts of IEA Task 41, twice: first in June 2010 with 13 countries participating, and then re-launched in October 2010, when Australia also joined the Task 41. Finally, there were 613 respondents (380 from Europe, 146 from Australia, 31 from Canada and 56 from South Korea). Of those who started to fill out the survey, 394 responded to all six questions (229 from Europe, 106 from Australia, 21 from Canada and 38 from South Korea). Although the number of responses received was lower than hoped, it is, to the authors' knowledge, still the largest response to similar surveys at this time: the literature review demonstrated that the largest previous number of responses to similar surveys was 170.

A detailed description of the survey method including the distribution of survey per country and estimated response rates are reproduced from the report by Horvat et al. (2011) and provided in the Appendix 1 of this document.

2.3 Results

In order to keep the main body of this report of efficient length, only figures that represent main clusters of results are shown. All additional figures, such as country by country results, additional comments, etc. are placed in the Appendix 2 of this document. Links as well as page numbers of those figures are always given for easier navigation through the document.

2.3.1. Question 1 – Importance of solar energy in architecture

The first question of the survey was aimed at mapping the interest level of the respondents: how important they considered the use of solar energy in their current architectural practice. Professionals were asked to choose among the following options: *important / neutral /*

unimportant / I don't know. There were 605 responses were received for this question. This provided data for analysis on an international and national level.

In general, most respondents found the use of solar energy in architecture important (80%, see Figure 1), some neutral (14%) and very few unimportant (6%). Such high numbers may be a result of a bias, i.e. most architects who filled out the survey could have been those interested in the topic in the first place. This ratio was similar in most countries, however, with some exceptions. Respondents from Northern-European countries like Norway and Sweden found the use of solar energy in architecture less important, especially in Norway, where only 45% voted for important, 26% for neutral and 29% unimportant (Figure 13, page 43). In Sweden this ratio was 61%, 25% and 14%, respectfully, as shown on the same figure. Climatic circumstances and availability of other forms of renewable energy (such as hydropower in Norway) may influence the interest in solar energy. Lack of knowledge of technological possibilities and product options hinders the use of the full solar energy potential in architecture that exists even in Nordic countries.

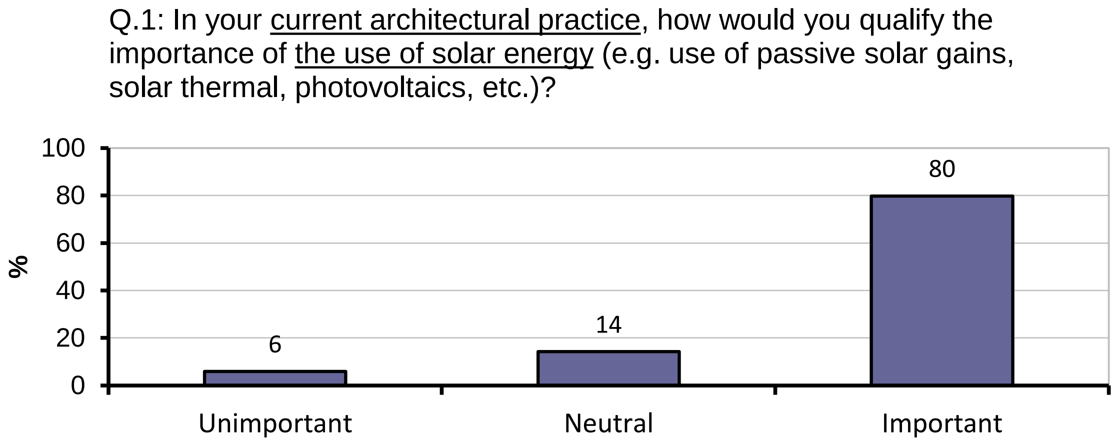

Figure 1 : Importance of the use of solar energy in architecture, all countries, n=605

2.3.2. Question 2 – Utilization of solar energy in architecture

The different possibilities for utilizing solar energy were presented in the second question. These were:

- photovoltaic technologies for electricity;
- solar thermal technologies for domestic hot water;
- solar thermal technologies for heating;
- solar thermal technologies for cooling;
- passive use of solar gain for heating; and
- daylight utilization strategies.

The respondents were asked how often their projects included these strategies, by selecting from five categories (always / often / sometimes / rarely / never) for each utilization. The overall responses, 547 in total, were received and the results were converted into percentages of respondents (Figure 2). The detailed responses for each country are presented in Appendix 2, pages 43 to 48.

In general, it can be observed that solar thermal technologies are used slightly more often than PVs, especially solar thermal for domestic hot water (18% of respondents use this technology “always” in their designs and another 29% use it “very often”). Most of the respondents “rarely” or “never” use solar thermal for cooling, which is understandable, since the first experiences with this technology are quite recent and respondents predominantly came from colder and moderate climates, and from firms that were mostly active nationally, as it will be seen later in the report. Passive solar and daylighting strategies were utilised in much higher percentages, as expected (Figure 2).

On national levels, however, there are some different tendencies. In countries that have a longer tradition in using solar technologies, like Germany and Switzerland, all active systems are more commonly used and responses are more uniform (Figure 20, p. 45 and Figure 27, p. 48). On the other hand, in countries such as Portugal, Spain and Australia, we can see the trend that one technology is much more used than the rest, at least by those professionals who responded to the survey. For example, 46% of Australian respondents selected using ST for domestic hot water “often” and additional 18% selected “always” (Figure 14, p.43); in Portugal, 42% of those who responded are using it “often” and additional 47% are using it “always” (Figure 23, p.46); in Spain, however, 76% selected “always” for utilising ST for hot water (Figure 25, p.47). Although the last values sounds very encouraging, however, they have to be observed in the context: the recent changes in Spanish Building Code made the use of DHW systems mandatory in all new buildings, as confirmed by IEA SHC Programme Ex-Co member from Spain, Mr. Ricardo Enriquez Miranda.

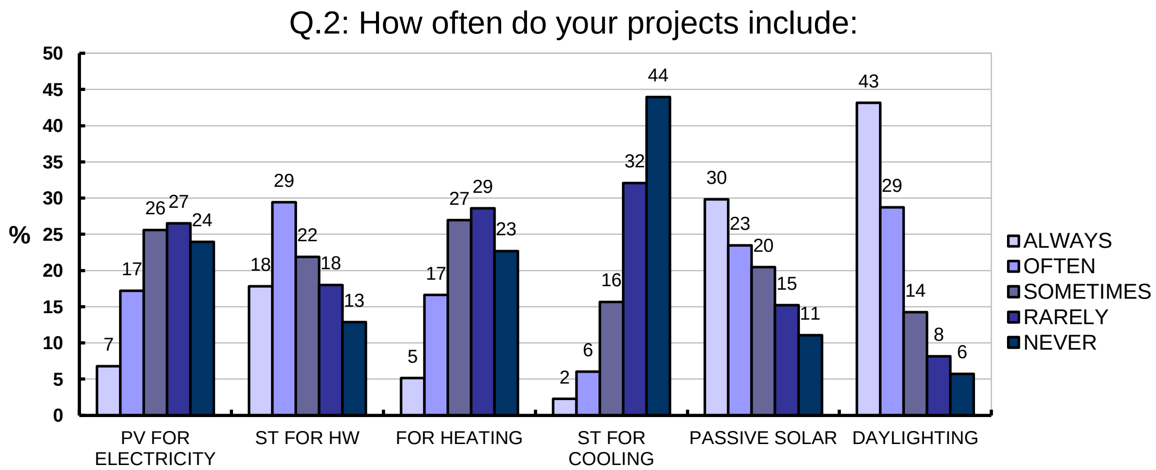

Figure 2: Utilization of solar energy in architecture – detailed results, n=547

Canada, Norway and Sweden showed a similar low use of active systems. In Norway, 70% of responders never use PVs in their projects. For solar thermal (ST) systems, the responses are as follows: for domestic hot water (DHW) 37% of respondents use it “never”, additional 33% “rarely”, but 22% use it “sometimes”. Similar trend is for ST for space heating (Figure 22, p.46). In Sweden, “never”, “rarely” and “sometimes” choices are more uniform for the use of PVs, ST for hot water and ST for heating (around 30% for each category). Surprisingly, the employment of passive and daylighting strategies is lower in Sweden than in other countries (Figure 26, p. 47). Canada’s results are similar to Sweden’s, with slightly higher use of passive and daylighting strategies (Figure 17, p. 44). The reasons for such responses may lay in inexpensive electricity and natural gas in Canada and, possibly, a general belief that Sweden and Norway may not receive enough solar energy for efficient use.

2.3.3. Question 3 – Architectural integration level

The third question was mapping how the solar technology/design was applied in architecture, with a special focus on the architectural integration level of active solar systems. Six main categories were defined with two other options to choose from:

- BIPV: Building Integrated Photovoltaic system architecturally/building integrated in the overall design concept, i.e. PV replaces other building component(s);
- BAPV: Building Added Photovoltaic system (simply mounted on the building);
- BIST: Building Integrated Solar Thermal system, architecturally/building integrated in the overall design concept, i.e. solar thermal components replace other building component(s);
- BAST: Building Added Solar Thermal systems (simply mounted on the building)
- Passive solar gains utilization;
- Daylight utilization (replacement of electric lights by natural daylighting);
- No experience/ not applicable; and
- Other (please specify)

The respondents were asked to select all the technologies/design concepts that they applied in their architectural practice. The data was collected and percentages were calculated on international and national levels, according to the number of respondents.

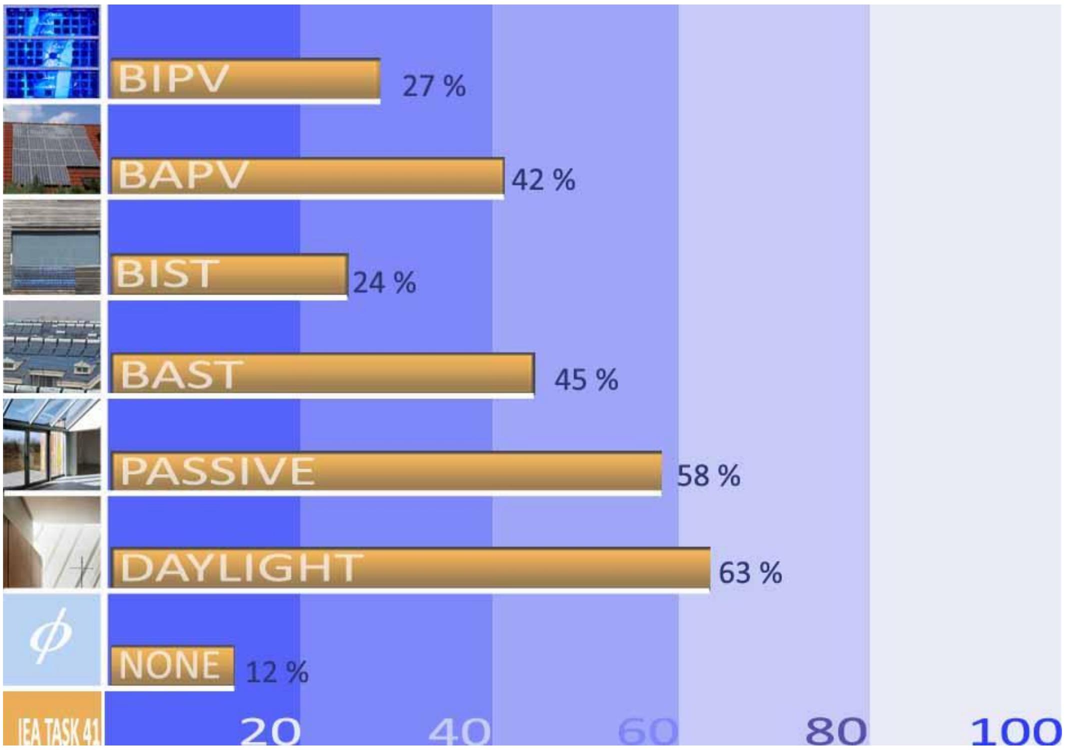

Figure 3: Integration of solar energy strategies in architecture - overall results, n =498

As expected, the overall results show that daylighting (63%) and passive (58%) strategies were more commonly applied than active systems with or without building integration (see Figure 3). Building Added Solar Thermal (BAST) and Building Added Photovoltaics (BAPV) received similar scores: BAST-45%-BAPV-42%. Building Integrated Solar Thermal (BIST) and Building Integrated Photovoltaics systems (BIPV) also were similarly ranked, but with a significantly lower score compared to building added systems (BIST-24%-BIPV-27%).

On the national level, tendencies similar to the ones in previous questions can be observed, with Norwegian architects having very low experience with active solar systems and Swedish doing slightly better (Figure 28, p. 49).

Regarding photovoltaics, Germany, Denmark and Italy presented similar results in building integrated and building added systems (Germany: BIPV-40%,BAPV-40%, Denmark: BIPV-50%,BAPV-50%, Italy: BIPV-51%,BAPV-53%), while in Switzerland the score for BIPV systems was even higher than for BAPV (BIPV-43%,BAPV-35%). The difference between integration levels (added or integrated) was much larger when considering solar thermal systems, with an average 20-30% higher score for building added systems.

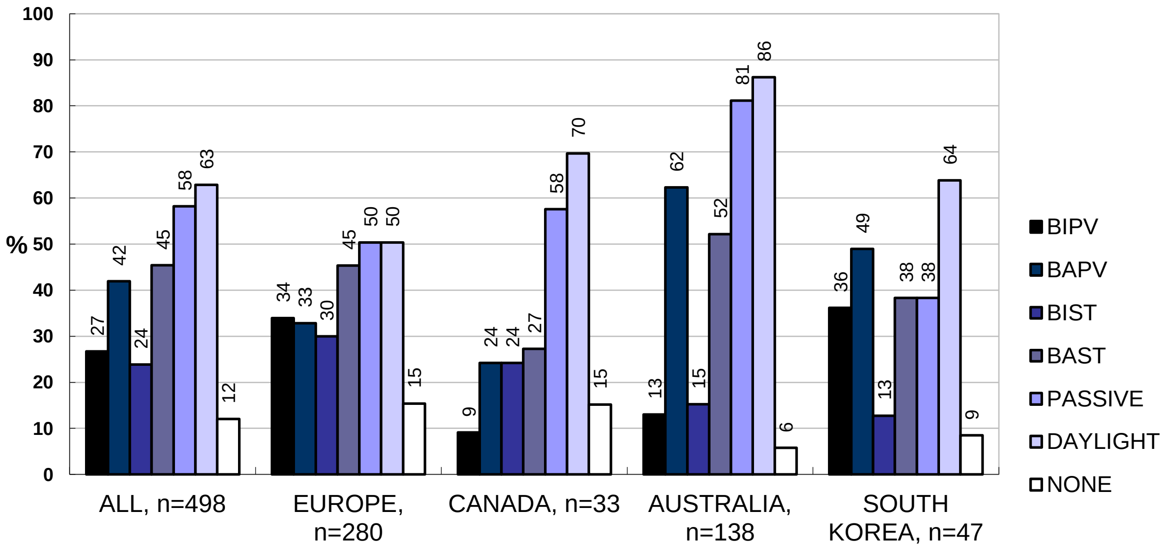

Figure 4: Integration of solar energy strategies in architecture – Comparison between different regions

Another interesting comparison is by region: between the overall results from European countries that participated in the survey (280 respondents), Canada (n=33), Australia (138 respondents) and South Korea (n=47). In Europe building integration BIPV scored the same value as BAPV (34%-33%) (see Figure 4); in South Korea, though, there is a higher percentage of utilization of building added PV components. In Australia BIPV (13%) is almost non-existent compared with BAPV (62%). BIPVs are even less used in Canada (9%). Furthermore, European passive and daylight utilization represent an average of 50%, while this goes up to 81% and 86% for Australia and 58% and 70% respectively for Canada. The global result (Figure 3) is a balance of these two quite different situations. It shows that even if the interest to use active solar energy is high in Australia, building integration is not yet as much in focus as in Europe. In all regions, with the exception of Europe, building integrated solar thermal strategies are used in much lesser numbers than the rest of the offered strategies. The reason for that will be explained in the next section of this report.

2.3.4. Questions 4 and 5 – Identifying barriers and strategies for using active solar systems in architecture

The results from the first three questions provide an overview of current practices, while the following two questions investigate the reasons behind this:

- what are the barriers to using solar energy in architecture, and
- what are the needs of architects.

As in the previous section of this document, the main body of the report contains only figures with overall results, while detailed, country by country responses are in the Appendix 2, pages 50 to 68 of this report.

The international expert group of IEA Task 41 identified 18 barriers and 7 strategies for solar systems' utilization in architecture based on their professional experiences. These were presented in the survey in question 4 (barriers) and question 5 (strategies). There were 439 respondents who answered these questions (approximately 73% of those who started the survey). The respondents were asked to select for three issues they considered the most important. However, the count of selection revealed that on average six issues were chosen. This emphasizes the fact that many respondents could not limit their answers to only three, since they deem more issues of significant importance, especially in identifying barriers.

BARRIERS - PV	STRATEGIES- PV
Not economically justifiable 73%	Lower product prices 74%
Lack of knowledge by client/developer 54%	Government incentives 58%
Lack of interest by client 50%	Availability of products 49%

BARRIERS - ST	STRATEGIES- ST
Lack of knowledge by client/developer 45%	Lower product prices 58%
Lack of interest by client 42%	Government incentives 48%
Lack of suitable products 36%	Availability of products 47%

Figure 5: Top 3 barriers and strategies for widespread integration of PV and ST in architecture

The offered options were structured into six main categories: interest, economy, knowledge, information, products and process. In the next section, the attempt is to look at the results category by category, with closer look at particular issues that had emerged from the results. In addition, the detailed response count was done issue by issue, and country by country in order to try to find if there are significant differences between countries, both for PV and ST. Those results are presented in the Appendix 2 on the pages 50 to 68 of this document.

2.3.4.1. Interest

Barrier: Lack of interest in solar design by architects and clients/developers
Solar modules are mostly considered to be technical devices, rather than building components. Therefore architects often have a resistance to use them in their design. This issue is mainly related to the lack of knowledge about the technology and available products, which is also

identified in literature review in the report by Montoro et al. (2008a). Clients are even less familiar with these technologies, have less knowledge and motivation and consequently have less interest in implementing new technologies. However, issues such as environmental awareness and long-term economic benefit can raise interest amongst clients.

Strategies

The strategies for raising the interest of clients/developers and architects are mainly related to knowledge distribution and economical affordability, discussed later in this document.

Results of the survey

The results of the survey showed that the lack of interest by clients/developers was one of the top issues defined as barriers in using solar energy in architecture: 50% for PV, 42% for ST (Figure 6). In the same figure, we can observe that the lack of self-interest among architects was one of the least pronounced barriers: 13% for PV, 9% for ST; therefore, it is not the architect who is not interested in implementing solar design, but rather the client, who, in the end, is financing the whole project. Similar notion was also expressed in the additional comments section by some respondents. However, it should be emphasized that it is likely that architects who took the time to respond to survey are already more interested in solar design in comparison to the general population of architectural professionals, which can make these results somewhat biased.

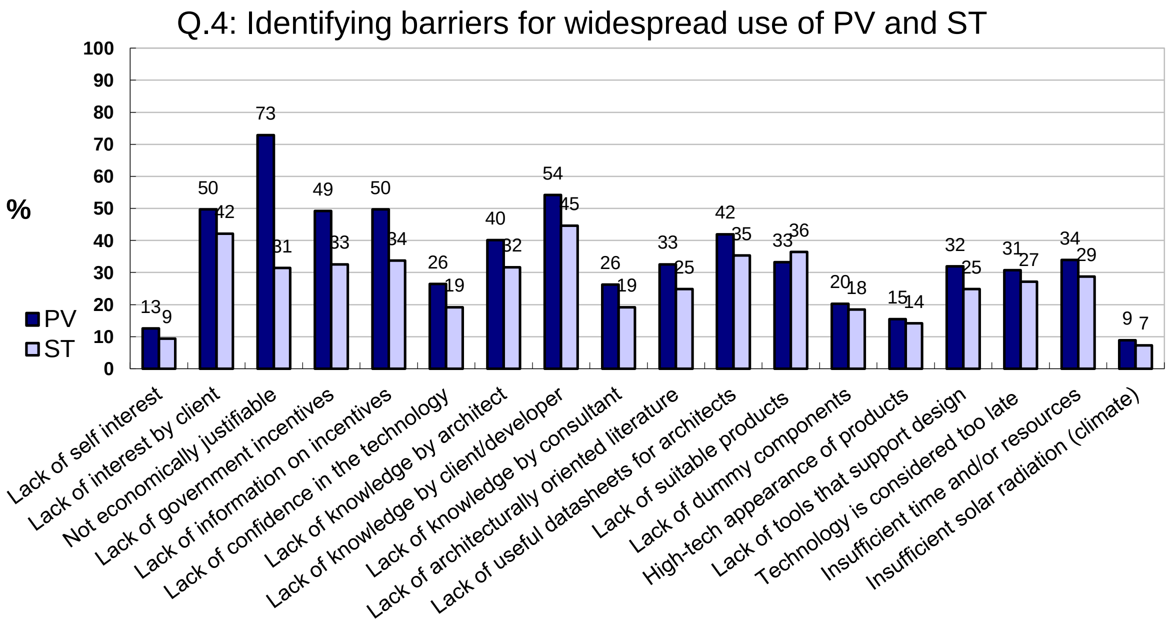

Figure 6: Barriers for widespread integration of PV and ST in architecture – all countries, n=439 respondents, 2765 selections for PV, 2111 selections for ST

3.3.4.2. Economy

Barriers: Not economically justifiable and lack of governmental incentives

Clients are mainly interested in investment costs. However, in the case of solar systems one should consider the costs (and incomes) also during operation, since solar modules produce energy and the initial investment costs of the material will eventually be paid back (Montoro &

et.al., 2008b). Moreover, solar components can replace other building components by their integration into the building envelope, consequently fulfilling multiple functions and making relative costs lower. Due to the higher investment costs, governmental incentives can be an important support. The two main forms of contribution are subsidies for the initial investment and feed-in-tariff mechanisms, where the electricity is bought at a mandated rate by the electricity distributor.

Strategies: Lower product prices and governmental incentives
Lower product prices are important in reducing initial investment costs. The case is much better for solar thermal systems, where the product prices are already lower than for PV due to a more mature and simpler technology. Governmental incentives can significantly reduce the barrier of investment costs. A well-defined feed-in-tariff system can also play a role in enhancing building integration of solar energy systems (Figure 7).

Results of the survey
Economic issues were found to be the most important barrier for PV in most countries, especially due to the high product prices (not economically justifiable - 73%, Figure 6). Answers to lower product prices as a strategy were similar to the answers on barriers (74%), Figure 7. The exception was Norway (not economically justifiable - 63% for PVs and 32% for STs), where the lack of interest by client (84% for PV and 79% for ST) and lack of knowledge of clients (74% for PV and ST each) together with lack of governmental incentives (74%) were the highest barriers (see Figure 37, p.54).

The case of product prices is different for solar thermal collectors on the barriers' side (not economically justifiable – 31% for ST, while 73% for PV) .However, on the strategies' side there was no such significant difference between lowering product prices category for ST and PV: 58% for ST, 74% for PV, Figure 7. This supports the findings from a literature survey on non-technical barriers to solar energy use which indicate that economic issues are the main barriers to uptake in society today (Margolis & Zuboy, 2006).

2.3.4.3. Knowledge

Barriers: Lack of sufficient technical knowledge by architect, by client/developer and by consultants
Solar energy systems, like other building components, require specific knowledge. Clients, architects and consultants are three different target groups, with different professional languages and with different roles in the process. Consequently, they require different kinds of knowledge.

Anecdotal evidence show that studies of solar design have predominantly not been included in the general architectural education in the last 25 years or so. Practicing architects usually require additional learning about these issues if they want / need to venture into solar design. There is also a resistance as solar systems are not considered building / architectural components, but technical devices. In order to understand the benefits of their investment, clients and developers should also have some awareness of solar energy systems. Without basic information, there is no proper confidence in these solutions, and this in turn leads to low interest. Even if the architects and clients are interested in and have sufficient knowledge of their own, they still need consultants with advanced knowledge of solar systems for their projects to be realized.

