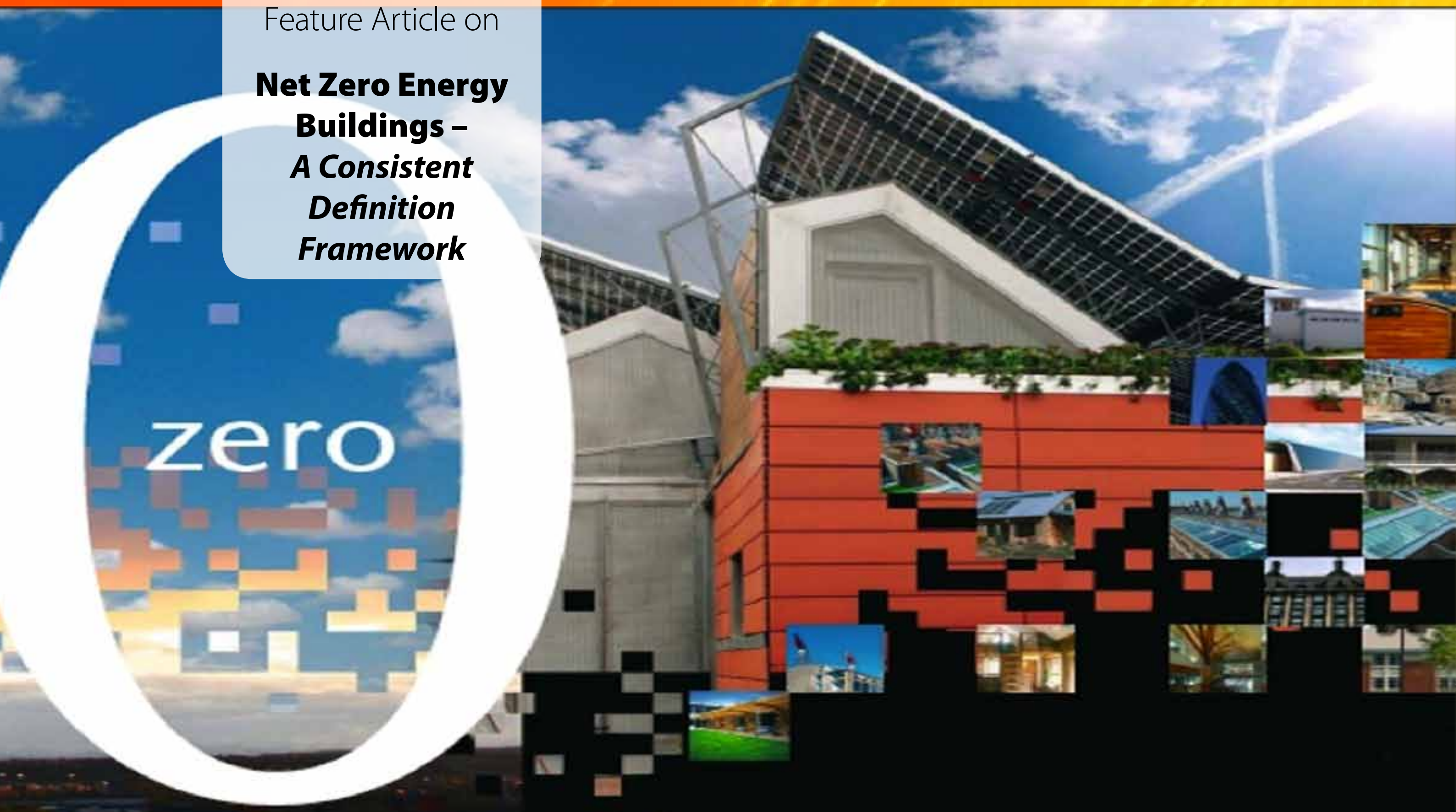
IEA SOLAR HEATING & COOLING PROGRAMME

2011

ANNUAL REPORT

Feature Article on

Net Zero Energy Buildings –
A Consistent Definition Framework



IEA Solar Heating & Cooling Programme

2011 Annual Report

Edited by
Pamela Murphy
SHC Secretariat
IEA Solar Heating and Cooling Programme

www.iea-shc.org

July 2012

IEA & SHC Programme

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.

The multilateral technology initiatives (Implementing Agreements) supported by the IEA are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organizations and non-government organizations to research breakthrough technologies, to fill existing research gaps, to build pilot plants, to carry out deployment or demonstration programmes – in short to encourage technology-related activities that support energy security, economic growth and environmental protection.

SHC MEMBER COUNTRIES 2011

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

More than 6,000 specialists carry out a vast body of research through these various initiatives. To date, more than 1,000 projects have been completed. There are currently 41 Implementing Agreements (IA) working in the areas of:

- Cross-Cutting Activities (information exchange, modelling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- Renewable Energies and Hydrogen (technologies and deployment)

The IAs are at the core of a network of senior experts consisting of the Committee on Energy Research and Technology (CERT), four working parties and three expert groups. A key role of the CERT is to provide leadership by guiding the IAs to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed. For further information on the IEA, the CERT and the IAs, please consult www.iea.org.

SOLAR HEATING AND COOLING PROGRAMME

The Implementing Agreement for a Programme to Develop and Test Solar Heating and Cooling Systems (referred to as the Solar Heating and Cooling Programme or SHC Programme) was established in 1977 as one of the first Implementing Agreements in the IEA. The SHC Programme's work is unique in that it is accomplished through the international collaborative effort of experts from Member countries and the European Commission. The benefits of such an approach are numerous, namely, it accelerates the pace of technology development, promotes standardization, enhances national R&D programmes, permits national specialization, and saves time and money.

SHC Mission

To advance international collaborative efforts for solar energy and provide significant added value to national R,D & D, and policy and program initiatives related to the built environment and for agricultural and industrial process heat to reach the goal set in the vision of contributing up to 50% of the low temperature heating and cooling demand by 2030.

This mission assumes a whole building approach to the application of solar technologies and designs. Based on this mission, the Programme will continue to cooperate with other IEA Implementing Agreements as well as the solar industry to expand the solar market. Through international collaborative activities, the Programme will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data, etc. and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for agricultural and industrial process heat applications.

To fulfill this mission, the Programme will direct its results to the design community, the solar manufacturers, and the energy supply and service industries that serve the end-users and building owners.

Our Objectives

The SHC Executive Committee has agreed upon the following objectives and associated strategies to fulfill its mission.

<u>SHC Objective 1</u>
To be the primary source of high quality technical information and analysis on solar heating and cooling technologies, designs and applications.

Strategies

- Assure that technical **information** and **analysis** developed in this Agreement is available and disseminated to the target audiences in useful formats.
- Working through relevant international standards organizations, support the development and harmonization of **standards** necessary for the widespread use of solar designs and technologies in the building, agricultural and industrial sectors.

<u>SHC Objective 2</u>
To contribute to a significant increase in the performance of solar heating and cooling technologies and designs.

Strategies

- Increase **user acceptance** of solar designs and technologies.
- Continue to develop **cost-effective** designs and technologies in collaboration with appropriate intermediary industries.
- Identify and prioritize **R&D needs** for solar heating and cooling that will lead to expanded markets

<u>SHC Objective 3</u>
To enhance cooperation with industry and government on increasing the market share of solar heating and cooling technologies and designs.

Strategies

- Work with appropriate **intermediary industries** and end users to accelerate the market penetration of solar designs and technologies.
- Work with governments to promote and expand **favorable policies** to increase the market share.
- Work towards or support the greater use of solar designs and technologies in **developing countries**.
- Work to address issues regarding building design, aesthetics and architectural value.

<u>SHC Objective 4</u>
To increase the awareness and understanding on the potential and value of solar heating and cooling systems by providing information to decision makers and the public.

Strategies

- **Communicate** the value of solar heating and cooling designs and technologies in publications, conferences, workshops and seminars to the public and relevant stakeholders.
- Provide **analysis** that links solar heating and cooling designs and technologies to energy security concerns, environmental and economic goals.
- **Quantify and publicize** the environmental, economic and climate change benefits of solar heating and cooling and supporting policy measures solar design and technologies in meeting environmental targets and addressing policies and energy, supply security.
- **Review** our products in relation to our objectives – Annual Reports, Solar Update Newsletters, National Programme Review Reports, "*Solar Heating Worldwide: Markets and Contributions to the Energy Supply report.*"
- **Present** the SHC Solar Award annually/bi-annually. **Maintain** the SHC web site.

The SHC Programme is headed by an Executive Committee composed of one representative from each Member country and Sponsor organizations, while the management of the individual projects (Tasks) is the responsibility of project managers (Operating Agents) who are selected by the Executive Committee. Forty-seven Tasks have been initiated since the beginning of the Programme.

The Programme's work is augmented through collaboration with other IEA Programmes, such as the Energy Conservation in Buildings and Community Systems Programme, the Photovoltaic Power Systems Programme, and the SolarPACES Programme, as well as solar trade associations in Europe, North America, and Australia.

Chairman's Report

Werner Weiss
AEE INTEC, Austria

2011 was once again a successful year for the Solar Heating and Cooling Programme even if the market in some regions was challenging for the industry. In this environment it is especially important to increase our efforts in informing policy and decision makers about the possibilities of solar thermal as well as the achievements of our Implementing Agreement.

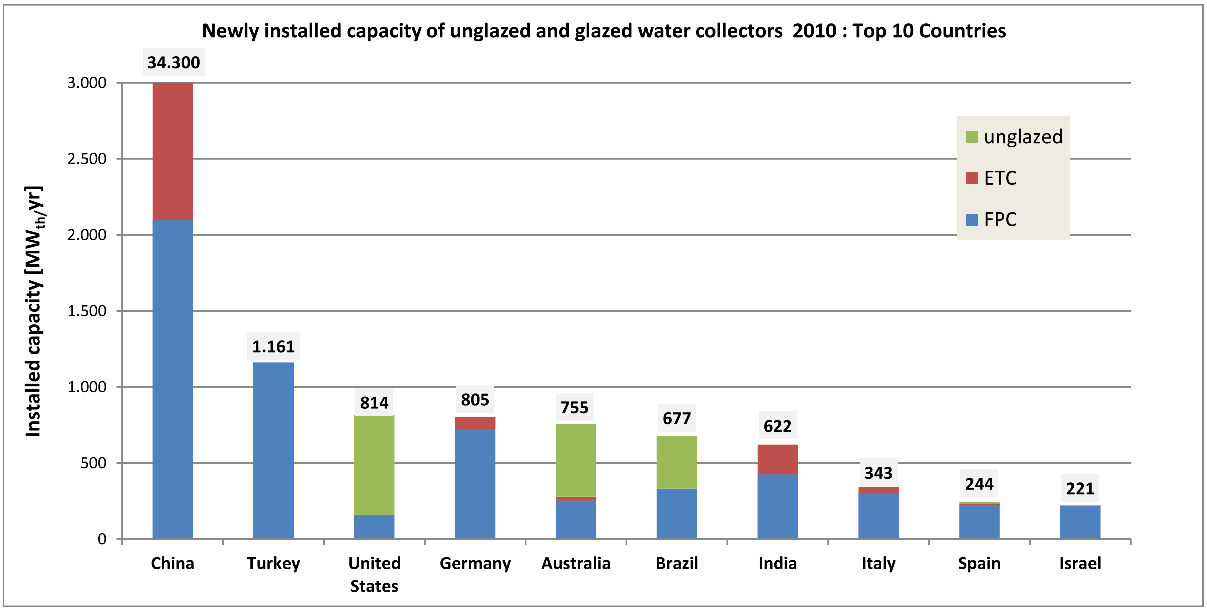
2011 marked the first year of the SHC Information Center. The main goal of this Center is to increase the awareness of the potential of solar heating and cooling. It will achieve this through focused information on our Task results, general up-to-date information on solar heating and cooling, and information on worldwide trends in the solar heating and cooling industry.

Another new activity that started in 2011 is our annual scientific and policy conference on solar heating and cooling. These conferences will be organized in close cooperation with solar trade organizations. The *1st International Conference on Solar Heating and Cooling for Buildings and Industry* was held on July 9 – 11, 2012 in San Francisco, California. The Executive Committee is happy to organize this conference in cooperation with Intersolar North America and the California Solar Energy Industries Association CALSEIA.

At the SHC 2012 conference, the prestigious *SHC Solar Award* was presented to Dr. Fred Morse. For further information on the conference please visit http://www.shc2012.org.

SOLAR THERMAL OUTLOOK

The SHC Programme publishes the only annual global statistics report, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply*. The 2012 edition reports that in 2010, solar thermal technologies produced **183,173 GWh** – which relates to an oil equivalent of over 27.9 million tons and annual avoidance of 85.5 million tons of CO_2 emissions. New installations grew 13.7 % compared to 2009 again with China as a main market driver and absolute leader in terms of cumulated area installed and followed by Turkey, the United States, Germany and Australia.