Strategies: More knowledge of the technologies by introducing specific courses about these technologies during the university studies

Education is the foundation of our future practice. Lately, more and more universities have realized the importance of introducing environmental issues in architecture and launched specific courses on solar energy in architecture. Already, many workshops and special courses are organized for practitioners as well.

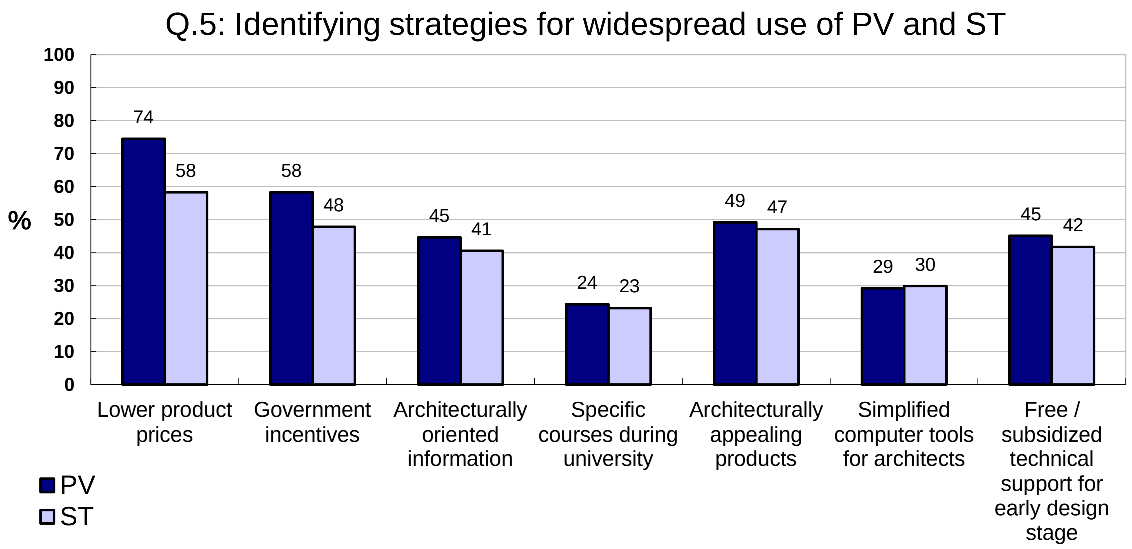

Figure 7: Strategies for widespread integration of PVs ad ST in architecture – all countries, n=439 respondents, 1428 selections for PV, 1267 selections for ST

Results of the survey

The lack of knowledge by clients/developers was found to be the most important barrier for ST (45%) followed by the lack of interest of clients (42%), and the second important barrier for PV (54%), behind the economic barrier (Figure 6). While in certain countries this issue was considered less important, the lack of interest of the clients (which is a step ahead of the knowledge of the clients) was found to be the major barrier. The lack of knowledge of architects was generally considered as an important barrier (40% for PV, 32% for ST), behind the economics and issues related to clients.

In some countries, such as Germany (Figure 35, p.53), Italy (Figure 36, p.53) and Switzerland (Figure 42, p.56), the architects' and clients' lack of knowledge are found to be the second important barriers for PV, after economic issues, while for solar thermal this was the major concern and economic factors were less critical.

Worldwide, the lack of knowledge of consultants was found to be one of the least pronounced barriers (26% for PV, 19% for ST, see Figure 6, p.22).

2.3.4.4. Information

Barriers: Lack of architecturally oriented literature covering these technologies and useful and understandable data for architects in the standard product datasheets (e.g. mechanical strength, actual performance)
Even if university education or seminars provide some basic knowledge for architects, it would be useful to have a handbook on solar systems. This should focus on architectural issues preferably in native language to make it easy to understand and use for architects of different nationalities.

There is a large selection of products on the market today. However, the datasheets of these products focus mainly on engineering data, which is not very useful for architects. Architects need mainly information on energy output/m^2, price/ m^2, structural integration potential and flexibility of formal characteristics (such as size, colour, texture, jointing).

Strategies: Availability of architecturally orientated information (handbooks/websites, seminars, etc)
There are a number of sources that can provide useful information to architects. These are, for instance, accessible internet databases and handbooks, special workshops and seminars organized nationally and internationally, specially designed for architects. It is the responsibility of the "solar energy community" to spread this knowledge through, for example, international dissemination networks such as the IEA SHC Task 41.

Results of the survey
In general, the issues above were of medium importance regarding barriers. However, in Australia (PV - 57%, ST - 42%, Figure 29, p.50), in Germany (PV - 35% and ST - 40%, Figure 35, p. 53) and in Switzerland (PV - 41%, ST - 35%, Figure 42, p. 56) the lack of useful datasheets was found to be one of the most important barriers. Germany has a longer tradition in using solar energy systems in architecture, but the focus has mainly been on energy issues. Architects, however, require different type of information, as listed above.

The need for a special publication was also expressed by one respondent, in the additional comments section, where a case study book would not only be a learning tool for architects, but informative resource for clients as well and possible communication tool in convincing client of the benefits of solar design. Here, we present the respond word for word: *Brochure with good examples, similar to „Holzbulletin" by Lignum. Important: Include beautiful photos and architectural thoughts, so the brochure will be read and maybe also kept in the architectural offices.*

2.3.4.5. Products

Barriers: Lack of products suitable for quality building integration and complementary building components
In the case of thermal collectors, the current market provides a limited variety of products suitable for architectural integration, while in the case of photovoltaics a variety of products has been developed for building integration. Still, in most cases aesthetical issues are not the focus of product development.

Certain building areas are not suitable for thermal heat or electricity generation (shading, unsuitable orientation, etc.) or cannot be covered with the solar products used in the building (due to different shape or size limitations), even though the architectural concept would require the use of the same material. There is a need for complementary building components such as dummy elements. These are fake solar components, which do not produce energy, but which have the same visual appearance (colour, texture, and pattern) as the solar products. This creates a homogenous outcome that fits more appropriately with the grid of the building form.

Strategies: Availability of architecturally appealing products designed for building integration
Architects require flexibility in formal characteristics (size, shape, colour, etc.) when choosing a product for their projects. Product developers should consider the needs of architects for architectural integration in order to provide products with a higher level of flexibility in design outcomes.

Results of the survey
The survey results showed that the main difference in perception of barriers of solar thermal and photovoltaics was product availability. For solar thermal collectors, the lack of suitable products for architectural integration was considered the third most important barrier (36%), after the lack of knowledge by client and the lack of interest by client, while for photovoltaics it ranked only as the ninth (33%), Figure 6, p. 22. The case is better for photovoltaics, where more products have been developed for building integration. In case of solar thermal, the possibilities are more limited. Despite this difference in barriers, the availability of appealing products was found to be the third most important strategy for both technologies - after the two economic issues (49% PV, 47% ST), Figure 7, page 24. This shows that even if the variety of PV products for building integration is higher, there is still a need for development of appealing products for successful aesthetical integration; this has been also confirmed in various studies mentioned in the literature review (van Mierlo & Oudshoff, 1999), (Kovácz et al., 2003), (Munari Probst & Roecker, 2011).

2.3.4.6. Process

Barriers: Lack of tools that support design and dimensioning/sizing of the system
Architects are working with surfaces and appearance when designing the buildings with solar products. They therefore need simple tools that give energy output as a function of size and orientation.

Strategies: Availability of simplified computer tools for architects
There are many tools for solar design. Most of these, however, require too much detailed input and do not provide suitable information for architects. There is therefore a need for simple computer tools that are compatible with architectural tools already in use.

Barriers: Technology is considered too late in the design process and insufficient time and/or resources in design process
For most architects, integrating solar products into their design is not yet a part of everyday practice. Often these technologies are considered too late in the design process, when the architectural concept is already in a developed phase and the integration of the solar components becomes problematic due to the potentially unsuitable orientation and limitations in the flexibility of the available solar products.

Where a technology solution requires a period of upskilling that consumes a lot of time and resources, developers often prefer to skip its use. This often happens with active solar systems, mainly related to the lack of easily accessible tools and usable information about these products.

Strategies: Free/subsidized technical support from professional associations for the early design stage
The integration of solar systems in the early design stage is a crucial issue for a successful project. Free/subsidized technical support from professional associations would encourage the use of solar products in architecture.

Results of the survey
In case of PV, the insufficient time and/or resources to consider the technology is listed as a main barrier in this category (34%, Figure 6, p. 22), immediately followed by the lack of tools that support the design (32%) and that the technology is considered too late, when modification to design would incur additional costs and efforts. Very similar picture is in the case of barriers for solar thermal in this category: 29% for time and resources, 25% for lacking tools and 27% for late consideration of the technology. The issue of tools and design processes is investigated in more depth in the separate international survey, done under the Subtask B: Methods and tools for solar design, of the IEA SHC Task 41; the results of this investigation are published in the separate report titled *Report T.41.B.2: International survey about digital tools used by architects for solar design,* by Horvat et al. (2011).

2.3.4.7. Comparing results and strategies for the different countries

Although the response rates were lower than hoped for, in some countries lower than the others, which makes it difficult to draw extremely precise conclusions, certain coherences can still be observed. Firstly, places where governmental subsidies or feed-in-tariff systems are well established or where the economy is strong, barriers related to knowledge and information become top issues (Figure 29, p. 50 to Figure 42, p. 56). In the rest of the countries which participated in the survey, economy (cost of components and pay-back time) is still the dominant barrier which will be difficult to overcome without further reduction of the component prices or regulations / directives that would mandate use of active solar components in order to reduce energy consumption from non-renewable sources and CO_2 emission.

In terms of strategies, with the exception of South Korea (Figure 53, p. 67) in all countries, lower product prices are listed by far as the top strategy to overcome barriers for widespread use of solar strategies in buildings (Figure 43, p. 64 to Figure 56, p. 68). It is followed by availability / easier access to government incentives. Availability of architecturally appealing products is another very strong demand from professionals that list this as a strategy to overcome barriers, which is in many cases followed by the availability of architecturally oriented information.

2.3.4.8. Additional comments regarding barriers and strategies

Quite informative and revealing were also additional comments that were entered by some respondents in this open end sub-category available both in questions Q.4 – Barriers and Q.5 – Strategies. Additional barriers were raised regarding restrictions related to urban planning and its restrictiveness to solar favourable orientations (from Australia and Italy), building regulations in relation to building permits, insurance, liability to architect and other legal issues that are often costly and time-consuming for architects to deal with in addition to regular building approval process (from Germany, Italy, Spain).

However, the most mentioned additional barrier that was voiced from several countries (Australia, Austria, Portugal, Spain) was the issue related to installation of the solar technologies: from the lack of qualified installers and consequential component failures or underperformance that gives bad reputation to the whole technology, to the potential conflict of interest where, as one respondent states, *"… it is hard to find people who design the systems without being the ones installing it and benefitting from oversizing the system."*

In terms of strategies, several respondents from different countries suggested the need for the politically driven decisions, such as mandatory inclusion of renewable energy components in every new building (Italy), implementation of substantial CO_2 emission fee (sic.) that would prompt building owners to turn to renewable energy sources (Switzerland), increasing government subsidies, feed-in tariffs easing the access to them, i.e. reducing the number of additional documents and other steps that needs to be done to qualify for such subsidies (Australia, Italy). Another respondent from Switzerland calls on public authorities to stop *"chatting and arranging expensive seminars and courses – in demand are action and progressive decisions"*. Finally, as one respondent from Austria states: "*a broad social campaign to educate public that solar technologies do not have to pay-off: (implementing them) is a sign of a moral, an ethical decision, sign of self-determined society".*

Another interesting strategy raised by several respondents from Australia is a demand for locally produced components that can be, then, *"easily fixed, recycled, future-proofed (sic.) and climate resistant to sea, salt, sun, wind"*, in addition to boosting a local manufacturing industry.

All the additional comments from the survey are also presented in the Appendix 2, starting on page 57 for Barriers, and 68 for Strategies.

2.3.5. Question 6 – Qualification of actual products offer

Question 6 of the survey aimed to investigate respondent's satisfaction with the current offer of active solar technologies components in the market and their suitability for successful architectural integration. The respondents were asked to choose among following options, for both PVs and ST: very good, good, fair, poor and very poor. Figure 8 presents global response to this question.

Figure 8: Suitability of current actual PV and ST products for successful architectural integration, all countries, n=388

The results of the survey
In general, the results showed that there is a slightly higher satisfaction with current photovoltaic products than with solar thermal products (Figure 8). The graph shows that selections for “very poor” quality solar thermal products were higher (12%) than for PV (5%), with “poor” and “fair” being similar (“Poor”: PV-24%, ST-30%, “Fair”: PV-40%, ST-35%), while for “good” quality, PV products achieved higher (23%) ranking than ST (16%) and for “very good” it was again similar (PV-7%, ST-5%).

Then, the responses were analysed by region/ on national level: results showed similar data on average. PV products were in general judged as “good” or “fair”, while ST products were “fair” or close to “poor”. Combined votes from European countries which participated in this survey are quite comparable with the overall results, especially in the case of PV components. However, responses from Canada, Australia and South Korea are giving slightly different picture, Figure 9. While Canadian respondents either disliked or liked current PV product offer, the number of those who have neutral opinion is quite smaller than in other cases (only 20%). Canadian professionals also have the highest vote on “very good”: 15%, while all the others are between 5%-8%. This is slightly puzzling as Canada has only handful examples of built project where PV integration achieved architectural integration of high quality, as it will be presented as a part of IEA Task 41, Subtask C deliverables in (T.41.C.A.1: Collection of case studies, 2012). On contrary, majority of answers by Australian professionals (46%) deem the current product offer “fair”, while professionals from South Korea expressed much harsher judgement: 37 % of them characterised current offer as “poor”.

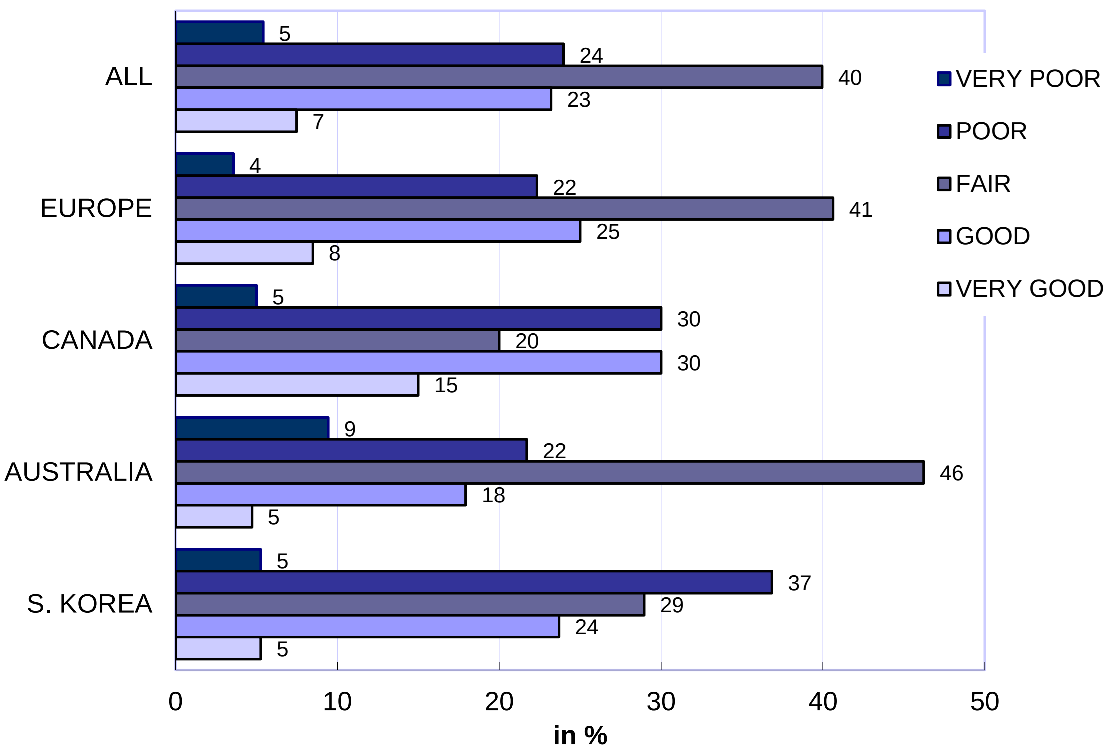

Figure 9: Suitability of actual PV product for quality architectural integration, by region, n=388

In case of solar thermal components, the percentage of “very poor” votes is more or less uniform across regions and much stronger than in case of PV components (Figure 10). Again, results from

Canada are slightly more lenient than the others, especially in "good" and "very good" categories[1]. Similarly as in the case of PVs, respondents from South Korea gave much less votes for "fair" than the others (24%) and 0 votes for "very good".

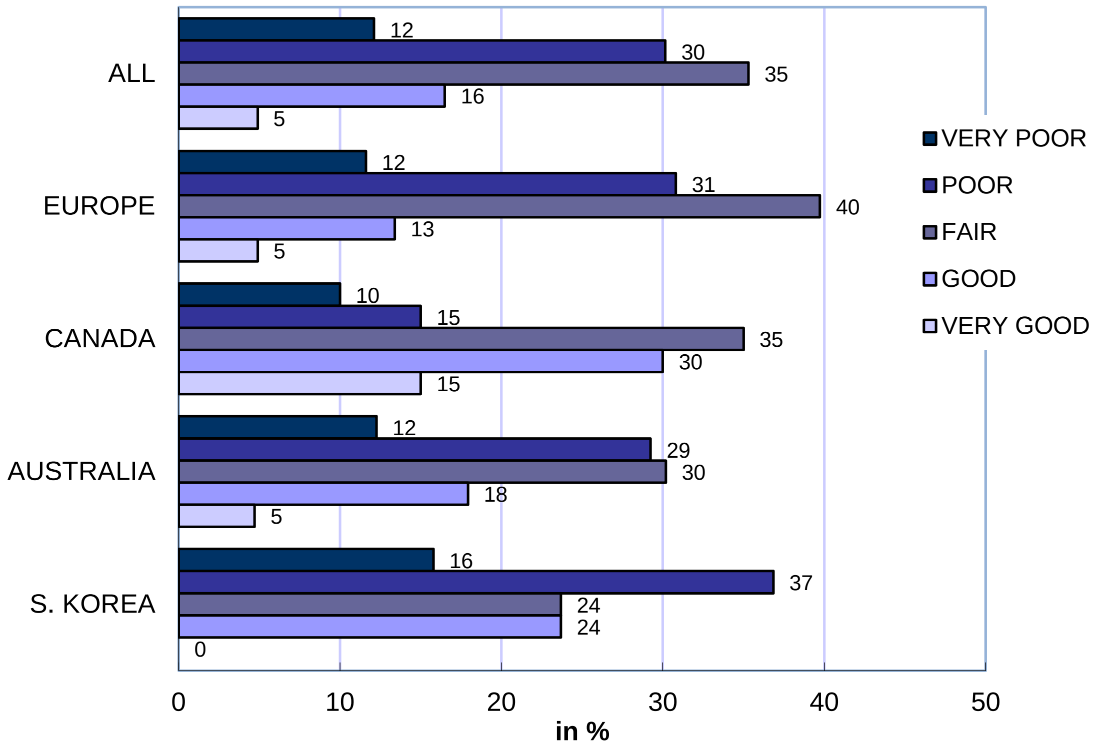

Figure 10: Suitability of actual ST products for quality architectural integration, by region, n=388

In summary, the overall results of this survey regarding the current offer of products that are suitable for successful architectural integration reflects the findings from the literature review presented earlier in this report: that, although considerable advancements have been made in the design, look and efficiency of active solar components, there is still quite a lot of room for improvements, as architects are still finding it difficult to find products on the current market that are visually inspiring and appropriate for integration.

2.3.5. Questions 7 to 11 – Factual information on design methods and processes

The next portion of the survey intended to acquire information that can influence design methods and processes that offices and firms are utilising when dealing with solar design, and to identify whether these processes differ from the traditional (conventional) design process that has been prevailing in contemporary architectural firms. Graphs with detailed results are presented in the Appendix 2, starting from page 72.

[1] If a speculation is allowed, this may possibly be due to the widespread reputation of SolarWall®, which is a Canadian product.

Analysis of this portion of the survey gave the insight to the cross-section of the professionals who answered this survey; from that, it can be estimated that, in general, the overall profile of respondents does correspond with the situation in contemporary architectural practices in the developed countries, as the next few paragraphs will show. This can provide an additional support to reliability of results achieved by this international survey.

Results show that there is more or less balanced mix of the size of companies that responders are coming from, with slight majority of those from small firms with less than 3 employees (Figure 11). Majority of the firms are involved in both renovation and newly designed projects (53%), with about one third working only on new projects (31%), and the rest dealing with renovations only. Residential projects are predominant with 29% of responses, while all the other types do not count with more than 15% of responses each (Figure 58, p. 72). The greatest majority of firms (72%) are active only nationally, the following 22% is active both nationally and internationally and the remaining 6% only internationally (Figure 60, p. 73).

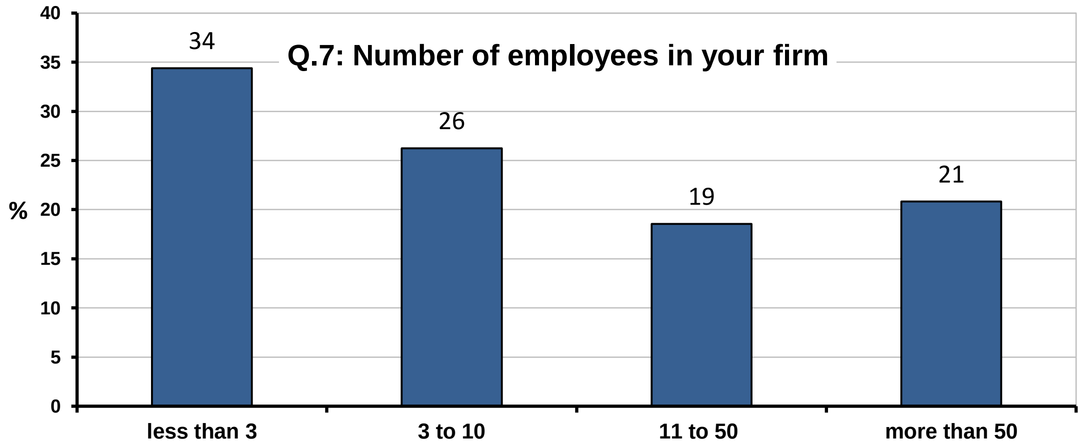

Figure 11: Size of the architectural firms which participated in the survey, all countries, n=422

In addition, the predominant number (71%) of the firms are traditional (conventional) practices with variety of projects, 15% are Design-build firms (DB), 9 % are Construction management firms (CM), and 4 % of the firms are various hybrids of these systems (Figure 59, p. 73). In terms of design processes, respondents were required to select options all that apply, which they did in almost all cases, so the distribution is again, more or less balanced, with the slight advantage for Integrated Design Process (IDP) (Figure 12) . However, in was interesting to observe that in cases where respondents made single choice of the design process, it was always the option for IDP. Out of 422 respondents who answered this question, 46 individual respondents choose solely IDP as their mode of work. This can be an encouraging trend, because, as low CO_2 emission buildings are getting more in demand, including various energy saving strategies, advanced mechanical systems as well as passive and active solar technologies from the very beginning, i.e. a conceptual design is becoming of utmost importance and IDP has so far proved to be the most appropriate for the task.

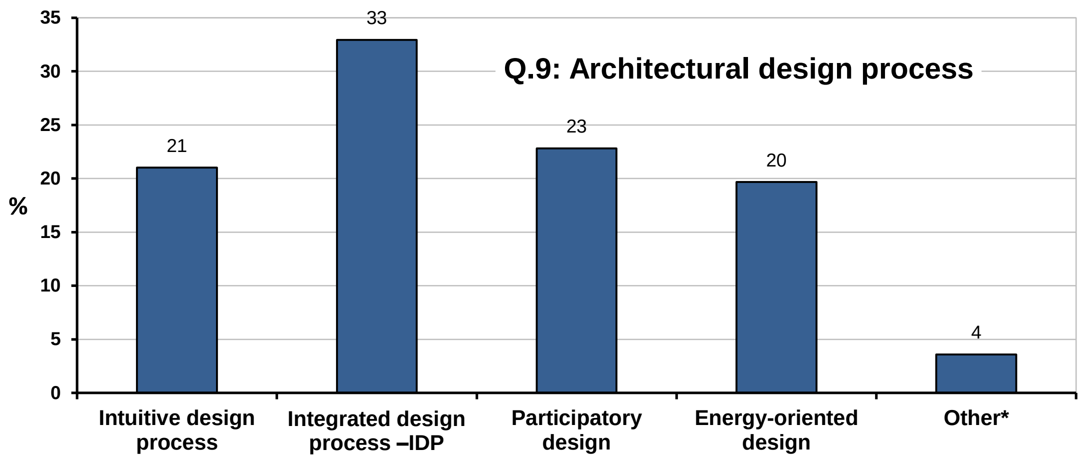

Figure 12: Type of architectural design process, all countries, multiple selections, n=890

2.3.6. Questions 12 to 15 – Demographics of respondents

The last portion of the survey was about demographic data of the respondents. Although it was an optional section, more than 94% of the professionals who responded to this survey chose to complete this part as well.