Total capacity of newly installed glazed and unglazed water collectors in the 10 leading countries in 2010

Key findings:

- Cumulated capacity in 2010 in operation was 221.1 GW_{th} (315.8 million square meters):
  - 198.3 GW_{th} flat-plate and evacuated tube collectors
  - 21.5 GW_{th} unglazed plastic collectors
  - 1.3 GW_{th} air collectors
- China and Europe accounted for 94.7% of the world's market for all new installations.
- Market penetration of newly installed glazed water collectors (installed capacity per 1,000 inhabitants) leading countries are:
  - Israel: 30.1 kW_{th}; China: 25.8 kW_{th}; Austria: 23.9 kW_{th}; Cyprus: 22.0 kW_{th}; Turkey: 14.9 kW_{th}
- 2011 data estimate total capacity in operation is 270 GW_{th}

One major trend shows that solar thermal systems reached the Megawatt-scale in several applications. The world's biggest solar thermal plant with a capacity of 25 MW_{th} (36,000 m² collector area) was installed in 2011 in Saudi Arabia. Also a huge 3.900 m² solar cooling plant with a cooling capacity of 1.6 MW was installed in Singapore and moreover large-scale district heating systems in Canada and especially in Denmark boomed in 2011. In all of these large-scale systems, experts of the Solar Heating and Cooling Programme played a central and important role and were able to apply the results of the various results of ongoing or completed Tasks.

25 MW solar thermal plant at the Princess Noura bint Abdul Rahman University in Riyadh, Saudi Arabia

SHC ACTIVITIES

Tasks

The SHC Programme continues to push forward on cutting edge topics in solar thermal as well as in the field of solar buildings and architecture, all of which support our strategic focus on market deployment and R&D. In 2011 –

Work started in the area of solar cooling:

- Task 48: Quality Assurance and Support Measures for Solar Cooling *(Lead Country: France)*

  The Task builds upon our solar cooling work in Task 25 and Task 38. Experts will collaborate to develop a strong and sustainable market for solar cooling systems. The focus is on systems that include any solar thermal cooling technology (no limitation on power or solar collector field area) that can be used in a heating mode.

Work will begin on SHIP in 2012:

- Task 49: Solar Process Heat for Production and Advanced Applications *(Lead Country: Austria)*

  The Task builds upon our work in Task 33 and collaboration with the IEA SolarPACES Programme. In this new field of solar thermal applications, international collaboration will focus on developing and improving components and systems, developing tools for system optimization and installing and monitoring large-scale demonstration systems.

Work was proposed in two key areas:

- Solar Energy and Urban Planning *(Task Organizer: Sweden)*

  This work will focus on helping urban planners and architects achieve urban areas, and eventually entire cities, with architecturally integrated solar systems. It is proposed to collaborate with other IEA Programmes, such as the PVPS and ECBCS Programmes.

- Advanced Lighting Solutions for Retrofitting Buildings *(Task Organizer: Germany)*

  This work will build upon SHC Tasks 21, 31, 46 and 47 as well as work in the ECBCS Programme.

Collaboration With Other IEA Programmes & International Organizations

To support our work, the SHC Programme is collaborating with other IEA Programmes and solar organizations.

Within the IEA

IEA Energy Conservation in Buildings and Community Systems Programme is collaborating in *SHC Task 40: Net Zero Energy Solar Buildings*.[1] In addition, another joint meeting of the Executive Committees will be held in June 2013 in Italy.

IEA Energy Conservation through Energy Storage Programme is collaborating in *SHC Task 42: Compact Thermal Energy Storage*. This is the first fully joint Task with Operating

[1] As outlined in the SHC Policy & Procedures Handbook

Agents from each Programme. The Executive Committees held a joint meeting in November 2011 in conjunction with their respective Executive Committee meetings.

Members of the *Solar Heating and Cooling Programme* and the *Energy Conservation through Energy Storage Programme*

IEA Heat Pump Programme is collaborating in *SHC Task 44: Systems Using Solar Thermal Energy in Combination with Heat Pumps.*

IEA Photovoltaic Power Systems Programme is collaborating in *SHC Task 46: Solar Resource Assessment and Forecasting*.

IEA SolarPACES Programme is collaborating in *SHC Task 46: Solar Resource Assessment and Forecasting.*

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC Programme to increase national and international government agencies and policymakers awareness of solar thermal's potential and to encourage industry to use solar thermal R&D results in new products and services.

To support this collaboration, the *6th SHC/Trade Association* meeting was held October 19, 2011 in conjunction with *estec 2011* in Marseille, France. The 7th meeting is planned for July 2012 in conjunction with the SHC 2012 conference in San Francisco, California.

ETP RHC (European Technology Platform on Renewable Heating and Cooling), the SHC Programme, represented by Mr. Lex Bosselaar and Mr. Werner Weiss, continues to serve on the ESTTP Steering Committee and on the Platform's board to support the Platform's objectives.

EXECUTIVE COMMITTEE MEETINGS

2011 Meetings

The Executive Committee held two meetings:

- June 6-8 in Copenhagen, Denmark
- November 9-11 in Bad Aibling, Germany

2012 Meetings
The Executive Committee will hold two meetings:

- July 12-13 in San Francisco, California, USA
- November 27-29 in Belgium

A SUCCESSFUL TEAM

Last but not least I want to thank the vice chairmen Markus Kratz and João A. Farinha Mendes, all members of the Executive Committee, the Operating Agents of the Tasks as well as all experts working in our projects, the secretariat, Pamela Murphy, the webmaster, Randy Martin, and our communication manager, Uwe Trenkner. This excellent team guaranteed that SHC had another successful year.

Werner Weiss

Membership

CONTRACTING PARTIES

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

Participation in the Programme remains strong with 19 Member countries and the European Commission actively involved in the Programme's management and the work of the Tasks.

Communication continued with countries invited to join the Programme–Brazil, Chile, China, India, Japan, Slovenia, South Korea, and Ukraine.

In 2011, the Executive Committee unanimously voted to invite:

- Luxembourg to join the Agreement as a Contracting Party,
- Gulf Organization of Research and Development (GORD) of Qatar as a Sponsor, and
- Economic Community of West African States' Regional Centre for Renewable Energy and Energy Efficiency (ECREEE) as a Sponsor.

REASONS TO JOIN

The SHC Programme is unique in that it provides an international platform for collaborative R&D work in solar thermal. The benefits for a country to participate in this Programme are numerous.

- Accelerates the pace of technology development through the cross fertilization of ideas and exchange of approaches and technologies.

- Promotes standardization of terminology, methodology and codes & standards.
- Enhances national R&D programs thorough collaborative work.
- Permits national specialization in technology research, development, or deployment while maintaining access to information and results from the broader project.
- Saves time and money by sharing the expenses and the work among the international team.

HOW TO PARTICIPATE

Learn More
Visit our website — www.iea-shc.org — to stay up to date on our Tasks, to find publications, to contact Executive Committee members and project managers (Operating Agents).

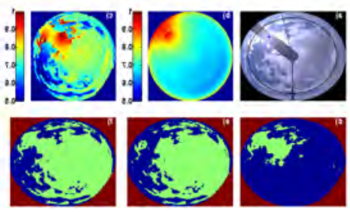
Become A Member
If your ***country is not a SHC Member*** of the Programme, but your government agency or organization is interested in joining the Progamme, please contact the SHC Secretariat for information *(secretariat@iea-shc.org).*

If you represent an ***international industry association or international non-profit organization*** it is possible to become a Sponsor Member, please contact the SHC Secretariat for information *(secretariat@iea-shc.org).*

Become An Expert
If your ***country is a SHC Member*** of then contact the Operating Agent of the Task you are interested in joining and contact the Executive Committee member from your country.

Task Highlights

TASK 36: SOLAR RESOURCE KNOWLEDGE MANAGEMENT



This Task ended June 2011. Work during the year has focused on finalizing reports and the publication, Handbook on Solar Radiation. This work area will be continued in the new Task 46: Solar Resource Assessment and Forecasting.

This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement and SolarPACES Implementing Agreement.

TASK 39: POLYMERIC MATERIALS FOR SOLAR THERMAL APPLICATIONS

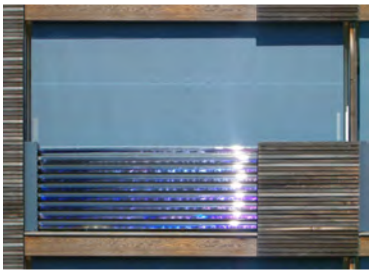
Comparative energy monitoring of pressure-less drain-back systems with polymeric collectors and conventional collectors were tested at the outdoor facilities of AEE INTEC in Gleisdorf, Austria.

TASK 40: TOWARDS NET ZERO ENERGY SOLAR BUILDINGS

The major highlight of 2011 was the publishing of Volume 1 of the NetZEB Sourcebook by a well-known German publisher in English as well as a German language edition. Volume 1 deals with the history, theory, and project experiences from all building types, including projects in North American and European countries, taking into account all projects of architectural & conception relevance. In 2011 about 1400 German copies and another 650 English were sold.

This is a collaborative Task with the IEA Energy Conservation in Buildings and Community Systems Implementing Agreement.

TASK 41: SOLAR ENERGY & ARCHITECTURE



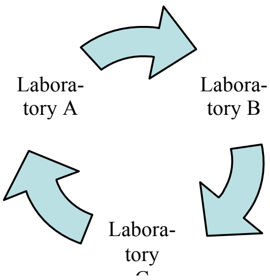
An international survey was conducted on architects' barriers, needs and criteria for tools and methods to support architectural design and integration at the early design stage. Results show that adequate tools for solar design, for use by architects in the early design phase, are still lacking. The report is available online, *International Survey about Digital Tools Used By Architects for Solar Design*.

TASK 42: COMPACT THERMAL ENERGY STORAGE

In 2011, important steps were made in the development of measurement procedures used to determine the properties of phase change materials (PCM). The Fraunhofer Institute for Solar Energy is leading the working group on Testing and Characterization and organized the PCM characterization work. Knowledge about the characteristics of storage materials is the basis for a good design of storage systems and for thermal simulations.

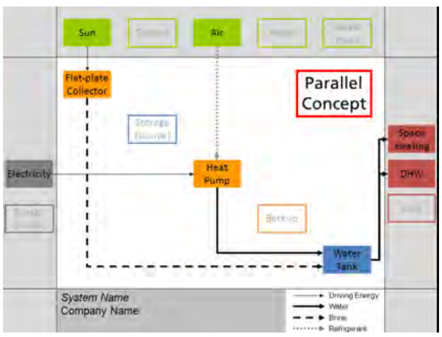
This is a collaborative Task with the IEA Energy Conservation through Energy Storage Implementing Agreement.

TASK 43: ADVANCED SOLAR THERMAL TESTING AND CHARACTERIZATION FOR CERTIFICATION OF COLLECTORS AND SYSTEMS



To confirm the consistency of collector efficiency and durability laboratories in Europe and North America are performing tests. Identical collectors from two single-lot purchases of both flat plate and tubular collectors are being tested by all SRCC accredited North American laboratories, and European laboratories are conducting similar identical lot testing. By testing the same or identical collectors according to EN/ISO and SRCC standards, Task Experts are able to provide an important check on the reproducibility of testing.

TASK 44: SOLAR AND HEAT PUMP SYSTEMS



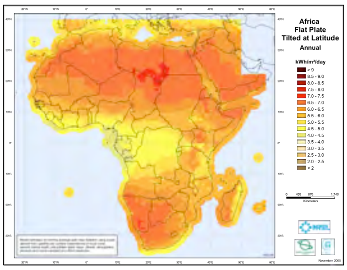
Conducted a survey to obtain an overview of the systems on the market in order to find "basic" combinations. As a broad variety of configurations from simple parallel running to very complicated system designs exist, experts found four basic configurations to represent most of the combinations. The work now is to understand the benefits of each and to quantify them in several climate and load configurations.

This is a collaborative Task with the IEA Heat Pump Implementing Agreement.

TASK 45: LARGE SYSTEMS: LARGE SOLAR HEATING/COOLING SYSTEMS, SEASONAL STORAGE, HEAT PUMPS

Began work on “guidelines for requirements for collector loop installation” and drafted procedures for collector field performance.

TASK 46: SOLAR RESOURCE ASSESSMENT AND FORECASTING



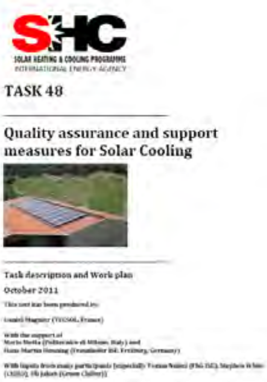
The Task focus in 2011 was to finalize planning for the 2012 work.

This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement and the SolarPACES Implementing Agreement.

TASK 47: SOLAR RENOVATION OF NON-RESIDENTIAL BUILDINGS

This Task began its work in 2011. One of the first work areas was agreement on a set of criteria for the selection of 47 exemplary renovation projects. The selection criteria are divided by Building Types, Energy, Economics, and Market Potential. A summary of each exemplary building will be posted on the Task website.