Results showed that almost two thirds of the respondents were professionals in the prime of their carriers: 29% were born 1971-80 and additional 28% were born 1961-70; they had more than 10 years of professional experience. Respondents were predominantly architects (78%), some were engineers (13%), and physicists (1%). The remaining 7% are of different, but related professions, such as architectural engineers, industrial engineers, mechanical engineers, builders, property developers, facility managers, etc. Seventy four per cent of respondents were male and 26% were female (Figure 61 to Figure 64, pages 73 to 74).

3. CONCLUSIONS

3.1. Use of solar energy in current architectural practice

The results of the first three questions regarding using solar energy in current architectural practice gave a clear picture: despite the great interest in these technologies/designs expressed in question 1, a great amount of the practical potential is not yet used.

Passive and daylighting strategies are more commonly used than active solar systems; however, the overall results from European countries that participated in the survey showed that even these aspects of solar designs are neglected in 50% of the cases.

Utilization of solar thermal systems for hot water is the most common one among active systems: 18% “always” and 29% “often” used them. This technology can be economically the most affordable and the most efficient in energy output in most occurrences. Photovoltaics for electricity and solar thermal for heating received a similar middle scores (PV: 7% “always”, 17% “often”; ST for heating: 5% “always’, 17% “often”). Economic reasons and availability of other energy resources for the same utilization somehow limits the potential of these technologies. Solar thermal technology for cooling is not yet completely developed for small systems, therefore current use in architectural practice is pretty rare, especially since most of the countries which participated in the survey are in colder climates and do not require significant cooling.

Building integration of active solar systems by making them an architectural component of the overall design has come very much into focus recently. The results confirmed this tendency, especially in Europe, where building integrated and building added systems received very similar scores. The aim of Task 41 is to encourage the use of building integrated active solar systems and improve the architectural quality of solar energy design outcomes.

3.2. Barriers and needs in using active solar systems in architecture

3.2.1. Comparing main categories of barriers and strategies

The results of the survey showed that both on the barrier and strategy sides and for both PV and ST, economic issues are the main influencing issues. However, regarding barriers, knowledge of the participants and available information on solar systems were found to have similar importance, while in the case of strategies, economic issues were found to have much higher impact than other issues. Obviously, there is a need to lower the product prices and to provide incentives as a first step to support the widespread use of solar systems in architecture.

Knowledge of the participants and available information is a precondition to gaining interest and commencing a project, while issues related to process and products are more practical matters. It is an interesting result that theoretical issues (knowledge and available information) were identified more important as barriers, while the practical matters were identified more important as strategies. Architecture is a practical profession that requires a wide range of theoretical knowledge. However, to inspire architects, practical matters, such as appealing products and technical support for design processes, should be more readily available.

3.2.2. Comparing results of detailed categories of solar thermal and photovoltaics

Even though the main categories showed no significant difference between PV and ST, the detailed responses on strategies highlighted that for solar thermal, product availability is a top barrier issue (36%), after the lack of interest (42%) and knowledge (45%) of the client, while availability of suitable products for PV is only the ninth barrier chosen by professionals. This is rooted in the difference between the two technologies. Photovoltaic applications have a higher degree of flexibility in formal characteristics (such as colour, shape and size, pattern, texture, possible translucency); moreover, their visibility has a representational role regarding environmental awareness. As soon as building integration came into focus, a wide range of products has been developed to suit architectural requirements. While in the case of thermal collectors, initial costs are lower, manufactures need incentives to adapt the technology to make it architecturally appealing. However, the third highest response rate for strategies was product availability both for PV (49%) and for ST (47%) - after the two economic strategies. This similarity indicates that there is still a need for producers of both technologies to understand and satisfy architectural integration requirements.

3.3. Satisfaction with actual product offerings

The results from question 6 are coherent with results from questions 4 and 5 about barriers and needs, where the lack of suitable products was found to be a major issue for ST, and from the strategy side for both PV and ST, availability of products was found to be the third main driving force countering the uptake of active solar systems in architecture.

Even if recently a variety of BIPV products have appeared on the market, there is still a need for product integration to suit the needs of architects from a high quality structural, formal and conceptual architectural perspective. The case is even more relevant for solar thermal products, where the market offer is poorer. Another barrier is the lack of knowledge about available products.

4. CONTRIBUTION OF THE IEA SHC TASK 41 TO REMOVE BARRIERS

The IEA Task 41 focuses on the architects' point of view on factors that cause limited use of solar energy in architecture. These are low product availability, low architectural knowledge and lack of simple tools for the early design stage. The survey showed that these factors are important issues and that there is a need for knowledge development and dissemination in this field.

Workshops have been organised at both national and international levels in the framework of the Task to share knowledge through key networks and to gather more detailed information on the needs of architects.

A collection of high quality architectural examples and datasheets of products will be presented on the web to provide updated information about possibilities and high quality products for building integration.

Moreover, a document for architects and documents for product developers for both technologies will be produced in order to provide knowledge for architects in a practical form and offer guidelines to producers on which directions their products should be developed to meet architects' needs.

Concerning developing methods and tools, a guideline will be provided and element libraries for design tools will also be made available.

The aim of the group of experts in IEA Task 41 is to help remove barriers described in the survey.

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APPENDIX 1

The survey method

The web-based survey was conducted internationally, including 14 countries (Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, South Korea, Norway, Portugal, Spain, Sweden and Switzerland) and was translated into 10 languages. The group of task experts from each country developed the content and layout of the survey during the IEA Task 41 meetings. For each country a contact list of selected architects was collected. The survey was launched on the internet by expert members of IEA Task 41. The data was collected by the Canadian Subtask B leaders and was analyzed by an international team, and form the contributors of this report. The survey was launched twice, first in June 2010 with 13 countries participating, then due to the low response rate, a second time in October 2010, when Australia also joined the group. Finally there were 613 respondents (380 from Europe, 146 from Australia, 31 from Canada and 56 from South Korea) who started to fill out the survey of whom 394 responded to all six questions (229 from Europe, 106 from Australia, 21 from Canada and 38 from South Korea).

Methods for reaching the focus group

The survey was launched together with a survey of IEA Task 41 Subtask B - Methods and Tools. The data collection of both surveys was coordinated by the Canadian Subtask B leaders. Their results are presented in an IEA report by Horvat et al. (2011), *International Survey About Digital Tools Used by Architects for Solar Design*, that can be found on this website: http://www.iea-shc.org/publications/task.aspx?Task=41 .

The following section of the different methods for reaching the focus group was written originally in the report mentioned above.

The focus group of this survey consisted mainly of architects and other building practitioners. In each country, one national coordinator involved in Task 41 was appointed for distributing the survey. Each coordinator used a different approach for reaching the focus group. Most national architectural associations have strict regulations regarding their members' contact details, and almost in all cases, they did not provide these details to the national coordinator responsible for the survey. In some countries, architectural associations were asked to put a link to the survey on their website. In other countries, the national coordinator placed announcements of the survey's launch in architectural magazines, or on websites of those architectural magazines and/or newsletters. One important difficulty about linking the survey on the internet was the fact that it makes it impossible to know how many professionals were reached and, therefore impossible to calculate response rates. Another way to reach the focus group was by building a special database of architects from the public telephone directories as well as from the lists provided by different organizations in the building industry. The next sections summarize the approach used to reach the focus group in each country.

Australia

In Australia, the survey was sent out via the Australian Institute of Architects (AIA) to their 9,000 members but it is impossible to be sure that the email sent reached all recipients. The national Australian coordinator was also able to encourage architects to complete the surveys during tours of the country to deliver an AIA national seminar series on integrating solar technologies.

Austria

In Austria, the involved institutes compiled a comprehensive distribution list from their contacts through regular cooperations with Austrian authorities, architecture and engineering offices, as well as manufacturers and installers concerned with solar technology. The survey was sent out via this distribution list addressing about 100 contacts, only counting direct addresses and no forwarding from the contacts which were done due to responses. Furthermore, the survey was sent out via newsletters and mailing lists, such as the expert platform KinG (Competence network for innovative building service engineering) that involves many architects and engineers, manufacturers, installers and real estate developers, and finally it was sent to specific members of the Austrian Architectural Association 'Arch+Ing'. As the 'Arch+Ing' holds an exclusive address list of all registered architects in Austria which is restricted to their own mailing, the survey had to be forwarded to members with the plea for distribution. It was not possible to maintain a full list of received contributions from the 'Arch+Ing', but due to some direct response it got well distributed within the Arch+Ing as well.

Belgium

In Belgium, the national Association of Architects has strict rules in place about providing their contact list information to others. Since it is very complicated to obtain required permission, the national coordinator of Belgium collected e-mail addresses of all the contacts from her own research team (Architecture et Climat, Université Catholique de Louvain). This database was updated with public information collected from the yellow pages and with personal contacts in architectural offices. The database included a total of 179 e-mail addresses.

Canada

In Canada, the national coordinator created a special database of architects from the Royal Architecture Institute of Canada – Institut royal d'architecture du Canada (RAIC – IRAC) and complemented by information from public telephone directories. This database was also supplemented with other lists provided by different organisations in the building industry as well as personal contacts in architectural offices. The Canadian database included a total of 1050 e-mail addresses. Surveys were distributed both in English and French.

Denmark

In Denmark, the survey was distributed through two channels: the national association of architects (Akademisk Arkitektforening) sent the survey through their two networks: 'Environmental Network' and 'Climate Network', to 230 members by direct e-mail. The survey was also distributed through the association Solar City Copenhagen by direct mail to members including 35 architects working with solar energy, and distribution to the architects in the Copenhagen Municipality.

France

France's participation in the Task 41 until September 2010 was informal. The national representative voluntarily participated in the development and distribution of the surveys. The links for both surveys were posted on the website of the Ordre des architectes and also distributed through Order's online newsletter. However, due to the lack of funding, they ceased further participation. Therefore no information could be collected regarding how many professionals were actually reached.

Germany

In Germany, it was not possible to get a personal email address for every office, or to get a list of all German architects. So, the collection of addresses was initiated with known professionals (architects, engineers, etc.). Then, an internet research was done. It would have been possible to get more email addresses out of the public telephone directory/ Branch Book, but that was considered too time-consuming. Finally, the survey was sent out to 76 professionals, including architects, engineers, and manufacturers, ten organizations and approximately 700 persons via the Fraunhofer Institute for Solar Energy Systems mailing list. Organizations were asked to distribute the survey link to their members or newsletter subscribers. One organization (DGS – German Section of the International Solar Energy Society) sent the survey link in a newsletter, one refused to send out the link, and others provided no feedback. In total, the German link was sent to at least 776 building practitioners in Germany; however the real number is unknown.

Italy
In Italy, the link to the survey was published on six websites for architects. The link was presented with a short description of the Task 41 activities. In addition, the survey was sent to 60 000 national architects (through a newsletter of the web site Edilio (www.edilio.it), and to 100 local architects who had previously agreed to be registered into the Task 41 Italian database.

Norway
The Norwegian group distributed the survey by email to their network. The emails were sent to 244 people from a personal contac list if predominately practising architects. Additionally, the survey was sent to the members of Norsk Solenergiforening (affiliated with International Solar Energy Society).

Portugal
In Portugal, the national coordinator collected e-mail addresses from a personal list of architects, engineers, academics and educators (university and research teams), manufacturers and organizations. The database was then updated with a collaborative and interactive 'email forwarding' between all the people involved and their contacts. In addition, the survey was distributed via members of the Portuguese Architects Association.

South Korea
In South Korea, the contact lists for the survey were initially taken from the address book of 2009 Korea Institute of Registered Architects with the balance of office size, practitioner's age and locations. Later, the national coordinator added more lists of the local architects who attended the sustainable architectural design academies organized by a local architect's organization and personal contacts. The survey was finally distributed to 286 practicing architects in South Korea.

Spain
In Spain, the national coordinators got in touch with the different Councils of Architects for every region (18 regions in total, some of them with sub-regions). A complete list of the different regions is summarized at the National Spanish Architects Council (Consejo Superior de los Colegios de Arquitectos de España, www.cscae.com). For each region the survey was announced to the architects through different web pages and/or official mailing list.

Sweden
In Sweden, the survey was distributed through the following channels:

- Style, a travelling agency for architectural travels, with a vast contact list of 7000 architects, but it was unfortunately impossible to send out a reminder to fill the survey a little later in the process.
- The national association of architects (Sweden's Architects, SA) helped by sending out two calls, the initial one and a reminder. They also sent the survey through their network on 'Environment & Technology', not to all SA members. The information also appeared for a while on the SA homepage under 'Environment & Technology'.
- The survey was also distributed within the company White architects throughout Sweden (~500 persons) in June 2010, where half of the recipients received an email with

questionaire A mentioned first and questionnaire B second, and the other half received the same email but with the questionnaires in reverse order. A reminder was sent in August 2010 and another one in October 2010.

- In August 2010, 31 offices were contacted through a list of architects connected to a national R&D association, ARKUS. The connected architecture offices consisted of 1-75 persons, where the average amount of architects per office was 25. A reminder was also sent in October 2010 to the ARKUS list.

Switzerland
In Switzerland, the survey was sent by email in three languages (French, German and Italian) to 100 authorities, 500 architects, 80 manufacturers and 240 installers. It was also published on various websites and forwarded using various mailing lists of associations. The following websites and associations are some examples of the ones used to reach the focus group in Switzerland :

- Swissolar- schweizerischen Fachverband für Sonnenenergie,
- SUPSI,
- Accademie d'architecture Mendrisio,
- Swissengineering,
- Schweizerische Zentrale Fenster und Fassaden,
- www.world-architects.com,
- www.ee-news.ch,
- Architects' Council of Europe (ACE),
- SIA- société suisse des ingénieurs et des architectes"

Response rates

Altogether 903 questionnaires were received. Out of these 209 were returned almost empty, 219 with only few unanswered questions and 394 complete. In the analysis the two last two groups were considered as valid responses (n=613) (Table 1).

Regarding the incomplete questionnaires the respondents seem to have stopped answering after the first or second question. Since two questionnaires (from IEA Task Subtask A and Subtask B) were launched together starting with the same questions, some of the respondents might have thought the two questionnaires are the same, and they stopped answering.

Table 1: Amount of complete, incomplete (missing few questions) and empty questionnaires, the total and valid amount of received questionnaires

Country		Complete	Incomplete (Missing few quest.)	Empty	Total	Valid (Complete+ incomplete)
Australia		106	40	48	194	146
Austria		19	7	13	39	28
Belgium		10	2	5	17	12
Canada	E	9	3	15	27	12
	F	12	7	7	26	19
	Total	21	10	22	53	21
Denmark		8	2	4	14	10
France		8	1	10	19	9
Germany		20	28	39	87	48
Italy		34	27	41	102	61
Korea		38	18	19	75	56
Norway		17	14	12	43	31
Portugal		18	2	11	31	20
Spain		16	6	3	25	22
Sweden		42	30	28	100	72
Switz.	G	20	21	20	61	41
	F	2	3	4	9	5
	I	15	8	9	34	23
	Total	37	32	35	104	69
total		394	219	290	903	613

The analysis showed that altogether from the 14 countries more than 5,800 practitioners (including architects, engineers, product developers) were contacted directly (by e-mail) and it is estimated that approximately 76,000 were contacted indirectly (website, magazine…etc.) (see Table 5.). Since we do not know whether the respondents answered to a direct or indirect call, the response rate cannot be precisely calculated. Although we can ascertain a response rate of 6,8% if we divide the sum of valid questionnaires (613) with the total amount of direct e-mails. This result is assumed to be acceptable for surveys of this type.

The response rates for the different countries vary a lot, due to the different methods used for data collection and the different levels of using solar energy in architecture.

Table 2: Amount of questionnaires sent directly or indirectly; the total amount of questionnaires, the response rates for indirect and direct calls per country:

Country	Indirect contact	Direct email	Total	Resp. rate (ind.)	Resp. rate (direct)
Australia	9000	0	194	1,2%	n/a
Austria	90	180	39	21,1%	10,6%
Belgium	0	179	17	n/a	5,6%
Canada E			27		
F			26		
Total	n/a	1050	53	n/a	2,0%
Denmark	n/a	265	14	n/a	3,0%
France			19		
Germany	n/a	776	87	n/a	2,6%
Italy	60000	100	102	0,1%	34,0%
Korea	0	286	75	n/a	13,3%
Norway	n/a	244	43	n/a	7,0%
Portugal	0	59	31	n/a	30,5%
Spain	n/a	n/a	25		
Sweden	7000	1775	100	0,6%	2,4%
Switz. G			61		
F			9		
I			34		
Total	n/a	920	104	n/a	4,0%
total	76090	5834	903	0.5%	6,8%

APPENDIX 2

International survey: country by country results

Question 1: Importance of utilizing solar strategies

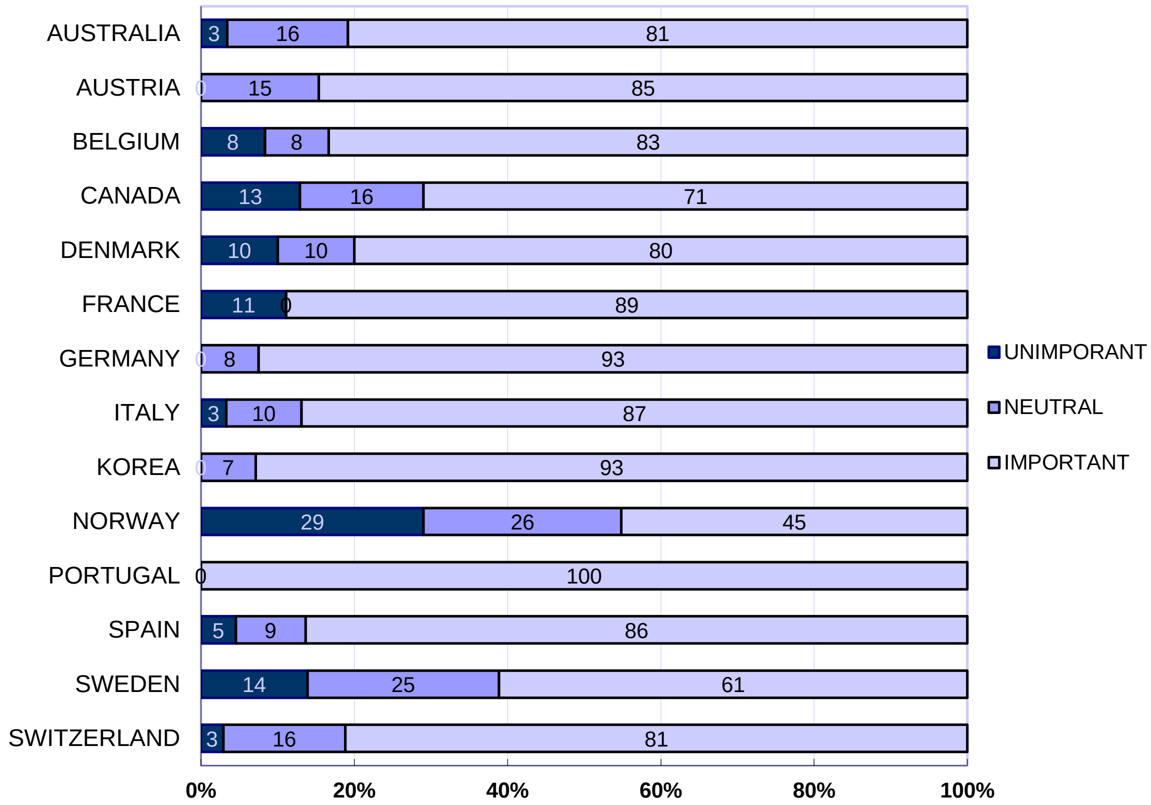

Figure 13: Importance of the use of solar strategies in current architectural practice, country by country results, in %, n=605

Question 2: Utilisation of solar energy in architecture

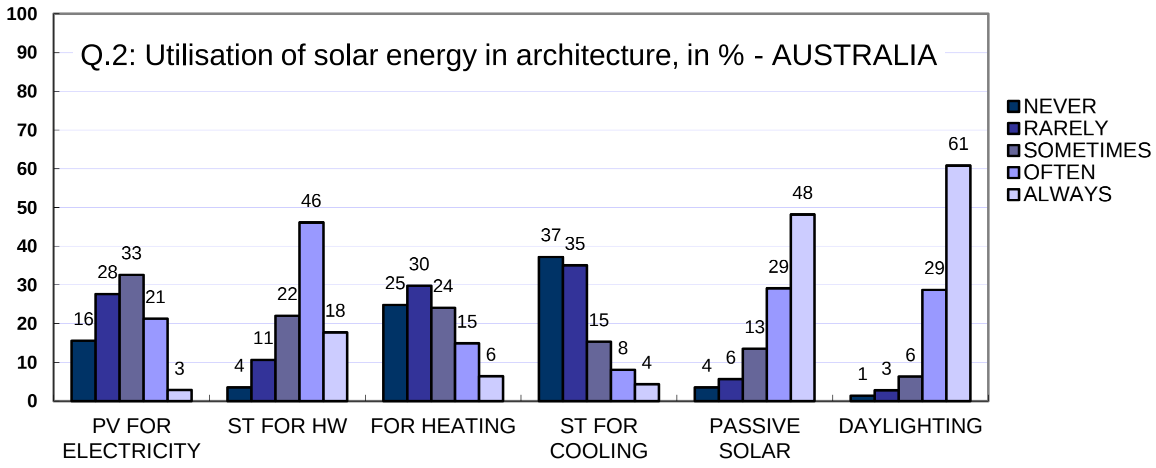

Figure 14: Utilisation of solar energy in architecture: Australia, n= 143

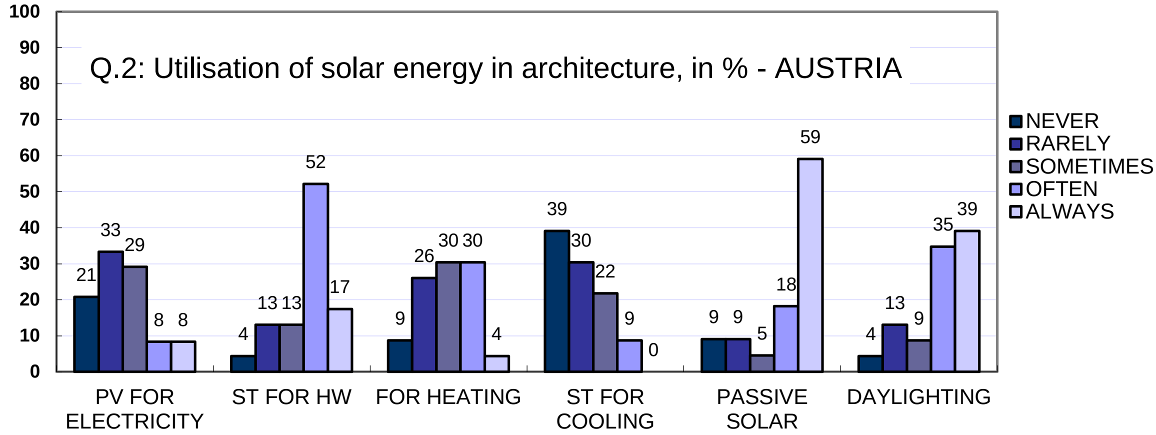

Figure 15: Utilisation of solar energy in architecture: Austria, n=23

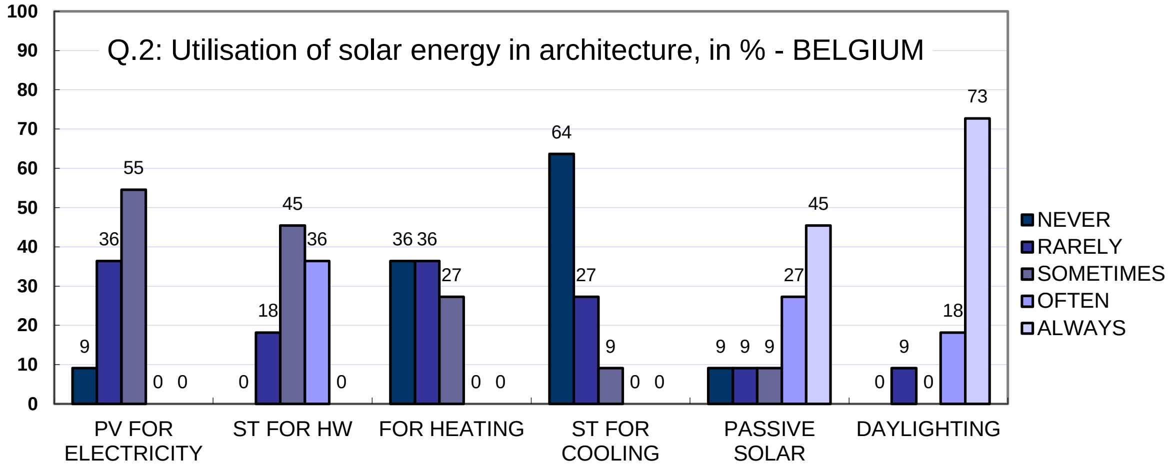

Figure 16: Utilisation of solar energy in architecture: Belgium, n=11

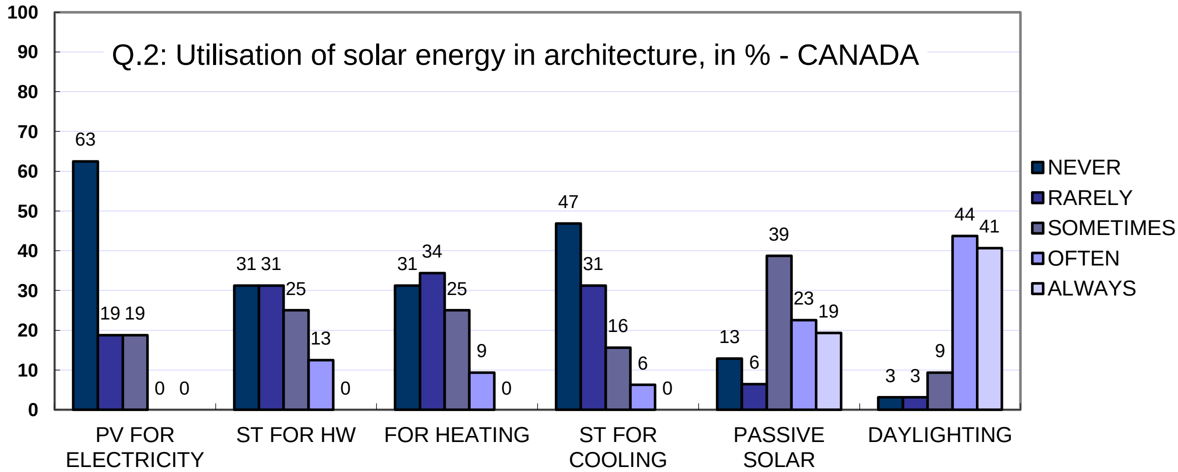

Figure 17: Utilisation of solar energy in architecture: Canada, n=32

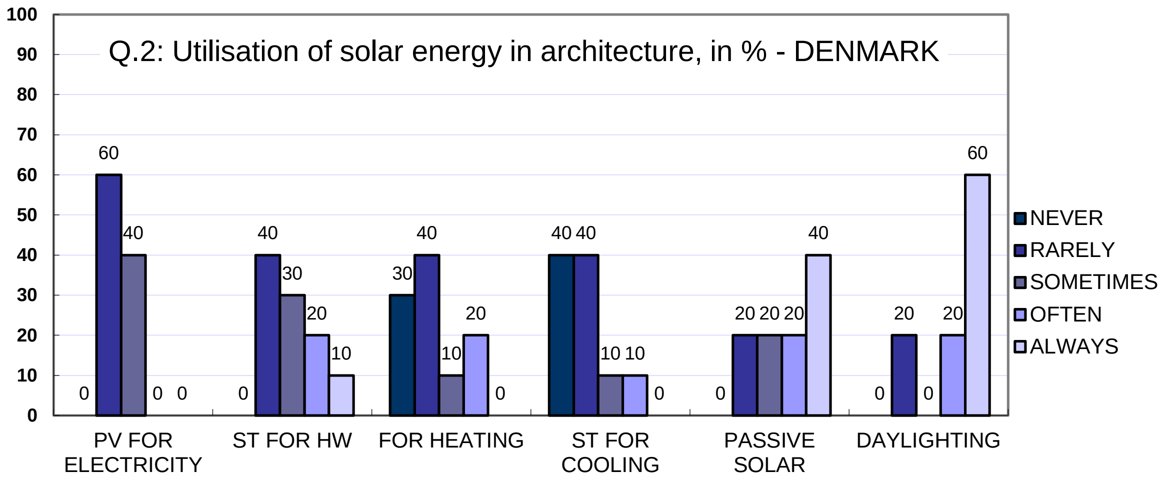

Figure 18: Utilisation of solar energy in architecture: Denmark, n=10

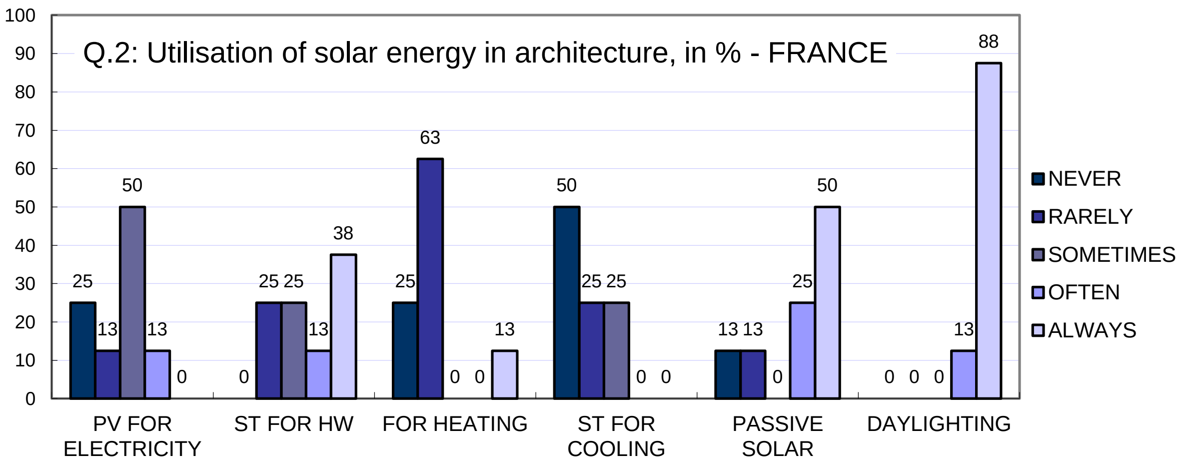

Figure 19: Utilisation of solar energy in architecture: France, n=8

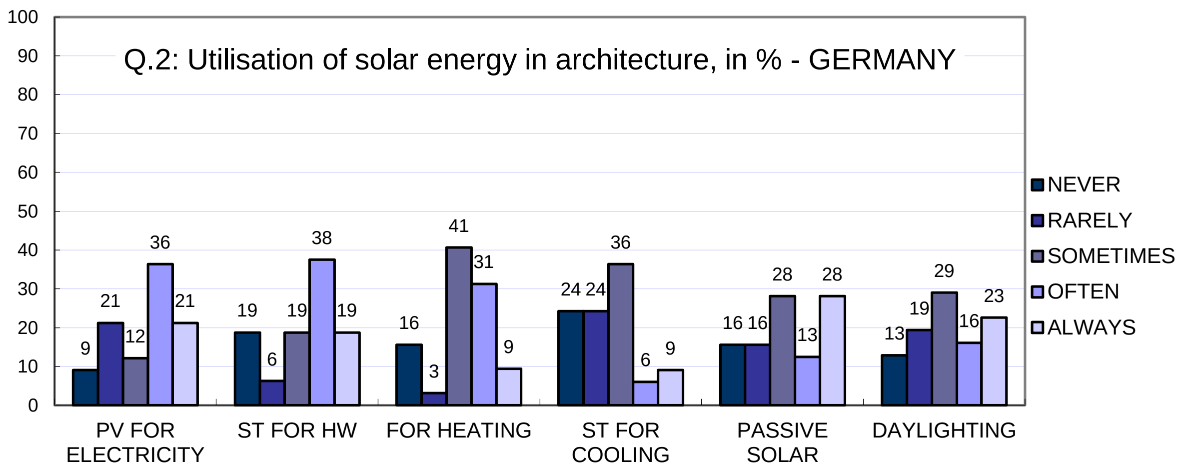

Figure 20: Utilisation of solar energy in architecture: Germany, n=33

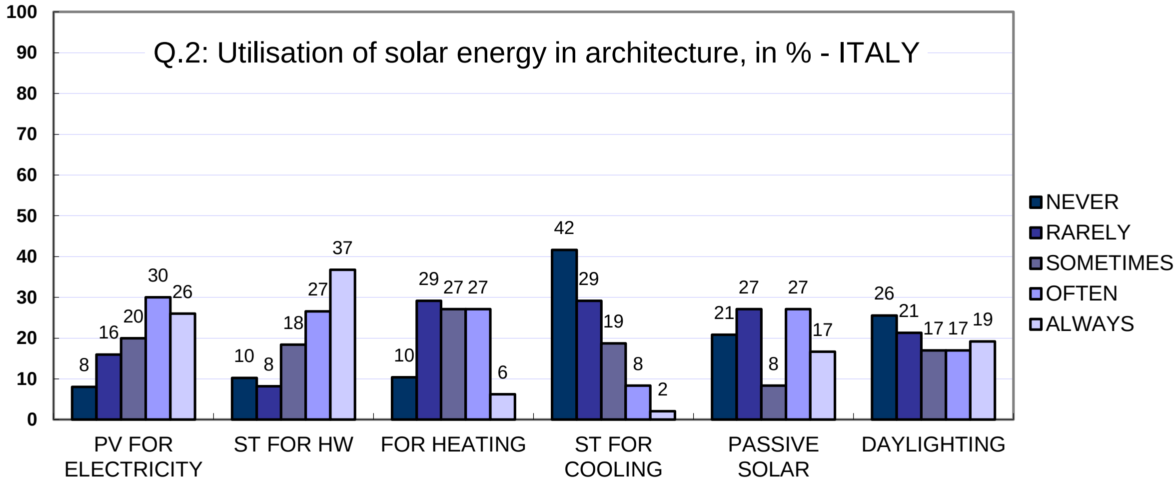

Figure 21: Utilisation of solar energy in architecture: Italy, n=50

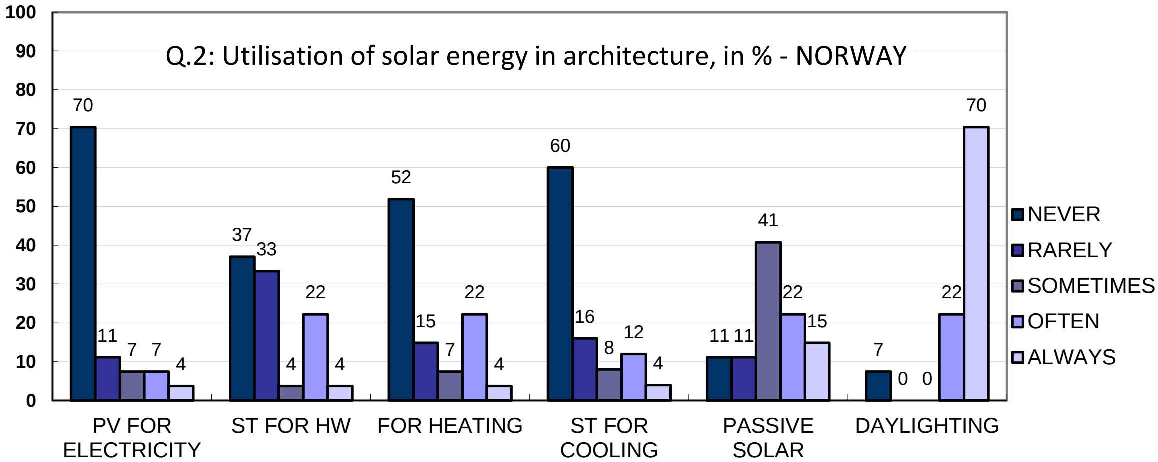

Figure 22: Utilisation of solar energy in architecture: Norway, n=27

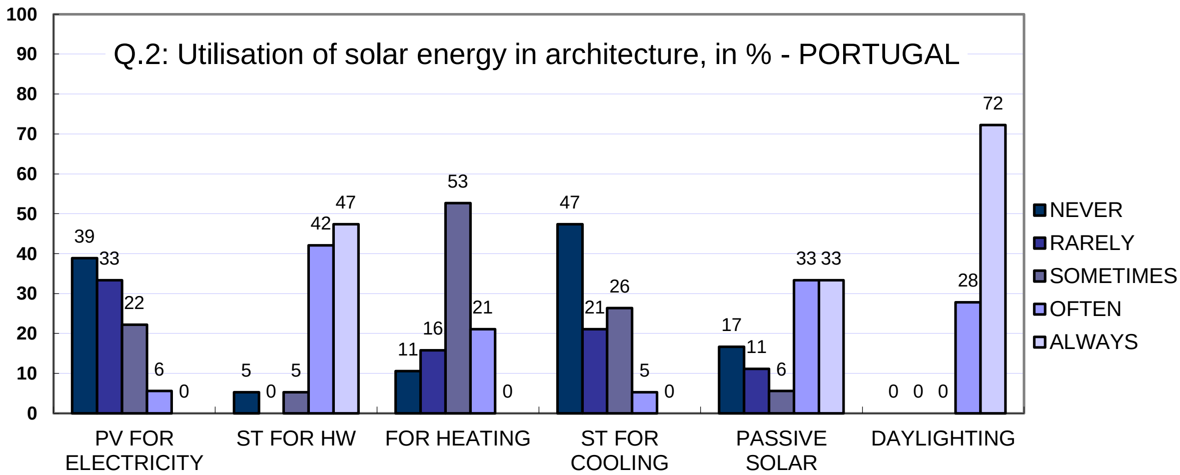

Figure 23: Utilisation of solar energy in architecture: Portugal, n=19

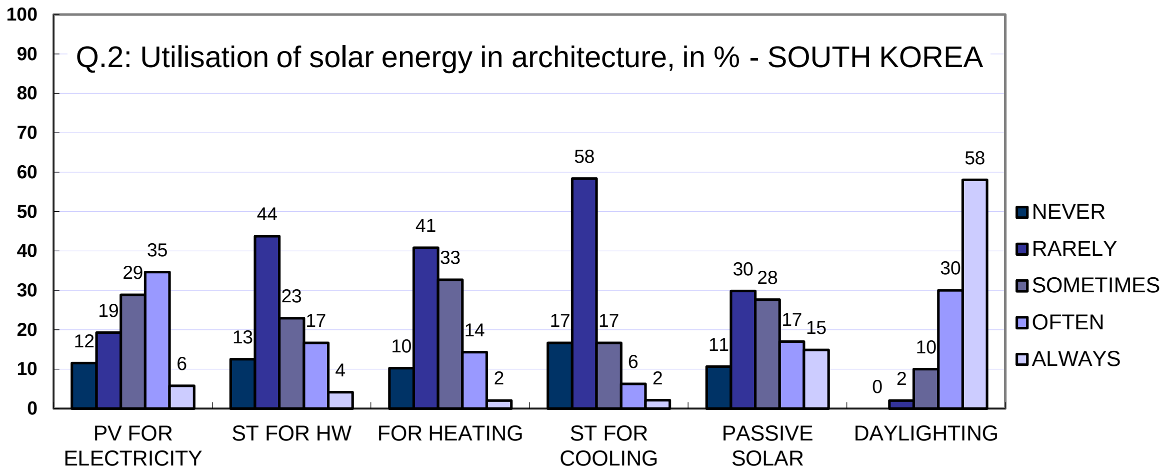

Figure 24: Utilisation of solar energy in architecture: South Korea, n=52

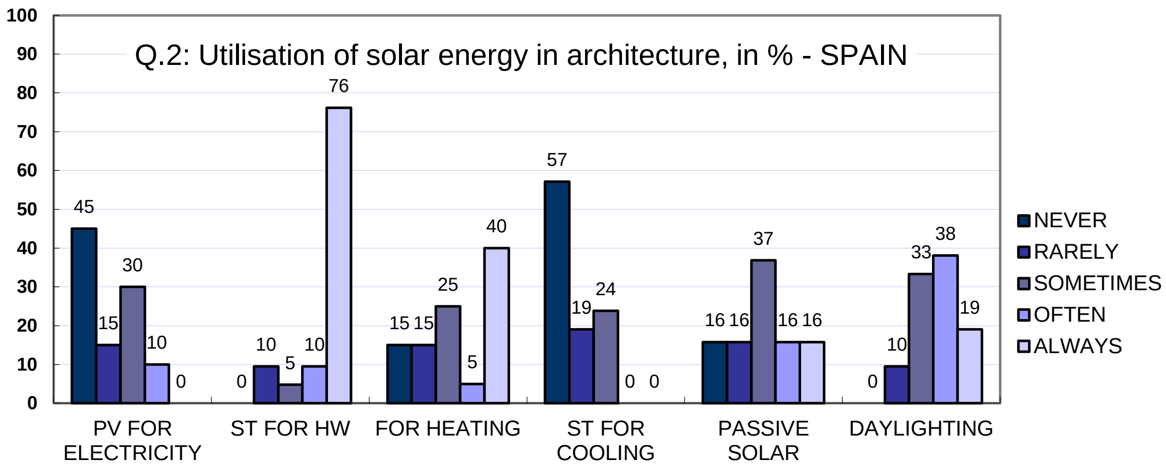

Figure 25: Utilisation of solar energy in architecture: Spain, n=21

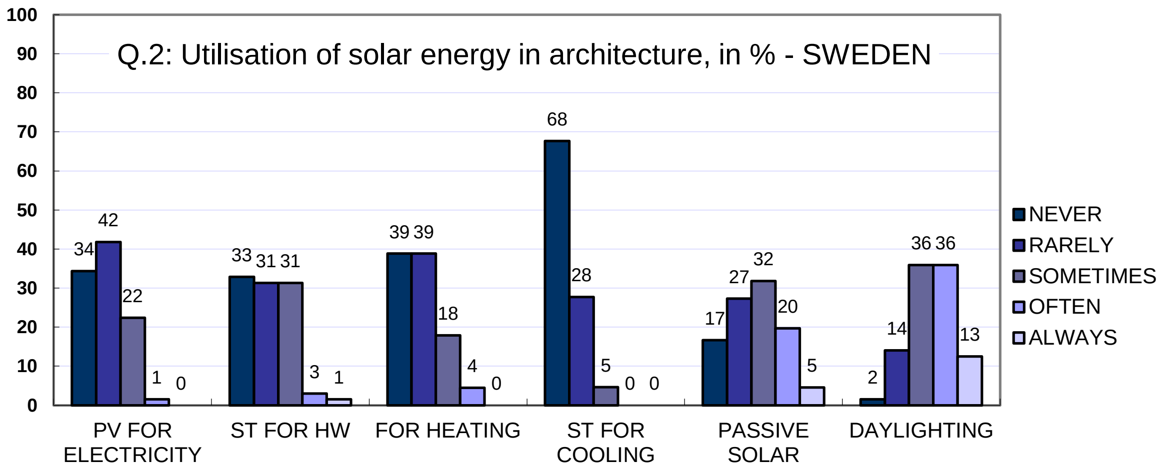

Figure 26: Utilisation of solar energy in architecture: Sweden, n=67

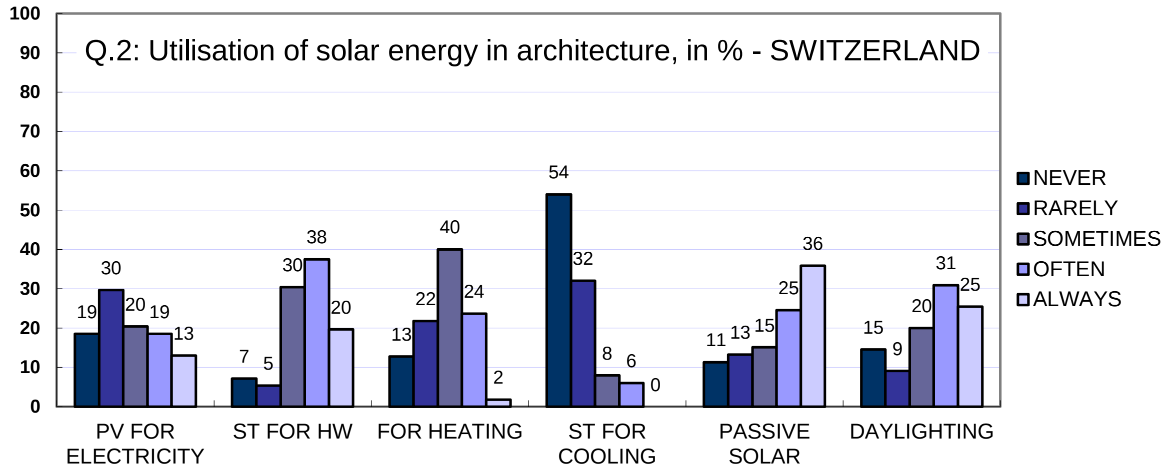

Figure 27: Utilisation of solar energy in architecture: Switzerland, n=56

Question 3: Levels of architectural integration, in %, by regions

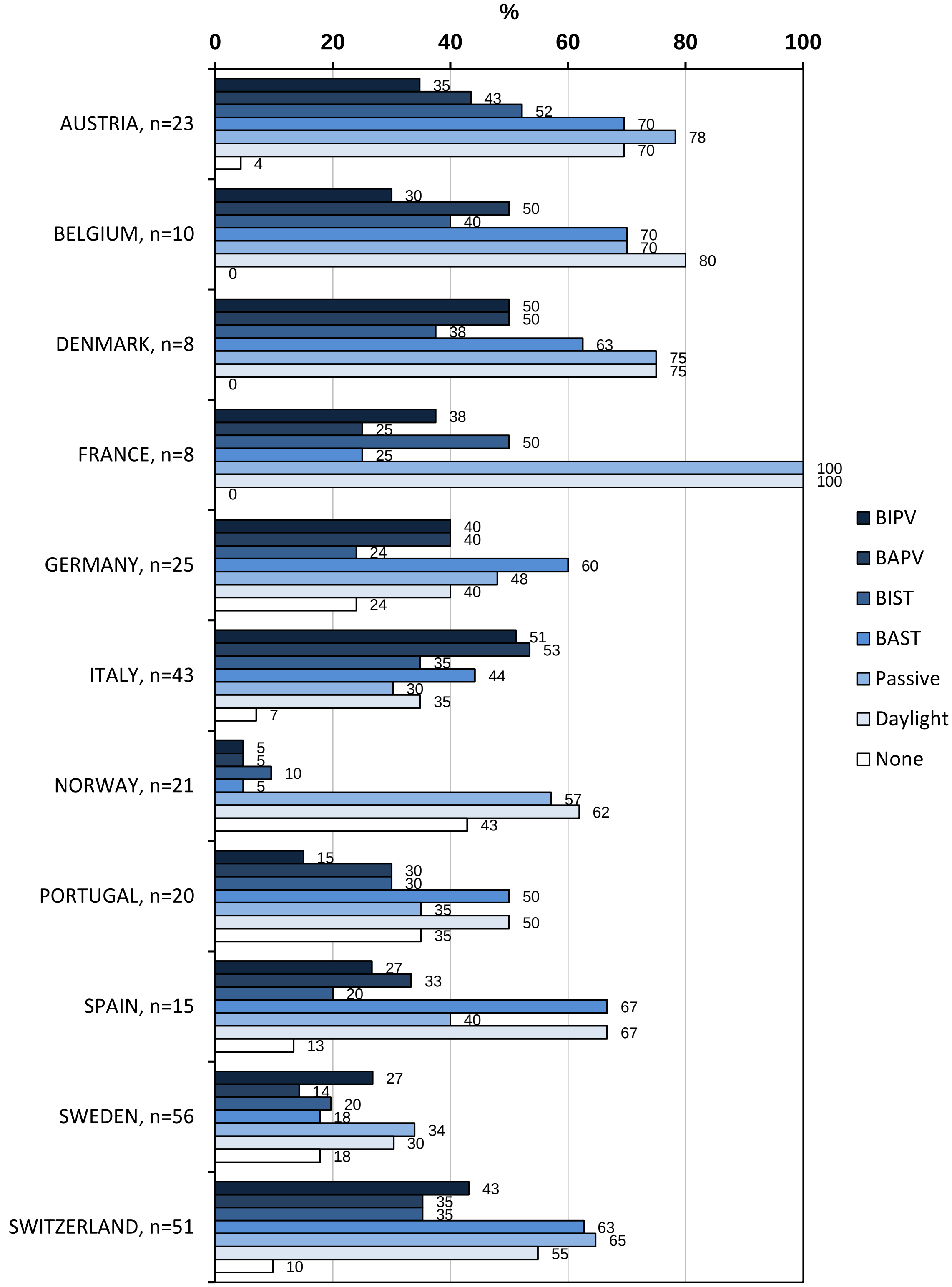

Figure 28: Architectural integration of solar strategies in Europe, country by country results, in %