TASK 48: QUALITY ASSURANCE AND SUPPORT MEASURES FOR SOLAR COOLING



This Task began in October 2011 and experts spent the last months of the year focused on planning future work. The first reports will be available the end of 2012.

Feature Article

Net Zero Energy Buildings: A Consistent Definition Framework

Igor Sartori of SINTEF Building and Infrastruture, Oslo, Norway; Assunta Napolitano of EURAC, Bolzano, Italy, and Karsten Voss of the University of Wuppertal, Germany
http://www.sciencedirect.com/science/article/pii/S0378778812000497

Introduction

The topic of Zero Energy Buildings (ZEBs) has received increasing attention in recent years, until becoming part of the energy policy in several countries. In the recast of the EU Directive on Energy Performance of Buildings (EPBD) it is specified that by the end of 2020 all new buildings shall be "nearly zero energy buildings" [1]. For the Building Technologies Program of the US Department Of Energy (DOE), the strategic goal is to achieve "marketable zero energy homes in 2020 and commercial zero energy buildings in 2025" [2]. However, despite the emphasis on the goals the definitions remains in most cases generic and are not yet standardised. A more structured definition, even though limited in scope to new residential buildings, is the one of 'zero carbon homes' in the UK, where there is a political target to build all new homes as zero carbon by 2016. The zero carbon definition has undergone a lengthy process that started in 2006 and was still subject to revisions in 2011 [3], [4]. Otherwise, the term ZEB is used commercially without a clear understanding and countries are enacting policies and national targets based on the concept without a clear definition in place. Commercial definitions may be partial or biased in their scope, for example including only thermal or only electrical needs in the balance, or allowing for energy inefficient buildings to achieve the status of ZEB thanks to oversized PV systems, but without applying relevant energy saving measures. For these reasons such definitions are not suitable as a basis for regulations and national policies.

Relevant work can be found in literature on existing and proposed definitions [5]–[13] and survey and comparison of existing case studies [14], [15]. Furthermore, an international effort on the subject is ongoing in the International Energy Agency (IEA) joint Solar Heating and Cooling (SHC) Task40 and Energy Conservation in Buildings and Community systems

(ECBCS) Annex52 titled “Towards Net Zero Energy Solar Buildings” [16]. It emerges from these analyses that little agreement exists on a common definition that is based on scientific analysis. There is a conceptual understanding of a ZEB as an energy efficient building able to generate electricity, or other energy carriers, from renewable sources in order to compensate for its energy demand. Therefore, it is implicit that there is a focus on buildings that are connected to an energy infrastructure and not on autonomous buildings. To this respect the term Net ZEB can be used to refer to buildings that are connected to the energy infrastructure, while the term ZEB is more general and may as well include autonomous buildings. The wording ‘Net’ underlines the fact that there is a balance between energy taken from and supplied back to the energy grids over a period of time, nominally a year.

As discussed in [15] the Net ZEB approach is one strategy towards climate neutral buildings, in addition to others based on energy efficient buildings combined with almost carbon neutral grid supply. Net ZEBs are designed to overcome the limitation given by a non 100% ‘green’ grid infrastructure. Exploiting local Renewable Energy Sources (RES) on-site and exporting surplus energy from on-site generation to utility grids is part of the strategy to increase the share of renewable energy within the grids, thereby reducing resource consumption and associated carbon emissions. On the other hand, especially for the power grid, wide diffusion of distributed generation may give rise to some problems such as power stability and quality in today´s grid structures, mainly at local distribution grid level. Development of “smart grids” is ongoing to fully benefit from distributed generation with respect to reducing the grids primary energy and carbon emission factors, as well as operation costs. Within a least-cost planning approach, on-site options have to be compared with measures at the grid level, which take advantage of the economy of scale and equalization of local peaks. However, it is clear that the mere satisfaction of an annual balance is not in itself a guarantee that the building is designed in a way that minimizes its (energy use related) environmental impact. In particular, Net ZEBs should be designed – to the extent that is in the control of the designers – to work in synergy with the grids and not to put additional stress on their functioning.

Considering the interaction between buildings and energy grids also leads to consider that every country, or regional area, has different challenges to face with respect to the energy infrastructure, on top of different climate and building traditions. Therefore every country has the need to adapt the Net ZEB definition to its own specific conditions, e.g. defining the primary energy or carbon emission conversion factors for the various energy carriers, establishing requirements on energy efficiency or prioritizing certain supply technologies.

What is missing is a formal, comprehensive and consistent framework that considers all the relevant aspects characterising Net ZEBs and allow each country to define a consistent (and comparable with others) Net ZEB definition in accordance with the country’s political targets and specific conditions. The framework described in this paper builds upon concepts found literature and further developed in the context of the joint IEA SHC Task 40/ECBCS Annex 52: Towards Net Zero Energy Solar Buildings [16]. The following Table 1 shows a list of nomenclature used in this paper.

Table 1 Nomenclature

CHP	Combined Heat and Power	g, G	generation, Generation weighted
COP	Coefficient Of Performance	g_m	net monthly Generation, annual total
DHW	Domestic Hot Water	G_m	net monthly Generation weighted
DSM	Demand Side Management	i	energy carrier
HVAC	Heating, Ventilation and Air Conditioning	l, L	load, Load weighted
Net ZEB(s)	Net Zero Energy Building(s)	l_m	net monthly Load, annual total
RES	Renewable Energy Sources	L_m	net monthly Load weighted
STD	Standard Deviation	m	month
d, D	delivered, Delivered weighted	max	maximum
e, E	exported, Exported weighted	min	minimum
f_{grid}	grid interaction index	t	time interval
f_{load}	load match index	w	weighting factor

Terminology and Net ZEB Balance Concept

The sketch shown in Figure 1 gives an overview of relevant terminology addressing the energy use in buildings and the connection between buildings and energy grids.