Question 4: barriers for widespread use of solar technologies

Country by country results

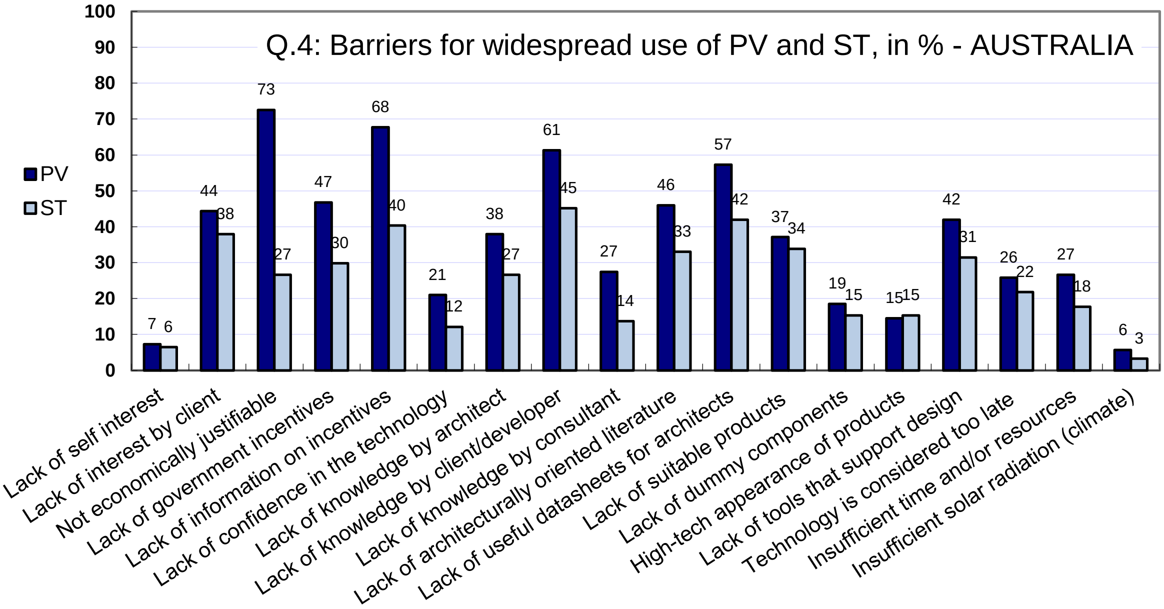

Figure 29: Barriers for widespread use of PV and ST, Australia, n=124

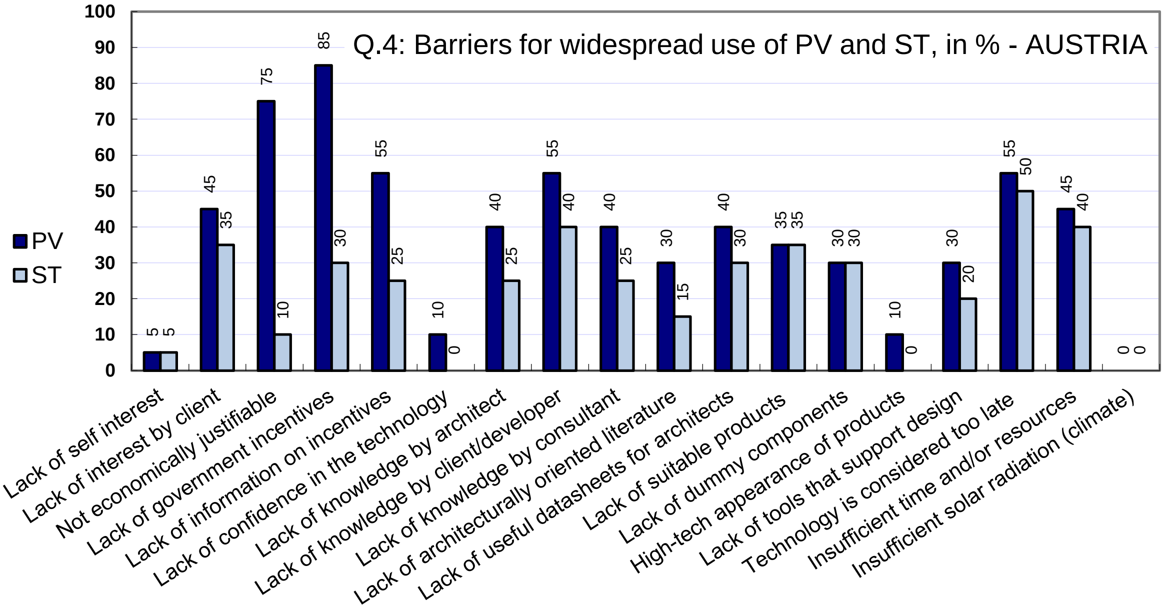

Figure 30: Barriers for widespread use of PV and ST, Austria, n=20

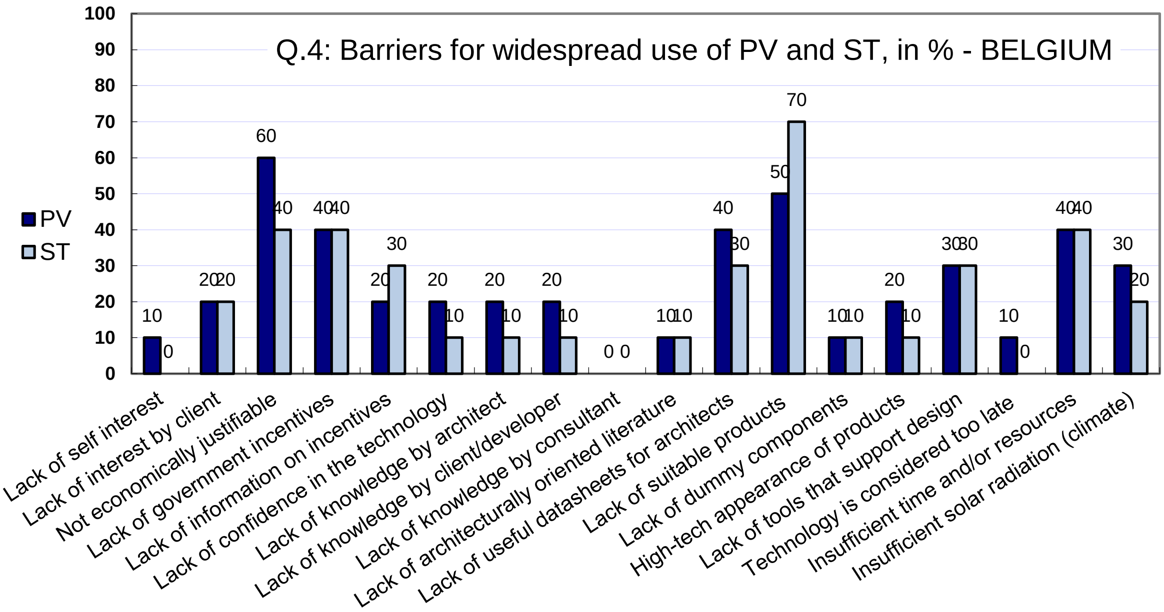

Figure 31: Barriers for widespread use of PV and ST, Belgium, n=10

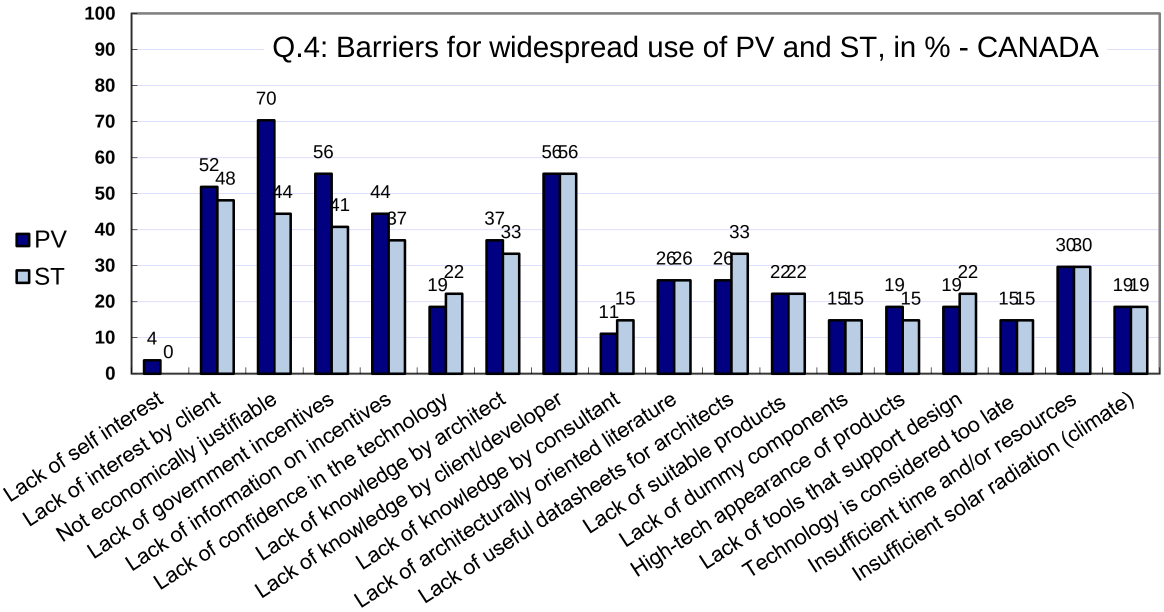

Figure 32: Barriers for widespread use of PV and ST, Canada, n=27

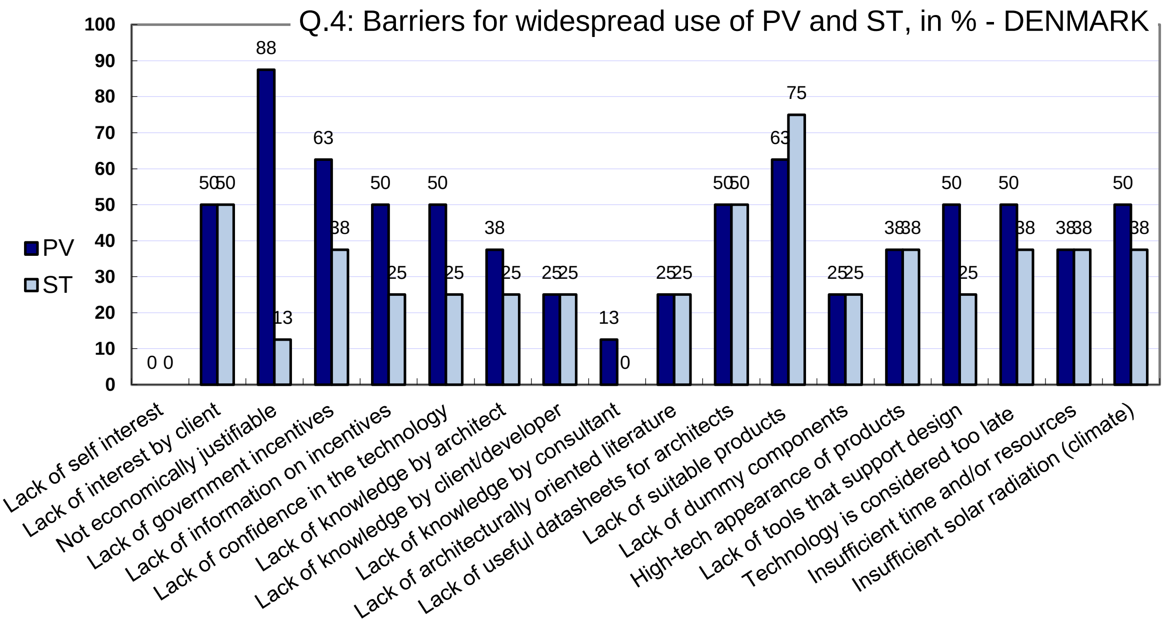

Figure 33: Barriers for widespread use of PV and ST, Denmark, n=8

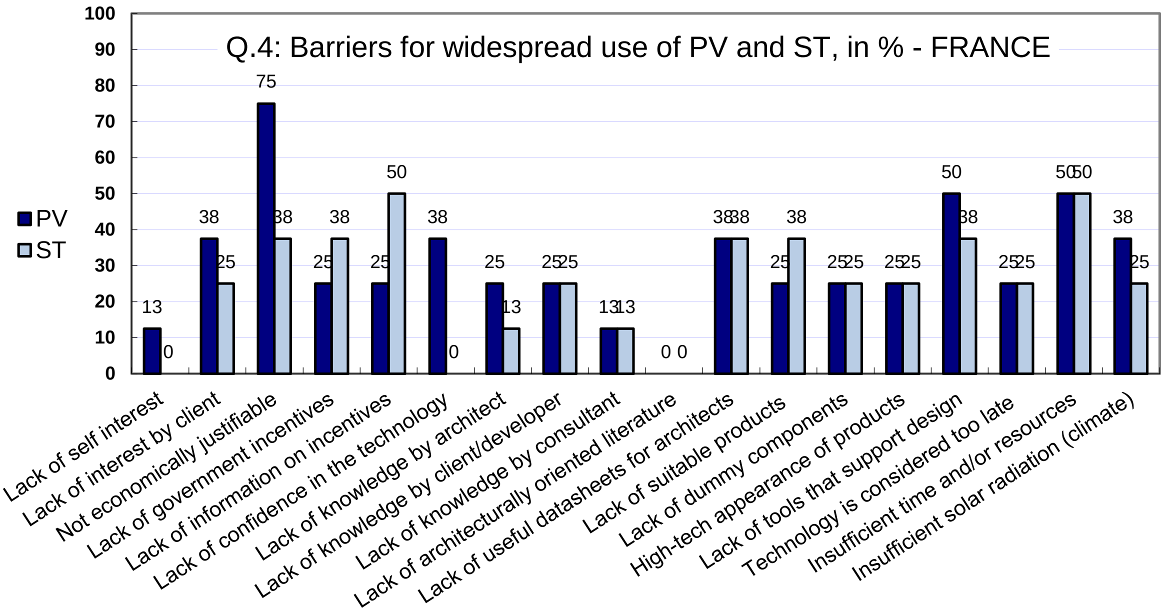

Figure 34: Barriers for widespread use of PV and ST, France, n=8

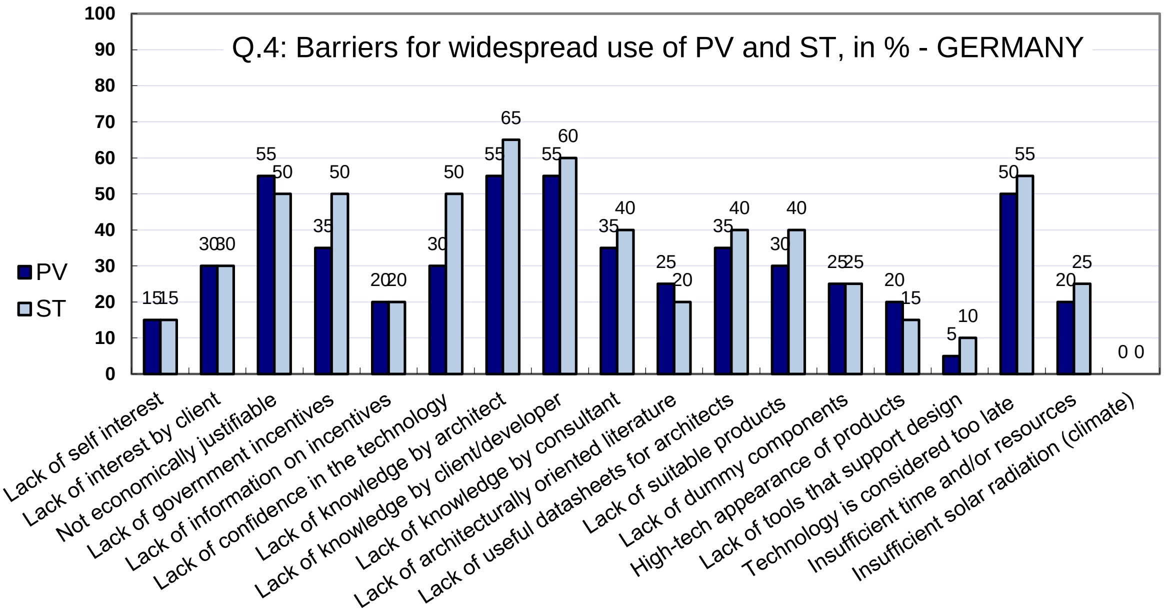

Figure 35: Barriers for widespread use of PV and ST, Germany, n=20

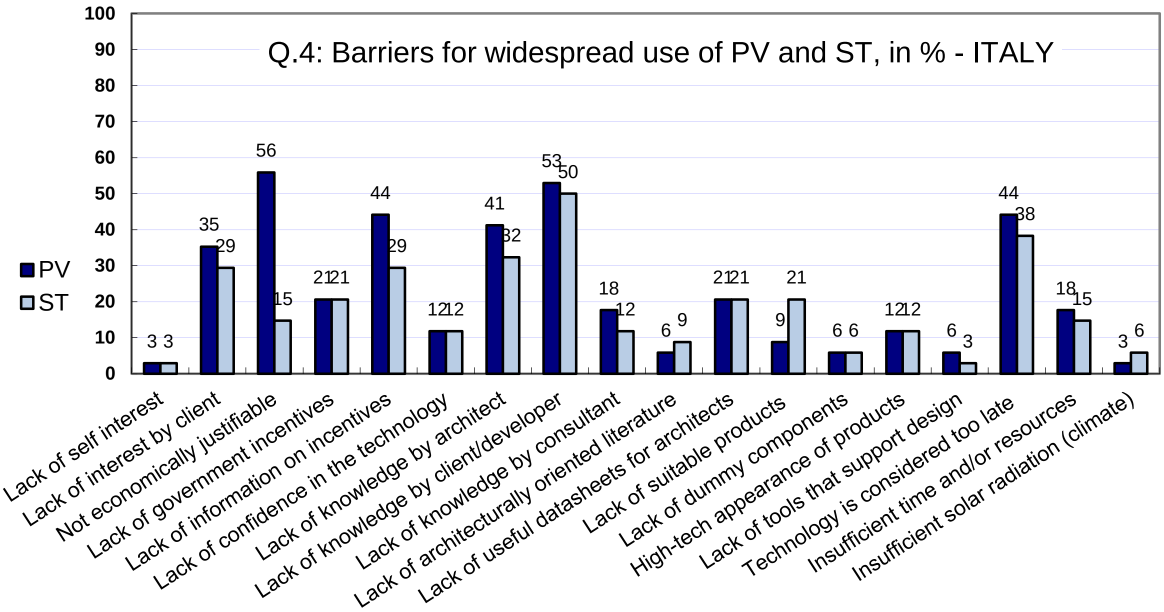

Figure 36: Barriers for widespread use of PV and ST, Italy, n=34

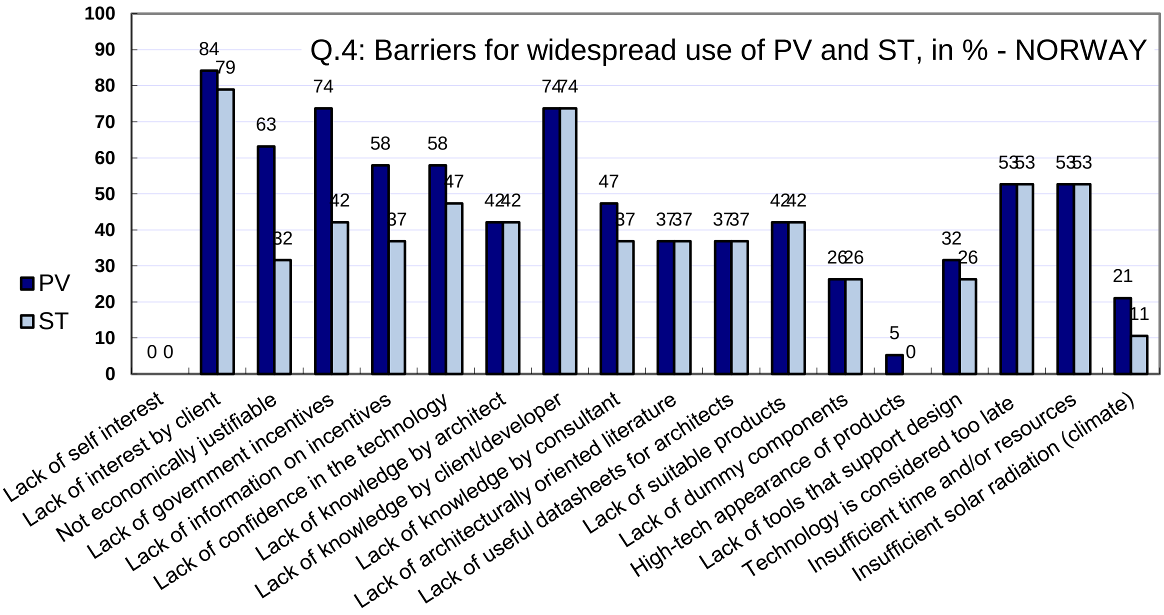

Figure 37: Barriers for widespread use of PV and ST, Norway, n=19

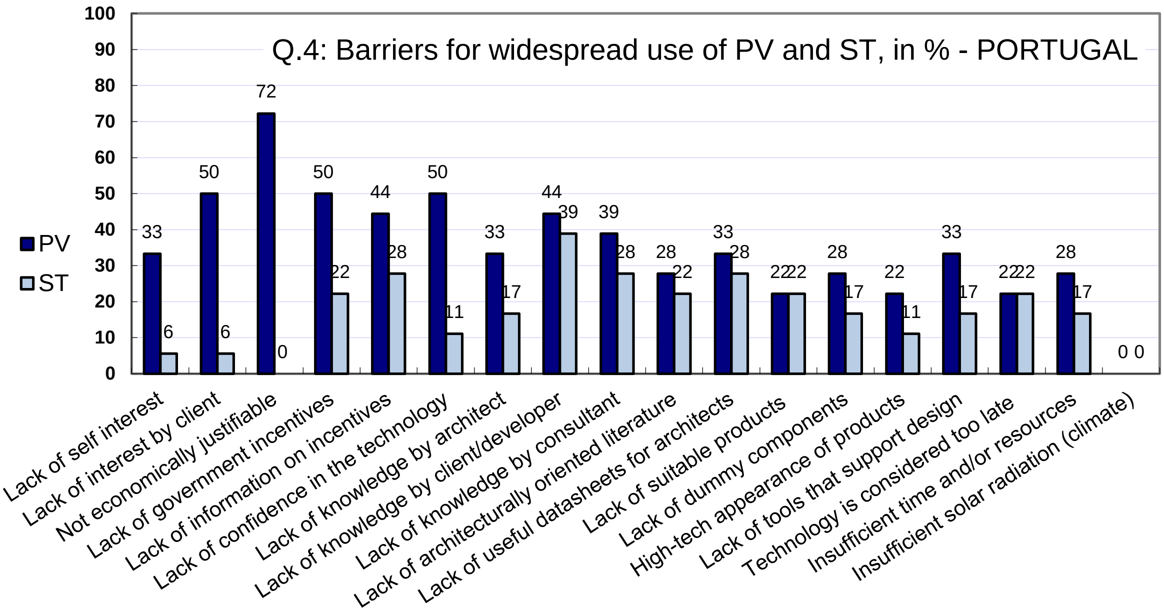

Figure 38: Barriers for widespread use of PV and ST, Portugal, n=18

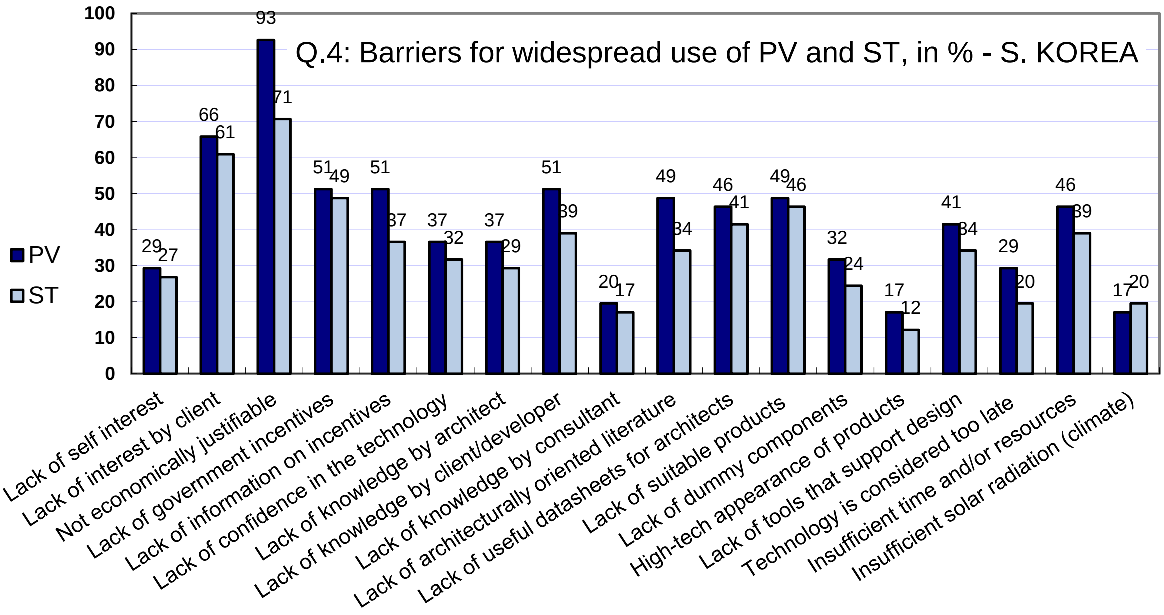

Figure 39: Barriers for widespread use of PV and ST, South Korea, n=41

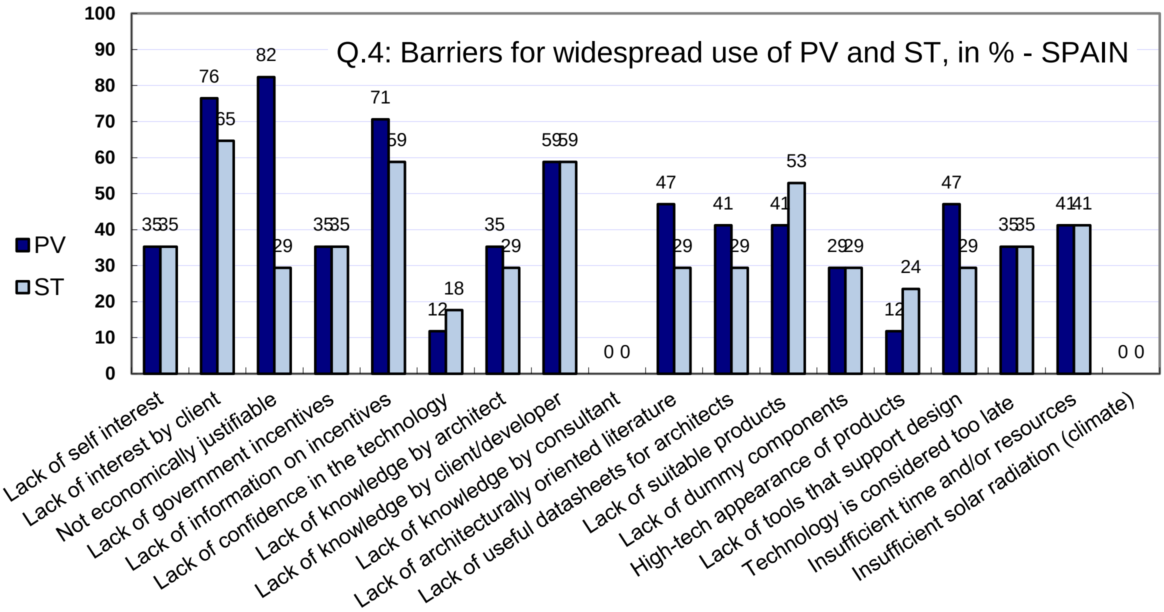

Figure 40: Barriers for widespread use of PV and ST, Spain, n=17

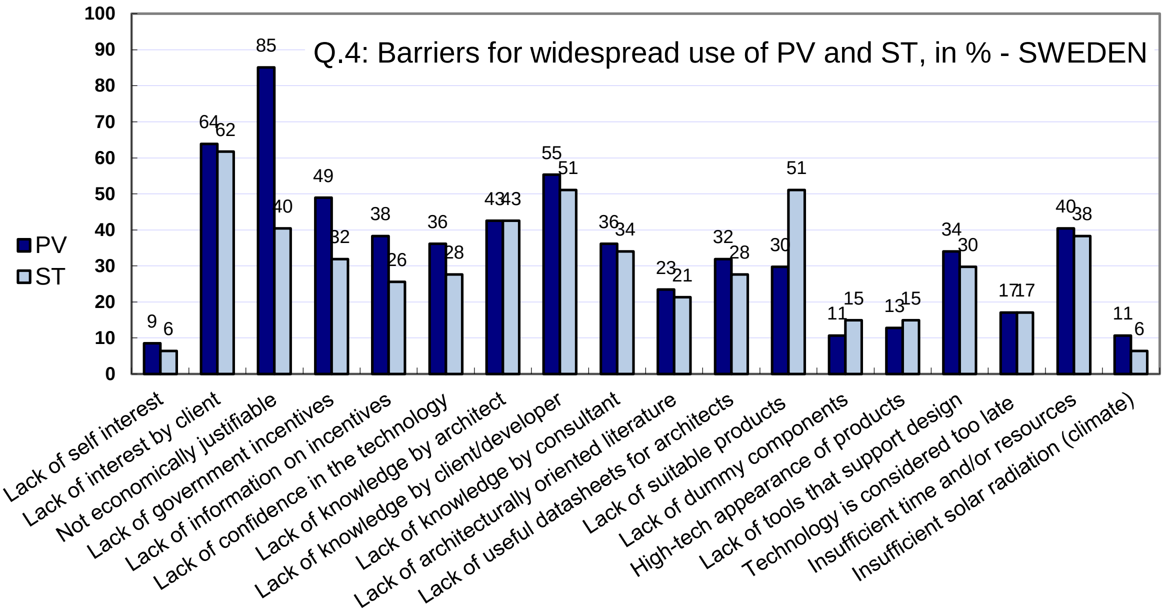

Figure 41: Barriers for widespread use of PV and ST, Sweden, n=47

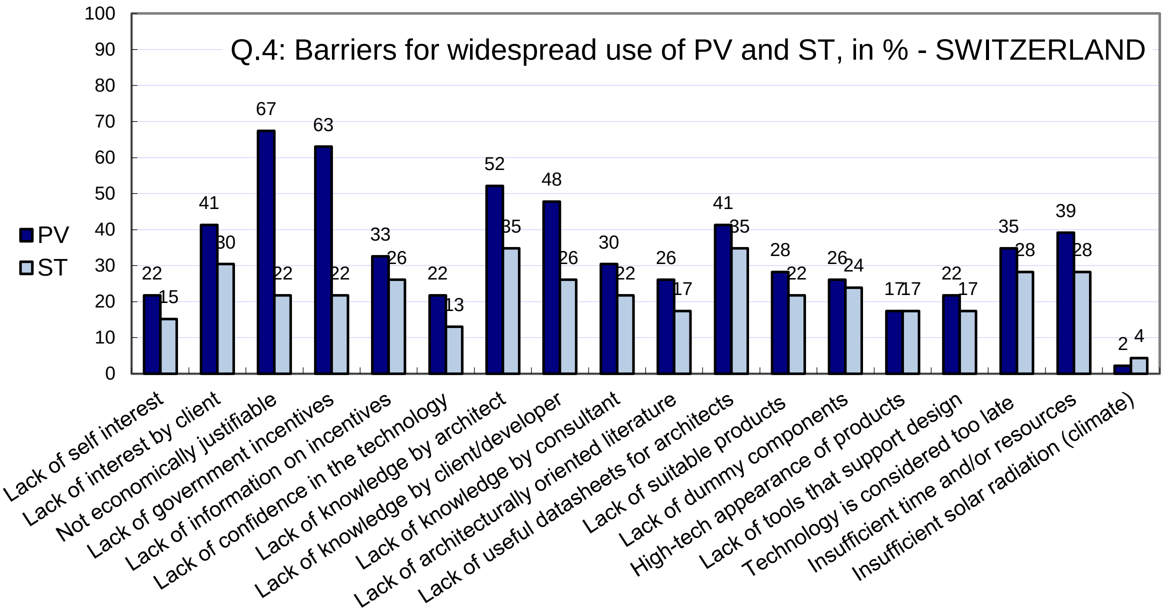

Figure 42: Barriers for widespread use of PV and ST, Switzerland, n=46

Question 4: Barriers for widespread use of PV and ST: other / additional comments

AUSTRALIA	I have found few barriers, particularly now the cost of PVs has decreased
	town planning of older suburbs inhibit ease of taking advantage of solar opportunities - i.e. building orientation due to street grid pay-outs and Council LEP and DCP control requirements, especially in acclaimed "heritage" conservation areas....
	Main issue we find in our practice is the inability for clients/developers to prioritise solar technology over other desires such as a larger house, more expensive finishes, appliances etc. There is a basic lack of commitment by the consumer.
	Product and supply misinformation Lack of suitably qualified installers, particularly plumbers for solar hot water
	I have experience in the USA where they usually use a single electricity supply meter and "wind it back" with local solar input. This works well for them. It's inexpensive for the consumer / local input supplier and it ensures basic fairness in the market power supply market place. This is a way that home owners can balance daytime power demands from businesses. Seems Fair for all.
	At the moment photovoltaics are not feasible given there need for direct light. A 1.5kw system that is the industry standard to put on a house and receives the maximum proportion of subsidies doesn't provide half the energy needed. Until a system can provide the whole buildings electricity photovoltaics will always be held back.
	PVs and BIPVs particularly seem to still be in development phase, not fully matured as commercial products. Concern with efficiency - a lot of product for small output. Cost ($ & effort) exorbitant compared to benefits so it becomes a philosophical choice not a commercial decision. Exception is in remote areas where cost compares favourably to grid connection, or grid connection not possible.
	Timing.....
	none of these are barriers for us
	cost of other building components blow the budget - something has to give, and usually its the solar add-ons
	Developers simply won't pay a cent more than they have to.
	Integration of technology is a question as not always the right solution. Application often easier and better. Questions above seem to be biased towards integration rather than application.
	The panels themselves are very inefficient. If there is any shadow on the panel even if a leaf falls on it it does not generate anything. The panel itself should be made up of separate modules that can overcome shadowing problems and allow for the rest of the panel to operate if this occurs. All these systems work OK if the output goes into a grid. When the output goes into storage batteries there

	are major problems when the sun does not shine, when there are any shadows on the panels and other things. The problem of stand alone systems should be properly addressed, talked about and be understood before one invests in this technology.
	PV on-going maintenance issues - client reluctance
	Photovoltaics are not proven technologies- suspicion is that upon nearing payback the panels lose efficiency and need to be replaced. Energy used in making the panels offsets much of the advantage in payback.
	Existing services still working well and sufficient for purpose
AUSTRIA	PV - katastrophalöe förderungen - bis zum break even müsste gefödert werden integration ins gebäude technisch mE nicht überzeugend - mW soll PV NICHT in die fassade integriert werden - dafür sollten mehrfachnutzungen zB sonnenschutz (als beschattungslemente) stärker technisch/wirtschaftlich aufgearbeitet werden solartechnik wasser (ist das mit ST gemeint?) - ich versuche "dächer" zu vermeiden - techisch und formal - also........... bleibt die aufgeständerte lösung - kombination mit sonnenschutz wäre auch hier wünschenswert detail am rande - optimierung während der ersten betriebsjahre ist für hersteller und solateure noch ein fremdwort - verscuhen sie einmal, einen "wartungsauftrag" der den namen verdient, von einem anbieter zu erhalten - ich bin (noch) nicht bereit, meinem bauherren eine leistung zu empfehlen, die in jedem anderen gewerk eine selbstverständlichkeit ist (sein sollte) - nämlich, dass die anlage das kann, was sie verspricht - dieser nachweis gehörte ins NORMGEMÄSSE leistungsbild !!!! *PV -catastrophic promotions – until the break even there should be support, integration into the building is from my point of view not convincing - …PV should NOT be integrated into the façade – instead: work off technically and economically multifunctional utilizations e.g. solar shading (as shading elements). Solar water technology (is that meant with ST?) – I try to avoid "roofs" – technically and formally – so …. It lasts the added on solution – combination with solar shading would here be desirable, little side note – optimization during the first operation years is still a stranger for manufacturers and solar installers – try to get an "maintenance contract" of a provider that really lives up to its name – I am (still) not ready to recommend to building owners something that in every other trade heading is a matter of course (should be) – namely that the system can do what is promised – this certificate should be part of a standard service definition.*
BELGIUM	coût trop élevé du photovoltaïque (et du thermique aussi, dans une moindre mesure) - investissement très rentable après quelques années, mais réservé à ceux qui peuvent débourser la somme de départ certains clients n'aiment pas avoir des tuyaux de fluides qui se balladent sur leur toit problème technique pour le solaire thermique : comment stocker de la chaleur à long terme ? *The costs of PV are too high. (For thermal as well, but to a lesser extent) – It is a very profitable investment after a few years, but only for those who can pay the initial fee. Some customers do not like the pipes of fluids all over their roofs. There are also some technical problems associated with solar thermal such as:*

	how can we store accumulated heat for a long term period.
	Dans les 2 cas : budgets trop restreints pour inclure l'accessoire quand on a à peine de quoi payer l'isolant de base. *In both cases (for PV and ST): the budgets are too small to include the accessories when one barely has enough to pay the basic insulation.*
CANADA	The specialization of the engineering profession means that you need yet another engineer to do a small job and coordination becomes a huge task.
	Our clients are not willing to pay for this extra technology.
	Autres économies d'énergies dans le bâtiment pas suffisantes, ce qui fait qu'on ne peut pas obtenir de point LEED dans le projet avec les photovaltaïc (ou autre procédé de production d'électricité sur le site) puisqu'il faut fournir 5% des coûts de l'énergie. C'est un incitatif de moins, le fait que le point LEED soit si exigeant. *The other energy savings in a building are not sufficient, therefore it is harder or impossible to get LEED points in the project with photovaltaïc (or other methods of on-site electricity production) because they must be provided 5% of energy costs. The fact that this LEED point is so demanding makes one less incentive to use them.*
	je fais de la programmation alors non applicable *Since I am doing programming, this is not applicable.*