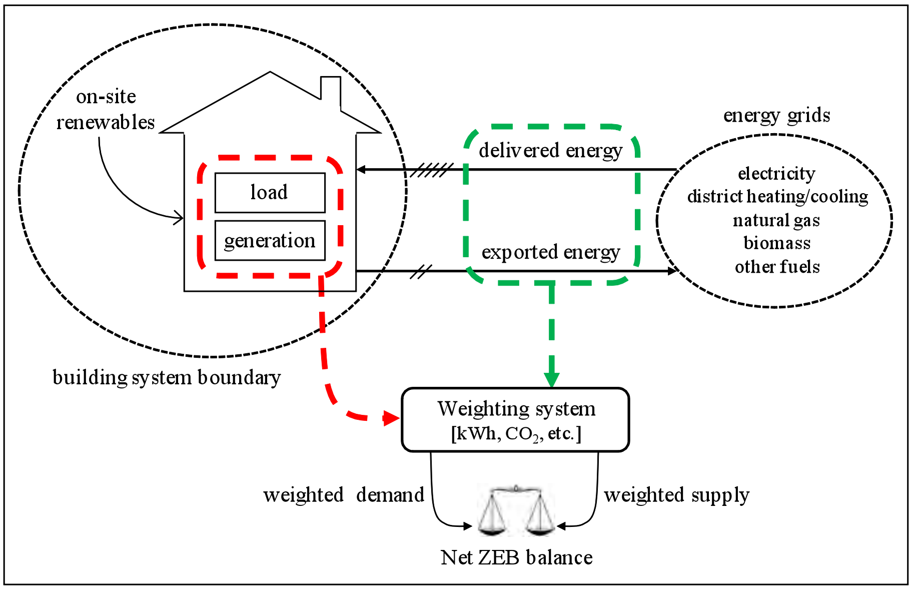


Figure 1. Sketch of connection between buildings and energy grids showing relevant terminology.

Building system boundary
The boundary at which to compare energy flows flowing in and out the system. It includes:

- Physical boundary: can encompass a single building or a group of buildings; determines whether renewable resources are 'on-site' or 'off-site'.
- Balance boundary: determines which energy uses (e.g. heating, cooling, ventilation, hot water, lighting, appliances) are included in the balance.

Energy grids (or simply 'grids')
The supply system of energy carriers such as electricity, natural gas, thermal networks for

district heating/cooling, biomass and other fuels. A grid may be a two-way grid, delivering energy to a building and occasionally receiving energy back from it. This is normally the case for electricity grid and thermal networks.

Delivered energy
Energy flowing from the grids to buildings, specified per each energy carrier in [kWh/y] or [kWh/m^{2}y]. This is the energy imported by the building. However, it is established praxis in many countries to name this quantity 'delivered energy', see for example [17].

Exported energy
Energy flowing from buildings to the grids, specified per each energy carrier in [kWh/y] or [kWh/m^{2}y].

Load
Building's energy demand, specified per each energy carrier in [kWh/y] or [kWh/m^{2}y]. The load may not coincide with delivered energy due to self-consumption of energy generated on-site.

Generation
Building's energy generation, specified per each energy carrier in [kWh/y] or [kWh/m^{2}y]. The generation may not coincide with exported energy due to self-consumption of energy generated on-site.

N.B. Design calculations to convert building energy needs, such as for heating, cooling, ventilation, hot water, lighting, appliances, into the demand for certain energy carriers (here 'loads'), accounting for system efficiencies and interactions are not covered in this paper; nor are calculations to determine on-site generation or possible self-consumption patterns. Readers are encouraged to refer to their relevant national methodologies and regulations for guidance.

Weighting system
A weighting system converts the physical units into other metrics, for example accounting for the energy used (or emissions released) to extract, generate, and deliver the energy. Weighting factors may also reflect political preferences rather than purely scientific or engineering considerations.

Weighted demand
The sum of all delivered energy (or load), obtained summing all energy carriers each multiplied by its respective weighting factor.

Weighted supply
The sum of all exported energy (or generation), obtained summing all energy carriers each multiplied by its respective weighting factor.

Net ZEB balance
A condition that is satisfied when weighted supply meets or exceeds weighted demand over a period of time, nominally a year. The net zero energy balance can be determined either from the balance between delivered and exported energy or between load and generation. The former choice is named import/export balance and the latter load/generation balance. A third option is possible, using monthly net values of load and generation and it is named monthly net balance.

The Net ZEB balance is calculated as in **Eq. 1**:

Net ZEB balance: | weighted supply | – | weighted demand | ≥ 0 Eq. 1

where absolute values are used simply to avoid confusion on whether supply or demand is consider as positive. The Net ZEB balance can be represented graphically as in Figure 2, plotting the weighted demand on the x-axis and the weighted supply on the y-axis.

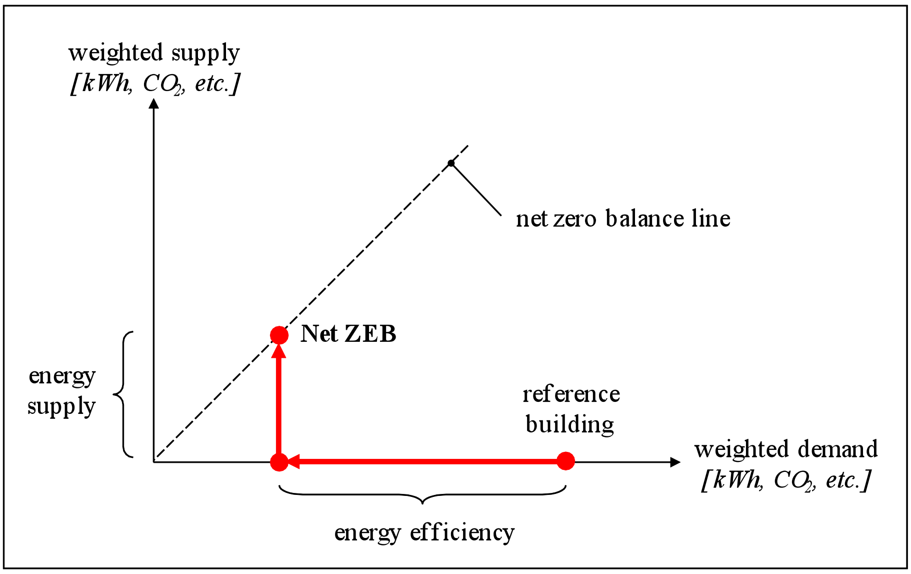


Figure 2. Graph representing the net ZEB balance concept.

The reference building may represent the performance of a new building built according to the minimum requirements of the national building code or the performance of an existing building prior to renovation work. Starting from such reference case, the pathway to a Net ZEB is given by the balance of two actions:

1) reduce energy demand (x-axis) by means of energy efficiency measures;
2) generate electricity as well as thermal energy carriers by means of energy supply options to get enough credits (y-axis) to achieve the balance.

In most circumstances major energy efficiency measures are needed as on-site energy generation options are limited, e.g. by suitable surface areas for solar systems, especially in high-rise buildings.