	Hydro-électricité trop peu cher, concurrence déloyale d'Hydro-Québec. Le coût du kW/h devrait doubler au Québec pour refléter le coût véritable de l'énergie et de permettre l'émergence d'alternatives au barrages géants, notamment l'éolien à l'échelle macro et le solaire à l'échelle micro. *Hydro-electricity is already cheap, this would become unfair competition to Hydro-Québec. In Québec, the cost per kW/h should double to reflect the true cost of energy, only then it would allow the emergence of these alternatives to compete with the great electricity dams. (Including wind power on the macro scale, and solar power on the micro scale.)*
FRANCE	Trop cher et parti pris pour du solaire au sud, non rentable au nord. *There is also a strong bias for the solar south, and solar north is not profitable*.
GERMANY	- Bauelemente Hersteller bieten Produkte zur Intergration nicht an. - PV und ST-Produkte haben meist keine Bauartenzulassung, können also von Architekten oder sonstigen Nutzern nicht einfach "aus dem Regal" verwandt werden. - Mangelnde Kooperation zw. z.B. Fassadenherstellern und Solarindustrie *- Manufacturers of components do not offer products for building integration.* *– PV and ST products mostly do not have construction type permissions, so architects or other users cannot simply use them “out of the shelf”.* *– Lacking cooperation between e.g. façade manufacturers and solar industry.*

	Heizungsinstallateure installieren ca. die Hälfte der solarthermischen Anlagen fehlerhaft *Installer for heating systems install approximately half of the solar thermal systems deficiently*
ITALY	Questione relativa alla necessità del N.O. in zona vincolata o di centro storico per i piccoli impianti fotovoltaici, o per il solare nel secondo caso: inutili e lunghe attese di N.O. a mio giudizio pleonastici. Basterebbe fornire CHIARE ed IMPRESCINDIBILI condizioni di integrazione architettonica da utilizzare nei diversi casi e nei diversi contesti. Inoltre, credo che la mancanza di rinnovo dell'incentivo per il 55% IRPEF per il solare termico possa costituire un motivo di rallentamento nell'applicazione della tecnologia. *Question concerning the need of N.O. in a bound (restricted) zone or zone of historical centre for small photovoltaic plants or for the solar (thermal) in the second case: unnecessary and long waiting for N.O, which is, in my opinion, redundant. It would be enough to provide CLEAR and MANDATORY rules for the architectural inclusion that has to be used in different cases and contexts. Moreover, I consider the elimination of IRPEF 55% income tax return incentive for solar thermal a possible reason for slowing down the application of technology*
	atteggiamento ostico da parte dei regolamenti edilizi che con una serie di vincoli di fatto ostacolano la diffusione delle tecnologie solari *Tough attitude of building regulations that, due to several liabilities, actually obstruct the diffusion of solar technologies*
	mancanza o difficoltà di accedere al finanziamento da parte delle Aziende erogatrici di credito, almeno nel sud italia. *Impossible or difficult access to credit funding companies, at least in Southern Italy*
NORWAY	Manglende synlighet, lite info om intergrering mot andre systemer. Mangler klare kost/nytte kalkyler *Lack of visibility, little information about integration with other systems. Lacking clear cost / benefit calculations.*
	Utilstrekkelig viten om mulighetene *Insufficient knowledge about possibilities (opportunities)*
PORTUGAL	fotovoltaico: a instalação para venda à rede está condicionada pela abertura de concursos públicos que são insuficientes para a procura. *The PV installations that receive state subsidies when selling the electricity to the grid are very limited compared with all that apply for it*.
	1. (para os projectistas) Falta de Bons exemplos: Bons arquitectos e bons projectos de arquitectura a aplicá-los; 2. falta de certificação para sistemas alternativos como fotovoltaicos maleáveis, para obtenção dos benefícios estatais

	3. dificudade de encontrar projectistas qeu dominem o tema sem serem fornecedores do equipamento, com a consequente suspeita de dimensionamentos das redes mal feitos 4. (para os clientes) falta de orçamento disponível, em particular com recente incremento de especialidade de mecânica que praticamente duplicou os custos. Os orçamentos são apertados e não 'sobra' *1. (Barriers) for architects: Lack of good examples on the architectural level* *2. Lack of subsidies for other types of PVs, such as the flexible type* *3. Hard to find people who design the systems without being the ones installing it and being beneficiary of oversizing the systems.* 4. (Barriers) for clients: lack of available budget, particularly with recent increase of specialty mechanical costs that almost doubled. Budgets are tight and there are no “left overs”
S. KOREA	시간과 비용 *Time and cost*
	부수 구성요소(PV 고정재 등)의 디자인 또는 성능 수준 미달 *Extra component’s (PV fixture etc.) design or lack of performance standard*
SPAIN	La normativa y el coste de los sistemasen referencia a losedificios de pequeña entidad es vista como un encarecimiento injustificado por parte de los propios clientes informados por los instaladores. *The norms (regulations) and the cost of building systems for small enterprises are seen as an unjustified increase in price for clients that get informed by people who install such systems.*
	Una cosa es la información de los fabricantes o proyectistas, ya sean arquitectos o ingenieros y otra muy diferente la capacidad del instalador medio de ejecutar adecuadamente la instalación, en muchas obras resulta una carga excesiva la pelea con la contrata como para librarla en beneficio de un tercero que no va a poder ver la ventaja si no se acaba en plazo. La información de productos nuevos no está bien encauzada, en muchas ocasiones es necesario consultar excesivas páginas o contactar con demesiados comerciales para tener una idea de las novedades, sería más sencillo que se puiera uno actualizar mediente una página con critero. Por otro lado no existe una realción real de las tarifas con el precio de la obra, ya que el instalador en cuanto comprueba que el cliente desconoce la instalación se encarga de aumentar el coste recurriendo a la excusa de que es nuevo, luego es caro. *One thing is the information from the manufacturers or architects or engineers. Something very different are the skills of average installation workers for implementing successfully an installation. In some constructions the ‘fight’ with the contractor is too much, considering that the benefit will be for a third party that is not going to see the advantage if the building is not delivered on time. The information of new products is not well channelled; in some cases it is necessary to consult too many pages or contacting too many salesmen to have an idea of innovations (new products). It would be easier that one could update*

	himself/herself with a website with criteria. On the other side, there is not a real relation between the investments (cost of the systems) in relation to the whole price of the construction because the installation worker as soon as realizes that the client lacks knowledge regarding the installation, he/she increases the cost of installation with the excuse that it is something new and therefore, it is expensive.
SWEDEN	Lack of awareness in both the profession and amongst clients of the need for building integrated solutions. i.e. why not just use offsite renewables or more nuclear power! Legislated targets (such as the Merton Rule) have been the main driver for uptake of onsite renewable technologies.
	Habit
	You can't sell own overproduced electricity back to supplier of electricity. You can't store overproduced hot water over 6 moth time.
	Conservative climate in the building process.
SWITZERLAND	In mittelfristiger Betrachtung und mangels efizienter Förderung noch nicht selbstragend > Idealismus ist vom Bauherrn gefordert. Deshalb noch keine Breitenwirkung *In intermediate term considerations and for lack of efficient promotion still not self-supporting > idealism of the building owner is required. These are reasons that still there is no widespread effect.*
	Photovoltaik: Effizienzsteigerung, Preisentwicklung abwarten *PV: Improvement in efficiency, await price development*
	Zu wenig Wissen der Architektinnen und Architekten über mögliche Anwendungen bei bestehenden Bauten; innovative Angebote fehlen auf dem Markt. *Too little knowledge of architects about possible applications in existing buildings; innovative offers are missing on the market.*
	Die gegenwärtige unbefriedigende Situation mit den Subventionen und der KEV im Speziellen ist verantwortlich, dass Solarenergie zu wenig genutzt wird. Letztendlich ist es die Politik, welche die Rahmenbedingungen setzt. Das Beispiel der Förderung von thermischer Solarenergie im Kanton Basel-Stadt, zeigt, dass eine nachhaltige Subventionspolitik möglich ist und in Folge dessen auch genutzt wird. *The present dissatisfactory situation with the promotions and especially the „KEV“ are responsible, that solar energy is used too little. Finally it is politics, which define the basic conditions. The example of the promotion of solar thermal energy in the canton Basel-Stadt shows, that sustainable promotion politics are possible and in succession also is utilized.*
	Sonnenenergie zum Heizen ist überholt. Das Passivhaus kann das besser. Sonnenenergie für Warmwasser ist teuer und in Konkurrenz zur