Framework for Net ZEB Definitions

The balance of **Eq. 1** represents the core concept of a Net ZEB definition. In order to use such formula in practice several aspects have to be evaluated and some explicit choice made, e.g. the metrics adopted for weighting and comparing the different energy carriers. Additionally, other features than the mere balance over a period of time may be desirable in characterizing Net ZEBs. These aspects are described and analysed in a series of five criteria and sub-criteria, and for each criterion different options are available. Evaluation of the criteria and selection of the related options becomes a methodology for elaborating Net ZEB definitions in a systematic, comprehensive and consistent way. The Net ZEB definition framework is organized in the following criteria and sub-criteria in the paper):

1. Building system boundary
    1.1 Physical boundary

1.2 Balance boundary
1.3 Boundary conditions
2. Weighting system
2.1 Metrics
2.2 Symmetry
2.3 Time dependent accounting
3. Net ZEB balance
3.1 Balancing period
3.2 Type of balance
3.3 Energy efficiency
3.4 Energy supply
4. Temporal energy match characteristics
4.1 Load matching
4.2 Grid interaction
5. Measurement and verification

1. Building System Boundary

Defining the building system boundary is necessary to identify what energy flows cross the boundary. The building system boundary can be seen as a combination of a physical and a balance boundary. Only energy flows that cross the system boundary, i.e. both physical and balance boundaries, are considered for the Net ZEB balance. This means, for example, that if a definition excludes plug-loads from the balance boundary, the electricity used for plug-loads is not to be counted. With design data this is not a problem. With monitoring data though, it represents a complication because the power meter normally does not discern between the different power uses. A Net ZEB definition that does not include all operational energy services poses a challenge on building performance verification because it requires a more sophisticated measurement system, see criterion 5-Measurement and verification.

1.1 Physical boundary

The physical boundary may be on a single building or on a cluster of buildings. In this paper the focus is mainly on single buildings, but the same framework would apply equally well to clusters of building. It is important to note though that a cluster of buildings implies a synergy between several buildings which are not necessarily Net ZEB as singles but as a whole.

The physical boundary is useful to identify so called 'on-site' generation systems; so that if a system is within the boundary it is considered on-site, otherwise it is 'off-site'. As analysed later in criterion 3.4-Net ZEB balance-Energy supply, off-site supply options may or may not be accepted for calculating the balance, or may be given different priorities. As an example, one may think of a PV system installed on the parking lot, detached from the main building. If the boundary is taken on the building's physical footprint such system would then be regarded as off-site. If the boundary instead is set on the building's property or if the power meter is taken as the physical boundary, then the PV system would be on-site.

Furthermore, the physical boundary can be used to address the property issue of RES installations. On one hand RES installations or investments not on the building site may be accountable in the balance if financed by the building owner/constructor, as in the UK zero carbon home definition, see [18], [19] and further discussion on allowable solutions in criterion 3.4-Net ZEB balance-Energy supply. On the other hand, a RES installation on the building site may not be considered accountable for the building balance if it is property of a third party, e.g. if the roof space has been rented to an investor (utility company, ESCO, etc.) who owns the PV system and runs it independently.

It has to be specified which two-way grids are available at the physical boundary. A two-way grid is a grid that can deliver energy to and also receive energy back from the building(s). Without a two-way grid it is not possible to define a Net ZEB. The power grid is normally available as two-way grid. Other two-way grids may be local thermal networks, such as district heating/cooling networks. Specific conditions are normally required by the grid operators in order to accept exported energy, such as on frequency and voltage tolerances (power grid) or temperature levels (thermal network).

1.2 Balance boundary

The balance boundary defines which energy uses are considered for the Net ZEB balance. Operational energy uses typically include heating, cooling, ventilation, domestic hot water, fixed lighting and plug-loads. National and commercial standards on energy performance may consider different combinations of them. Other energy uses may be included in the balance, even though they are typically not considered in building energy performance codes and standards. This may include treatment of rain water or charging of electric vehicles. Electric vehicles are not a building related energy use but charging their batteries may be used as a way to optimise the interaction with the grid (see criterion 4.2-Temporal energy match characteristics-Grid interaction).

Other energy uses that do not occur in the operational phase, but in the life cycle of a building may be considered, such as embodied energy/emissions in materials and technical installations. More energy efficient and energy producing buildings are likely to deploy more materials (e.g. insulation) and technical installations (e.g. PV system) including materials whose manufacturing is energy intensive. Consequently, the importance of embodied energy/emissions increases and including it into the balance broadens the scope of Net ZEBs as environmental friendly and sustainable buildings. Embodied energy/emissions should be annualized for proper accounting in addition to operational energy use; this implies making assumption on the life time of the building and its components. Likewise, also energy used for erection and demolition of the building could be considered, even though their relative importance is generally low and it may be justifiable to neglect it [18].

1.3 Boundary conditions

A consistent Net ZEB definition should allow a meaningful comparison between similar buildings in similar climates, as well as between the expected performance of a building from its design data and the measured performance revealed by monitoring data, see criterion 5-Measurement and verification. It is important to understand if any deviation from expected values is attributable to technical operating or design mistakes, or if it is simply due to different conditions of use. For this purpose it is necessary to explicitly specify a set of boundary conditions: functionality, space effectiveness, climate and comfort.

The functionality describes what type of uses the building is designed for, such as residential, office, school or hospital. In case of multi-functional buildings it is necessary to specify how the floor area is distributed between the different functions. The space effectiveness can be expressed in terms of people/m^2 or, consequently, of energy use per person. Variations from expected functionality and/or space effectiveness are important and should be taken into consideration before comparing the expected performance with the monitored one. For example, higher/lower people density causes different energy demand.

The reference climate and the comfort standards used in design also need to be specified. Variations from expected outdoor climate and/or indoor comfort conditions are important and should be taken into consideration before comparing the expected performance with the monitored one. For example, hotter/colder years or different temperature settings cause different energy demand.

2. Weighting System

The weighting system converts the physical units of different energy carriers into a uniform metrics, hence allowing the evaluation of the entire energy chain, including the properties of natural energy sources, conversion processes, transmission and distribution grids. Choosing a common balance metrics also allows taking into account the so-called fuel switching effect, e.g. when export of PV electricity during summer compensates for imported biomass or fossil fuels in winter.

2.1 Metrics

In [5] four types of metrics are considered: site energy, source energy, energy cost, and carbon emissions related to energy use. Advantages and disadvantages of each choice are discussed and it is shown how the choice would affect the required PV installed capacity. Other possible metrics are the non-renewable part of primary energy, exergy [6], environmental credits and politically/strategically decided factors. The choice of the metrics, especially with political factors, will affect the relative value of energy carriers, hence favouring the choice of certain carriers over others and influencing the required (electricity) generation capacity. For an analysis of the details and the implications for design of each choice reference is made to the mentioned literature [5]–[13].