	Lüftungswärmepumpe. Die Stromerzeugung mit kleinen PV-Anlagen mit Netzeinspeisung ist vergleichsweise teuer und im Winter fast wirkungslos. *Solar energy for heating is outdated (obsolete). The passive house does better. Solar energy for hot water is expensive and competes with ventilation (?) heat pumps. The generation of electricity with small PV systems feeding into the grid is comparatively expensive and during the winter almost without effect*.
	Baureglemente *Construction rules*
	SIEHE KOMMENTAR auf vorderem Blatt *See comment on earlier page [sic.]*
	zu teuer !! *too expensive!!!*
	Infos und Unterstützung sind für mich als Architekte / Energieberater genügend vorhanden *For me as an architect/energy consultant, information and support are sufficiently available*
	Complexité accrue dans l'installation et la mise en exploitation d'une installation solaire par rapport à une installation "traditionnelle". *Increased complexity in the installation and operation of a solar installation compared to a "traditional" installation.*
	Photovoltaïque : Politique de rachat du courant par les fournisseurs totalement dissuasive. *PV: The policies for re-selling and buying electricity by the suppliers are totally dissuasive*
	Soprattutto la resistenza dei committenti anche solo a prendere in consoderazione il problema. Il committente squasi sempre i muove solo se ci sono certissimi vantaggi economici. *Mostly the resistance of customer, even to think about the problem. The customer basically “moves” only if there are certain economic benefits.*
	pochi incentivi statali per il reinserimento della corrente elettrica nel circuito publico (vedi conto energia italiano) *Too few incentives from the Government for those who sell electricity back to the public grid (look to the Italian “conto energia”) [conto energia is Italian system of incentives for electricity produced from PV cells]*

Question 5: Strategies to promote use of PV and ST – country by country results

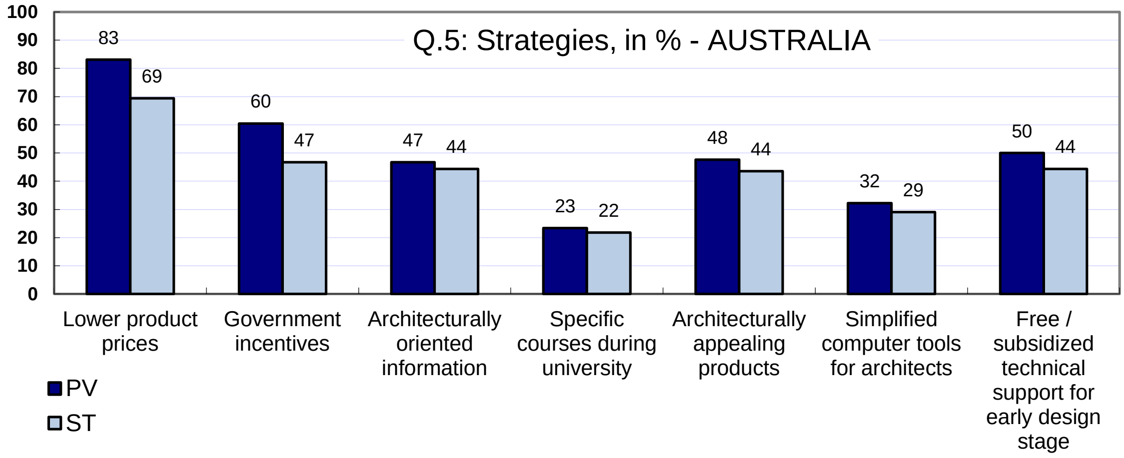

Figure 43: Strategies to promote use of PV and ST, Australia, n=124

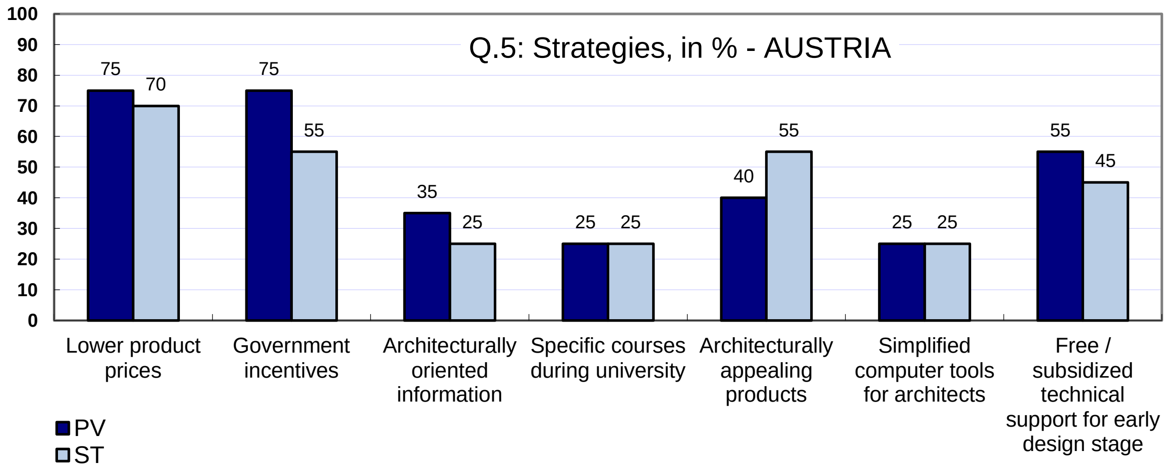

Figure 44: Strategies to promote use of PV and ST, Austria, n=20

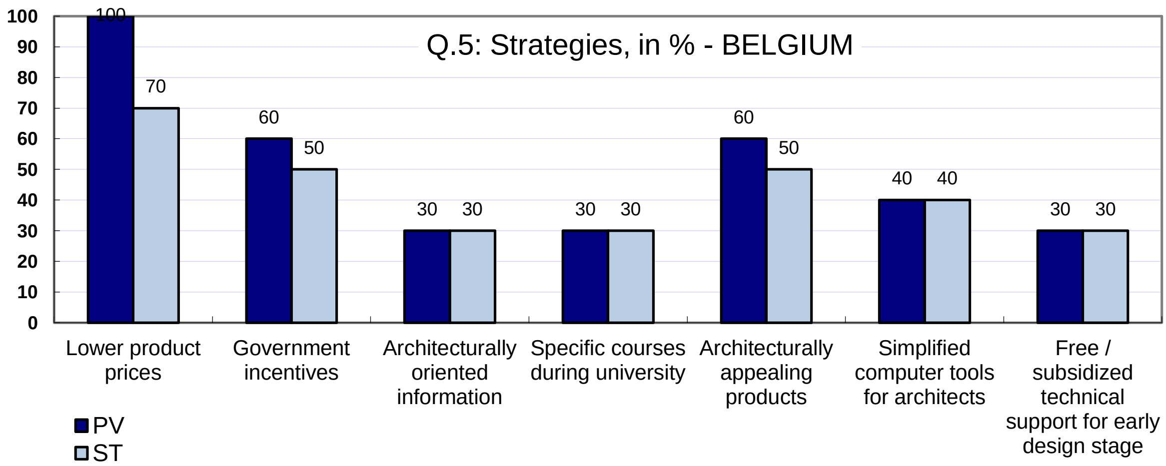

Figure 45: Strategies to promote use of PV and ST, Belgium, n=10

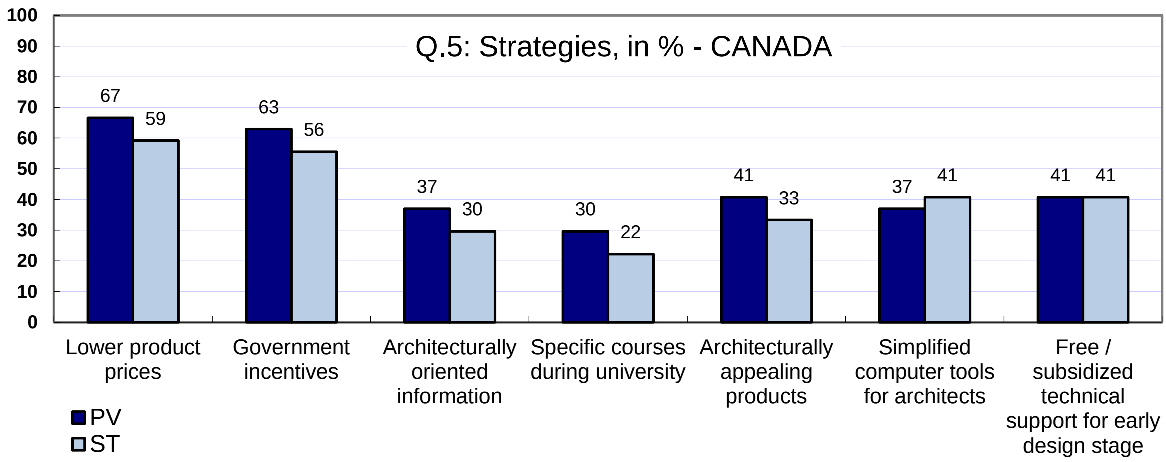

Figure 46: Strategies to promote use of PV and ST, Canada, n=27

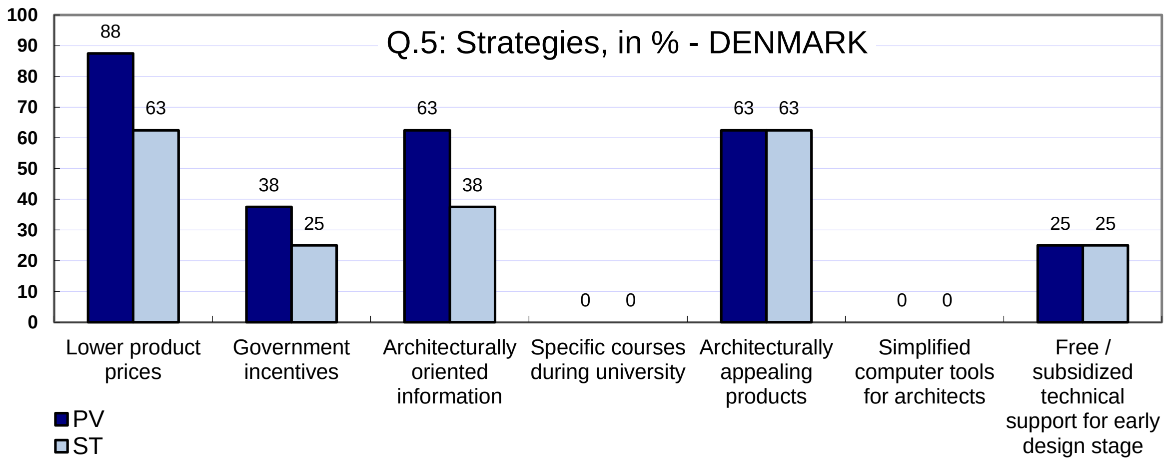

Figure 47: Strategies to promote use of PV and ST, Denmark, n=8

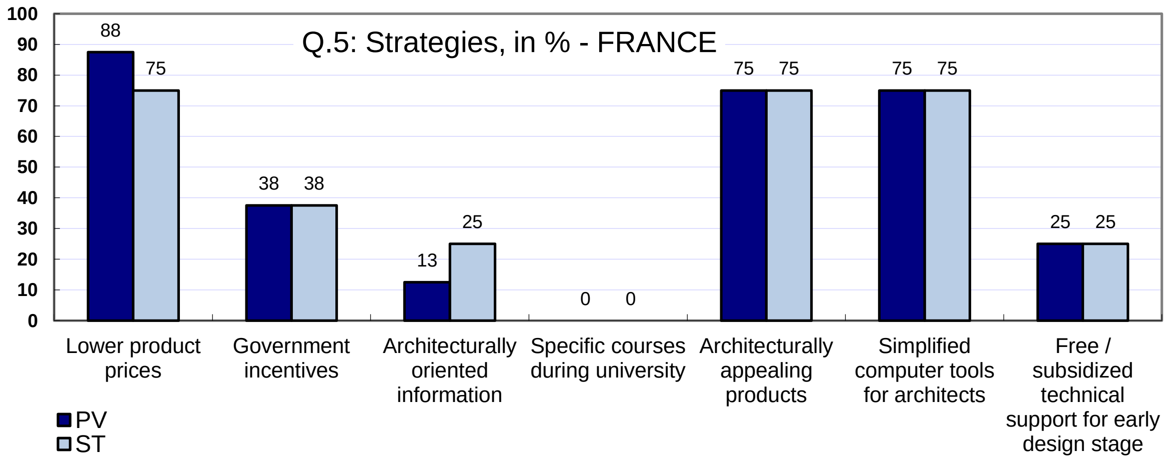

Figure 48: Strategies to promote use of PV and ST, France, n=8

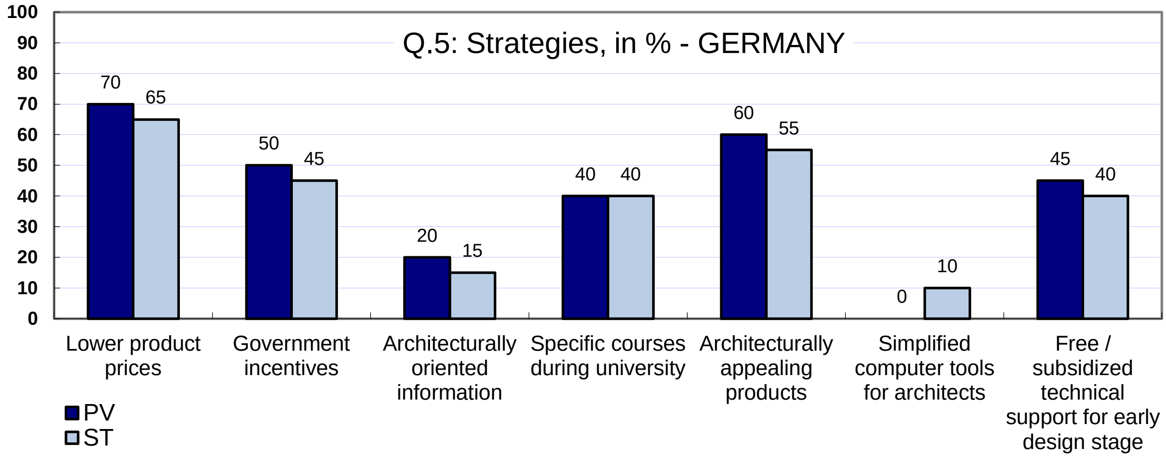

Figure 49: Strategies to promote use of PV and ST, Germany, n=20

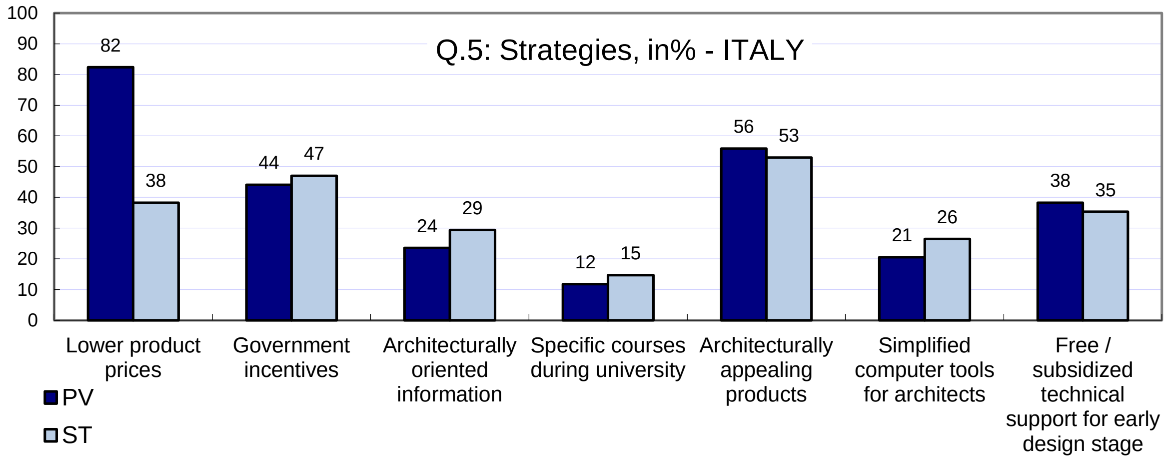

Figure 50: Strategies to promote use of PV and ST, Italy, n=34

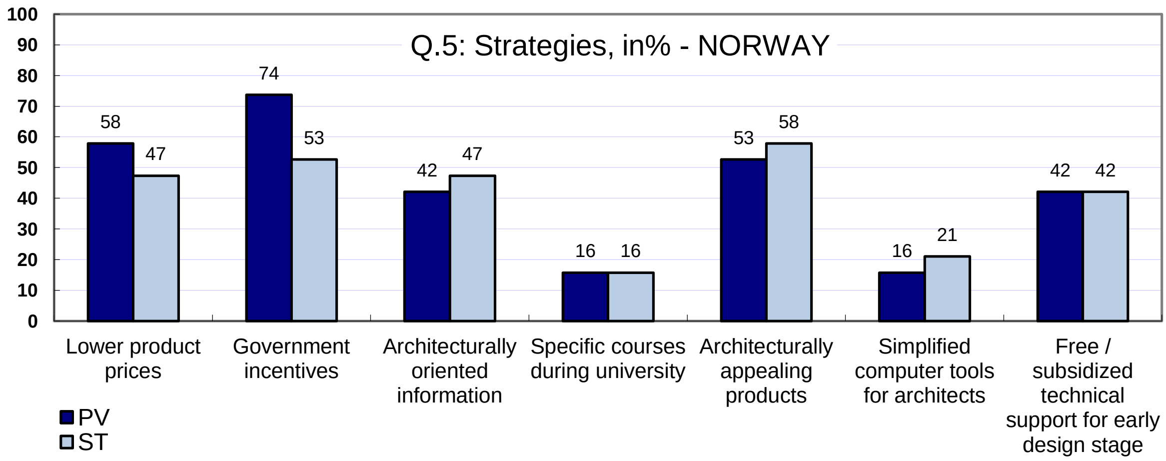

Figure 51: Strategies to promote use of PV and ST, Norway, n=19

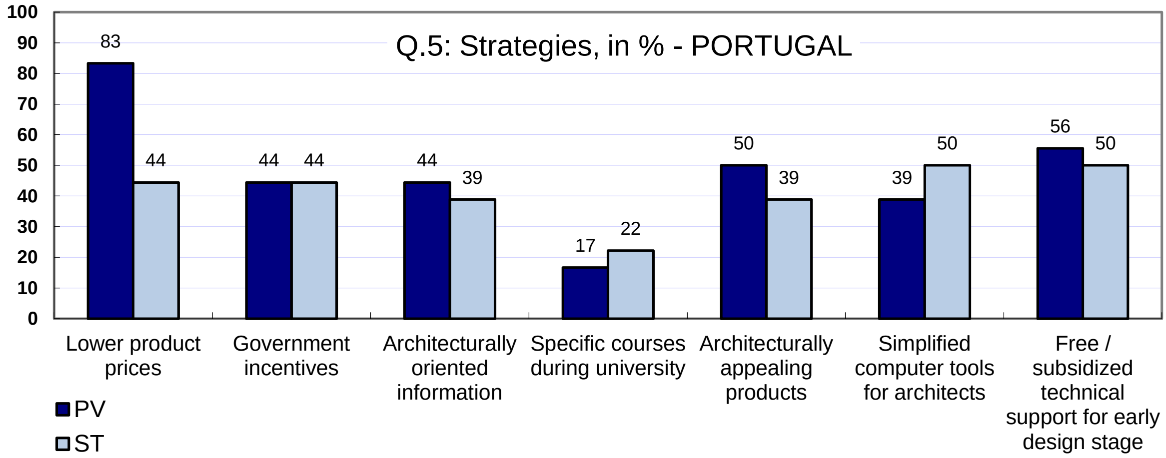

Figure 52: Strategies to promote use of PV and ST, Portugal, n=18

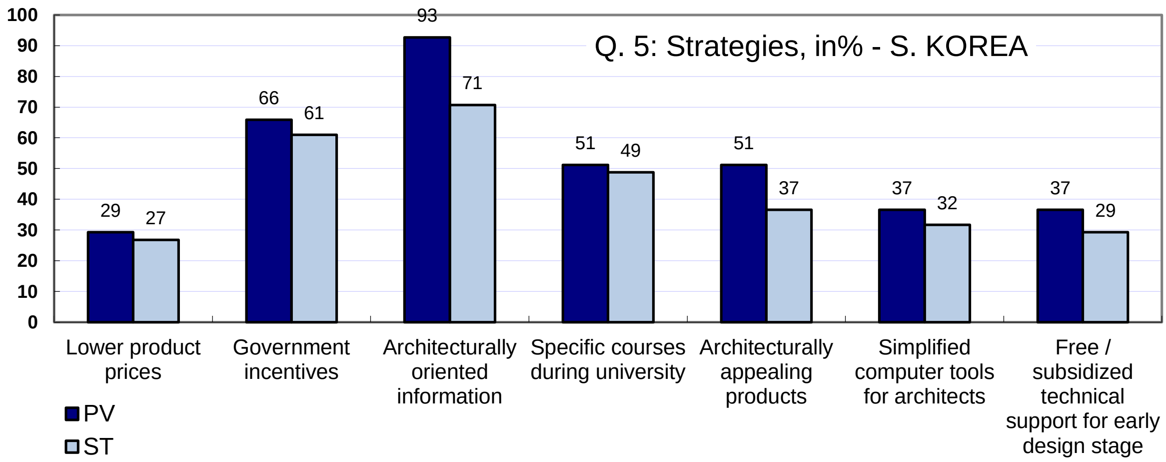

Figure 53: Strategies to promote use of PV and ST, South Korea, n=41

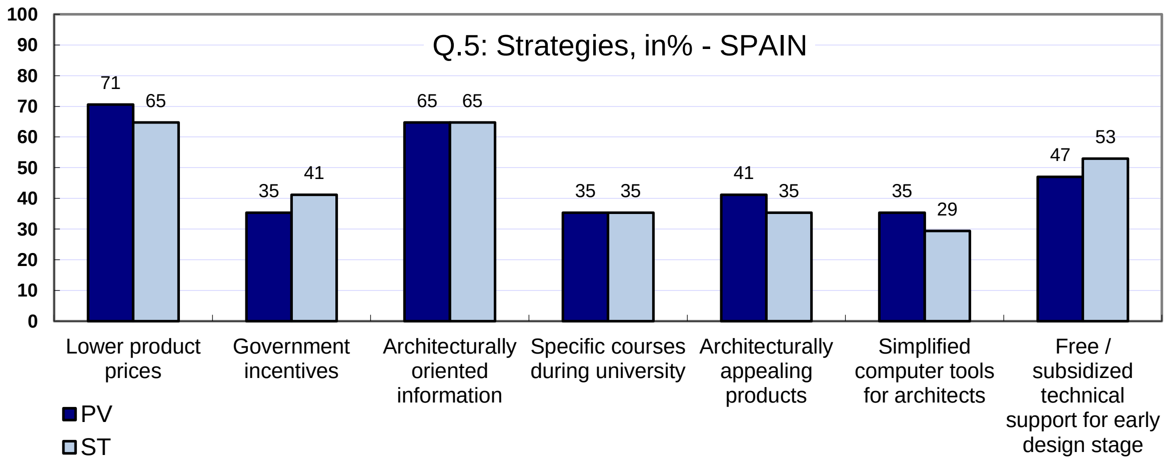

Figure 54: Strategies to promote use of PV and ST, Spain, n=17

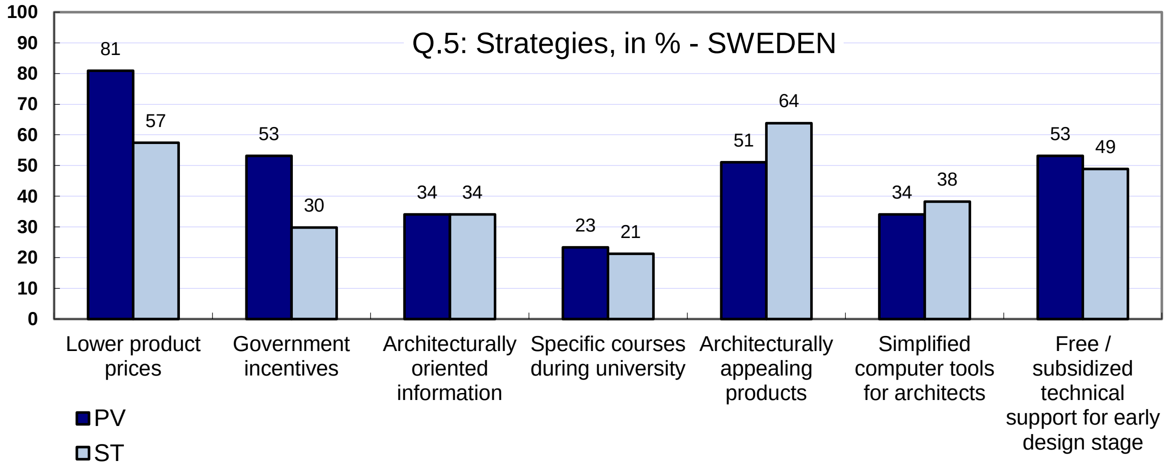

Figure 55: Strategies to promote use of PV and ST, Sweden, n=47

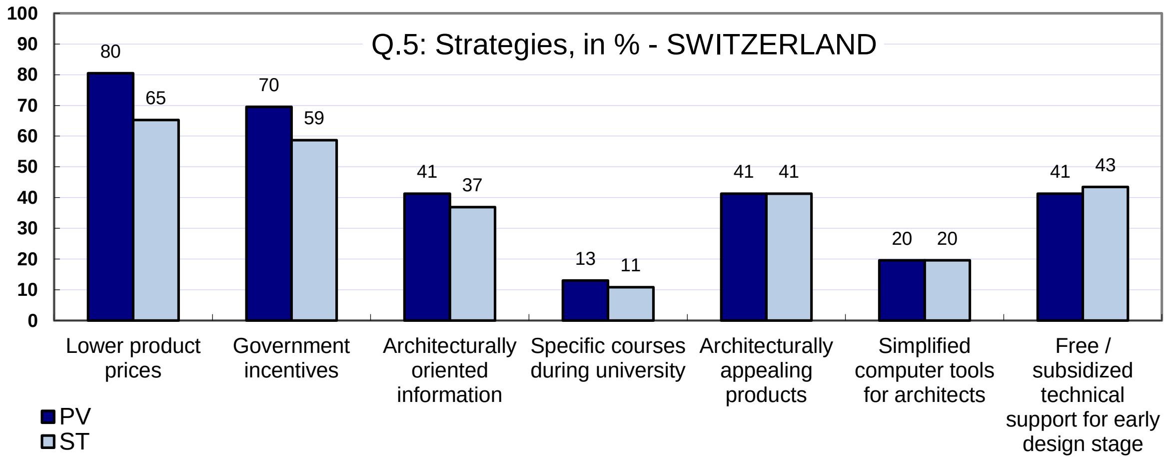

Figure 56: Strategies to promote use of PV and ST, Switzerland, n=46

Question 5: Strategies to promote use of PV and ST – other/additional comments

AUSTRALIA	More knowledge for the profession
	education the client, tv ads etc.
	We integrate solar thermal into all of our projects as a standard. Integration of PV's tends to be purely dollar based. The only way I can see peoples commitment to installation is for the price of PV's to reduce or for electricity supply cost to increase. Australian made products would also assist in convincing clients/developers to proceed. Most PV technology is imported; therefore there is a view of lack of support for local industry and lack of on-going service/maintenance as there is not a local manufacturer.
	Clear sources of information to clients which architects can refer clients to for their own detailed/job specific information.

	Availability and de-bullsh*tting.... There are so many charlatans in the industry now it is really hard to know who to trust! Another strategy would be to encourage the manufacturing of these technologies n Australia , so it is easily fixed, bought, recycled, future-proofed etc and climate resistant to sea, salt, sun, wind etc!!!
	Very happy to include in project but not always as integrated. I think you need to separate the issue to get better answers.
	Decent government subsidies should be available. When the system costs $20,000 and the subsidy is only $2,500 this is not equitable. Especially when to get the subsidy there are many extra requirements placed upon one.
	Sustained Federal and State Government support for both research and development of the technologies AND their transition to the AUSTRALIAN manufacturing sector - as opposed to taxpayer subsidising of technological gifts to competing countries.
	Availability of architecturally orientated information is equally important
	A database where an international accreditation system can be viewed ranking product according to lifespan, recyclability and supply chain. Possibility to lease these technologies as an ongoing building maintenance solution
	Definitely an industry professional association offering technical support would encourage wider understanding/use.
AUSTRIA	PV und ST wie vorher: verbindlicher nachweis der zielerreichung 2. strategie - breite aufklärungskampangne, dass sich solartechnik nicht "rechnen" muss - dass solartechnik zeichen einer moral, einer notwendigen kulturellen ethik ist - zeichen einer selbstbestimmten gesellschaft(sordnung) ist - kein mensch fragt nach, wann sich die klimaautomatik im auto "rechnet" *PV and ST like before: mandatory certificate for target achievement. 2. Strategy – broad educational campaign, that solar technologies do not have to “pay off” –solar technology is a sign for moral, a necessary cultural ethic – a sign for a self determined society (social order) – nobody asks, when will the car’s air-conditioning “pay off”*
CANADA	we also need to develop different contract documents that allow for sequential sub-consultants, OR go design build.
	non seulement le coût des produits mais le retour sur l'investissement est trop long, il ne doit jamais dépasser 5 ans. *Not only the cost of products is too high, but the payback is too long, it should never exceed 5 years.*
	Augmenter les coûts de l'hydro-électricité pour refléter le coût réel. Offrir alors des subventions pour améliorer l'enveloppe des bâtiments existants et éduquer les gens à une bonne pratique énergétique, surtout pour les ménages à faibles revenus.

	There needs to be an increase in the costs of hydropower to reflect the actual cost first. Then, there should be subsidies granted to improve the existing buildings and to educate people to make good use of energy resources, especially in low-income households.
FRANCE	Le principal frein est le surcoût. *The main obstacle is the extra cost.*
GERMANY	Bewusstsein, fossile Energie zu substituieren *Awareness to substitute fossil energy*
	umfassende Energieberatung *Extensive energy consulting*
ITALY	Occorre obbligare i comuni, tramite sanzioni per chi non si adeguerà, a recepire le normative e le leggi che obbligano l'installazione di fonti rinnovabili su edifici civili e commerciali-industriali, di nuova costruzione, in modo tale da mettere in condizione gli architetti, di progettare l'edificio già in fase preliminare, con impianti architettonicamente integrati in spazi predisposti. *Municipalities should be obliged, through penalties for those who do not adapt, to incorporate regulations and laws requiring the incorporation of renewable energy sources for residential and commercial-industrial buildings, new construction, from the stage of building permit, thus enabling architects to include integration of renewable energy systems from the preliminary design stage.*
	Prezzi più bassi *Lower prices*
	vedasi punto precedente (accesso al strumenti di finanziamento) *Look the previous point (access to funding instruments) [referring to Q.4 comment]*
PORTUGAL	No caso dos sistema fotovoltaicos, disponibilização de tecnologia com mais elevado rendimento; no caso dos sistemas solares térmicos, mais implementação de soluções integradas para AQS e climatização. *In the case of the photovoltaic system, availability of technology with higher performance; in the case of solar thermal systems, better implementation of integrated solutions for DHW and heating.*
	Solar Fotovoltaico e Térmico: Formação de arquitectos e engenheiros (outras especialidades que não a das energias renováveis, especialmente AVAC, electricidade, águas e esgotos) *Photovoltaic and Solar Thermal: Better education of architects and engineers (other than the specialties of renewable energy, especially HVAC, electricity,*

	water and sewerage)
	there is no such thing as free lunch > apoio técnico gratuito tem que ser pago por alguem sem que saibamos quem exactamente: o consumidor ou o fabricante... Ordens não podem pagar apoio técnico gratuito! *there is no such thing free lunch the > free technical support has to be paid by someone, either the consumer or the manufacturer ... Orders cannot afford free technical support! [referring to the survey option of free technical support]*
SPAIN	Acceder a la información dese una única instancia. En las jornadas de INVISO se hablaba de esta disponbilidad de la información, pero no se llega a desarrollar, o si lo ghace a los arquitectos no nos llega. *Accessibility to information from a single source. In the training of INVISO people talked about availability of information, but it is not developed or architects do not know about it.*
SWEDEN	More expensive other energy would make solar energy systems more interesting for the investor
	promotion by good showcases, and visits/study trips
SWITZERLAND	verständliche Infos für die Investoren, Endverbraucher *understandable information for investors, final consumers*
	Substantielle CO_2-Abgabe zur Förderung von Solartechnologien einführen ;) Leider ist kein politischer Wille da. *Implementation of substantial CO2-fee for support/promotion of solar technologies ;) Unfortunately there is no political will.*
	Ich habe sie von 1976-1995 angewandt. Mit der Passibhaustechnik verschwindet der Heizenergiebedarf ganz, resp. er verlagert sich so sehr in den Winter, dass die Sonnenenergie keinen Beitrag mehr leisten kann. *I used it between 1976 and 1995. With the passive house technology the heating demand disappears, respectively it is dislocated extremely to wintertime, so that solar energy can't contribute anymore.*
	FÜR DIE ÖFFENTLICHE HAND: NICHT SCHWATZEN UND TEURE SEMINARIEN UND KURSE VERANSTALTEN - GEFRAGT SIND TUN UND FORTSCHRITTLICHE ENTSCHEIDE¨¨¨ *For the public authorities: no chatting and arranging of expensive seminars and courses – it is in demand action and progressive decisions.*
	Von mir wird nur kosteneckende Einspeisevergütung für Photovoltaik gewünscht *I only desire cost-covering feed-in tariffs for photovoltaics.*
	Broschüre mit guten Beispielen, ähnlich Holzbulletin der Lignum. Wichtig:

	Schöne Fotos und architektonische Überlegungen mit einbeziehen, so dass die Broschüre in den Architekturbüros gelesen und vielleicht sogar aufbewahrt wird. Es soll zum guten Ton gehören, Solarenergie ins Gebäude zu integrieren. *Brochure with good examples, similar to „Holzbulletin" by Lignum. Important: Include beautiful photos and architectural thoughts, so the brochure will be read and maybe also kept in the architectural offices. It should be considered good manners (good thing to do) to integrate solar energy into the building.*
	Photovoltaïque : Acceptation réelle et sincère de la filière par les entreprises électriques. Négociations entre partenaires. *PV: There needs to be a sincere acceptance of the sector by the existing electricity companies. Negotiations between partners.*
	difficoltà a gestire questi prodotti nell'ambito dei sistemi informatici (CAD) più utilizzati (ArchiCAD e AutoCAD) *Difficulty to manipulate/manage these systems in the predominantly used CAD tools (ArchiCAD and AutoCAD)*

Questions 7 to 11 – Factual information on design methods and processes

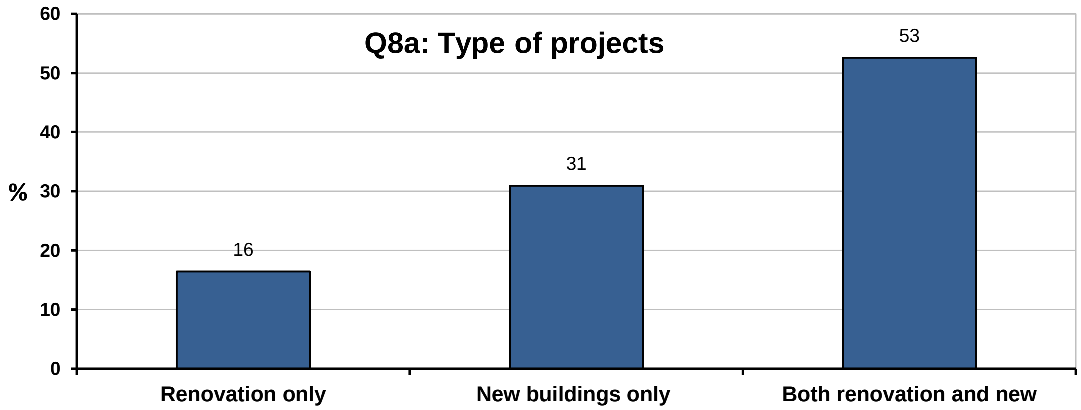

Figure 57: Type of projects, all countries, n=407

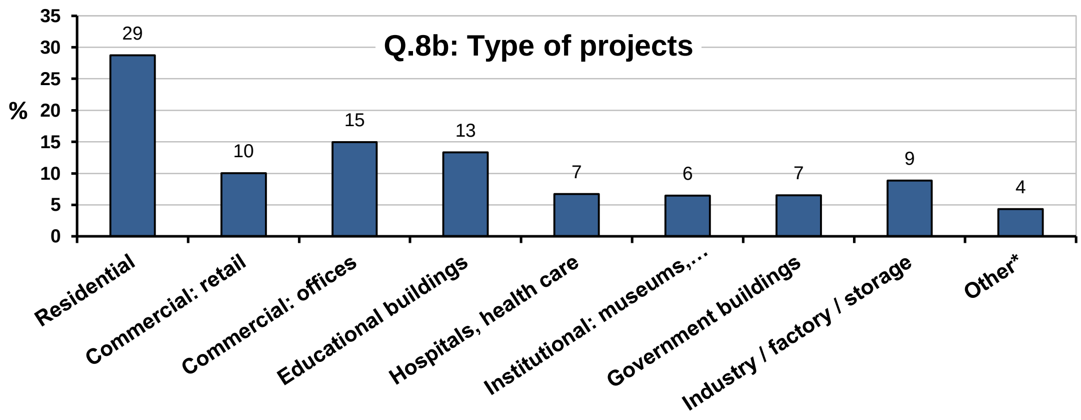

Figure 58: Type of projects, all countries, multiple selections, n=1176

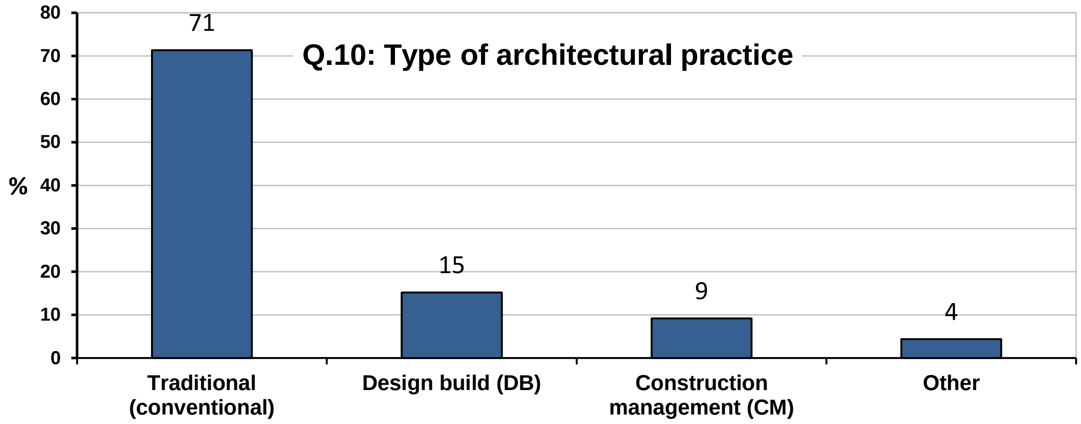

Figure 59: Predominant type of architectural practice, all countries, n=415

Figure 60: National vs. international portfolio, all countries, n=408

Questions 12 to 15 – Demographics of respondents

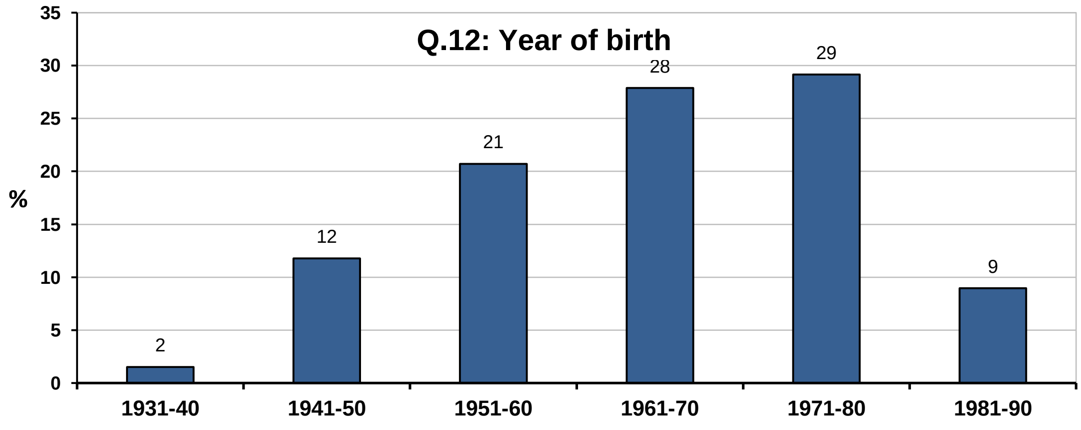

Figure 61: Respondents' year of birth, all countries, n=391

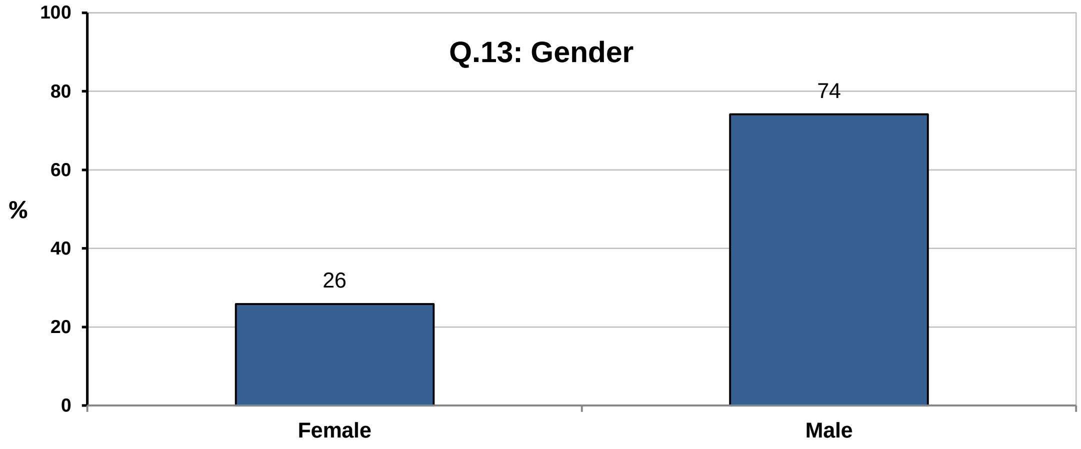

Figure 62: Gender of the respondents, all countries, n=414

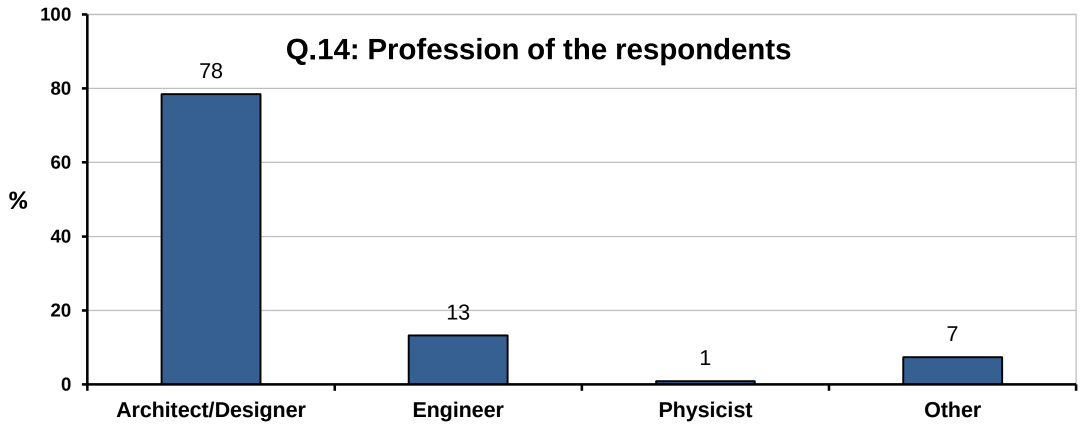

Figure 63: Profession of the respondents, all countries, n=446

Figure 64: Respondents' years of professional experience, all countries, n=404

APPENDIX 3

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA Solar Heating and Cooling Programme

The International Energy Agency (IEA) is an autonomous body within the framework of the Organization for Economic Co-operation and Development (OECD) based in Paris. Established in 1974 after the first "oil shock," the IEA is committed to carrying out a comprehensive program of energy cooperation among its members and the Commission of the European Communities.

The IEA provides a legal framework, through IEA Implementing Agreements such as the Solar Heating and Cooling Agreement, for international collaboration in energy technology research and development (R&D) and deployment. This IEA experience has proved that such collaboration contributes significantly to faster technological progress, while reducing costs; to eliminating technological risks and duplication of efforts; and to creating numerous other benefits, such as swifter expansion of the knowledge base and easier harmonization of standards.

The Solar Heating and Cooling Programme was one of the first IEA Implementing Agreements to be established. Since 1977, its members have been collaborating to advance active solar and passive solar and their application in buildings and other areas, such as agriculture and industry. Current members are:

Australia	Germany	Portugal
Austria	Finland	Singapore
Belgium	France	South Africa
Canada	Italy	Spain
China	Mexico	Sweden
Denmark	Netherlands	Switzerland
European Commission	Norway	United States

A total of 49 Tasks have been initiated, 35 of which have been completed. Each Task is managed by an Operating Agent from one of the participating countries. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition to the Task work, a number of special activities—Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops—have been undertaken.

Visit the Solar Heating and Cooling Programme website - www.iea-shc.org - to find more publications and to learn about the SHC Programme.

Current Tasks & Working Group:

Task 36	Solar Resource Knowledge Management
Task 39	Polymeric Materials for Solar Thermal Applications
Task 40	Towards Net Zero Energy Solar Buildings
Task 41	Solar Energy and Architecture
Task 42	Compact Thermal Energy Storage
Task 43	Solar Rating and Certification Procedures
Task 44	Solar and Heat Pump Systems
Task 45	Large Systems: Solar Heating/Cooling Systems, Seasonal Storages, Heat Pumps
Task 46	Solar Resource Assessment and Forecasting
Task 47	Renovation of Non-Residential Buildings Towards Sustainable Standards
Task 48	Quality Assurance and Support Measures for Solar Cooling
Task 49	Process Heat for Production and Advanced Applications

Completed Tasks:

Task 1	Investigation of the Performance of Solar Heating and Cooling Systems
Task 2	Coordination of Solar Heating and Cooling R&D
Task 3	Performance Testing of Solar Collectors
Task 4	Development of an Insolation Handbook and Instrument Package
Task 5	Use of Existing Meteorological Information for Solar Energy Application
Task 6	Performance of Solar Systems Using Evacuated Collectors
Task 7	Central Solar Heating Plants with Seasonal Storage
Task 8	Passive and Hybrid Solar Low Energy Buildings
Task 9	Solar Radiation and Pyranometry Studies
Task 10	Solar Materials R&D
Task 11	Passive and Hybrid Solar Commercial Buildings
Task 12	Building Energy Analysis and Design Tools for Solar Applications
Task 13	Advanced Solar Low Energy Buildings
Task 14	Advanced Active Solar Energy Systems
Task 16	Photovoltaics in Buildings
Task 17	Measuring and Modeling Spectral Radiation
Task 18	Advanced Glazing and Associated Materials for Solar and Building Applications
Task 19	Solar Air Systems
Task 20	Solar Energy in Building Renovation
Task 21	Daylight in Buildings
Task 22	Building Energy Analysis Tools
Task 23	Optimization of Solar Energy Use in Large Buildings
Task 24	Solar Procurement
Task 25	Solar Assisted Air Conditioning of Buildings
Task 26	Solar Combisystems
Task 27	Performance of Solar Facade Components
Task 28	Solar Sustainable Housing
Task 29	Solar Crop Drying
Task 31	Daylighting Buildings in the 21st Century
Task 32	Advanced Storage Concepts for Solar and Low Energy Buildings
Task 33	Solar Heat for Industrial Processes
Task 34	Testing and Validation of Building Energy Simulation Tools
Task 35	PV/Thermal Solar Systems
Task 37	Advanced Housing Renovation with Solar & Conservation
Task 38	Solar Thermal Cooling and Air Conditioning

Completed Working Groups:

CSHPSS; ISOLDE; Materials in Solar Thermal Collectors; Evaluation of Task 13 Houses; Daylight Research