Quantification of proper conversion factors is not an easy task, especially for electricity and thermal networks as it depends on several considerations, e.g. the mix of energy sources within certain geographical boundaries (international, national, regional or local), average or marginal production, present or expected future values and so on. A sample of conversion factors for primary energy and carbon equivalent emissions as applied in current building design practise is shown in Appendix A – Conversion factors. There are no correct conversion factors in absolute terms. Rather, different conversion factors are possible, depending on the scope and the assumptions of the analysis. This leads to the fact that 'politically corrected' weighting factors may be adopted in order to find a compromise agreement.

Furthermore, 'political factors' (or 'strategic factors') may be used in order to include considerations not directly connected with the conversion of primary sources into energy carriers. Political factors can be used to promote or discourage the adoption of certain technologies and energy carriers. For example biomass and biofuels, in case of carbon emissions as the metrics, would have a very low conversion factor making it an attractive solution. However, availability of biomass is not infinite and it needs to be used also for other non-energy purposes such as food production. Hence, even in regions of abundant local availability it may be desirable to 'politically' increase the conversion factor in order to reduce the attractiveness of biomass and favour other solutions, e.g. solar systems.

2.2 Symmetry

Each two-way energy carrier (e.g., electricity) can be weighted symmetrically, using the same weighting factors for both delivered and exported quantities, or asymmetrically, using different factors.

The rationale behind symmetric weighting is that the energy exported to the grids will avoid an equivalent generation somewhere else in the grid. Hence the exported energy has a substitution value, which is equal to the average weighting factor for that grid. This is a valid approach as long as the energy generated on-site does not have any negative effect on the balance or if that effect is accounted for somewhere else. First example: with on-site cogeneration the negative effect is the increase of purchased fuel because of the reduced thermal efficiency. The delivered energy entering the physical boundary is increased, therefore accounting for the negative effect and the exported electricity can be fully credited for its substitution value. Second example: with on-site PV generation the negative effect is the increase in embodied energy. If the balance boundary does include embodied energy of the PV system, then the total demand to be balanced off is increased, accounting for the negative effect and the exported electricity can be fully credited for its substitution value.

Asymmetric weighting may be used to account for the negative effect of on-site generation if that is not accounted for somewhere else in the balance. For example, in the above case with PV system, if embodied energy is not part of the boundary balance then each kWh of exported electricity should not be fully credited because it did cost something – in energetic terms – to produce it. Rather than omitting this aspect, it is possible to associate a negative value to the kWh generated (in terms of the adopted metrics, such as primary energy or emissions) and credit the exported kWh net of it, i.e. the substitution value minus the negative effect value. This way it is possible to give different weighting factors to different generation technologies generating the same carrier, e.g. PV and cogeneration in the same building, hence valuing their different properties, possibly in combination with political factors as discussed in criterion 2.1-Weighting system-Metrics. The drawback is that each system should then be equipped with a separate meter, at least in theory. Similarly, also delivered energy may have different weighting factors for the same carrier, as for example in the case of a portion of purchased electricity being covered by green certificates.

However, the main rationale behind asymmetric weighting is that energy demand and supply do not have the same value, hence delivered and exported energy should be weighted differently in order to reflect this principle. Two situations are possible:

a) Delivered energy is weighted higher:
This takes into account the cost and losses on the grids side associated with transportation and storage of exported energy (and in case of electricity also possible earthing of feed-in power) as in the German tariff system since 2009, see [21]. This option may serve the purpose of reducing exchange with the grids – hence promoting self-consumption of on-site generation – in a scenario of wide diffusion of energy consuming and producing buildings;
b) Exported energy is weighted higher:
This option may serve the purpose of promoting technology diffusion in a scenario of early technology adoption, e.g. the early PV feed-in tariffs adopted in Germany, Italy, Spain and other countries, where feed-in electricity is paid two to three times higher than what delivered electricity is charged for (here the asymmetric metrics is the energy cost).

2.3 Time dependent accounting

Due to the complexity of the energy infrastructure, it is often feasible to estimate the weighting factors only as average values for a period of time. This is a static accounting, and it typically applies to primary energy and carbon emission factors. For an overview of static (and symmetric) conversion factors used in several countries see Appendix A – Conversion factors.

Weighting factors will vary over time and space. Electricity, for example, may be evaluated for large regions while district heating/cooling or biomass may be evaluated at local scale, according to the actual availability of resources in the area. In any case the evaluation of weighting factors should be updated at regular intervals to reflect the development of the grids. To this respect it is possible to consider different scenarios on the possible evolution of weighting factors, as for example in [22] where the European electricity grid is analysed towards 2050. In the evaluation of electricity and district heating/cooling weighting factors it is also important to distinguish between average and marginal production and specify which choice is made.

It is also possible to evaluate weighting factors on hourly basis, therefore leading to a dynamic accounting. As an intermediate option a quasi-static accounting would have seasonal/monthly average values and/or daily bands for base/peak load. For energy prices it is already quite common to have seasonal or hourly fluctuating prices, while for other metrics such as primary energy and carbon emissions this is not the standard praxis today but it may become more common in future. Examples of this are given by the hourly energy emission factors for electricity generation in the US [23] and the power demand tracking in real time of the power grid in Spain [24].

Dynamic and quasi-static accounting would help, at least in theory, the design of buildings that optimise their interaction with the grids. The Time-Dependent Valuation of saving [25] is such an example. However, including dynamic accounting in the Net ZEB balance would considerably increase the complexity of calculations and the assumptions on future time dependent patterns. It is rather preferable, in the authors' opinion, to calculate the Net ZEB balance with static or quasi-static values and then use, in addition, dynamic values to address the temporal energy match characteristics, see criterion 4-Temporal energy match characteristics.

3. Net ZEB Balance

The balance of **Eq. 1** may be calculated in different ways, depending for example on the quantities that are of interest or available and the period over which to calculate the balance. Furthermore, policy makers must decide whether or not to enforce minimum energy efficiency requirements and/or a hierarchy of renewable energy supply options.

3.1 Balancing period

A proper time span for calculating the balance is assumed, often implicitly, to be a year. An yearly balance is suitable to cover all the operation settings with respect to the meteorological conditions, succession of the seasons in particular. Selection of shorter time spans, such as seasonal or monthly balance, could be highly demanding from the design point of view, in terms of energy efficiency measures and supply systems, in order to reach the target in critical time, such as winter time. On the other hand, a much wider time span, on the order of decades, could be selected to assess the balance along the entire building's life cycle including embodied energy. Nevertheless, as noted in criterion 1.2-Building system boundary-Balance boundary, embodied energy can be annualized and counted in addition to operational energy uses. It is therefore held that the balance is calculated on a yearly basis.

3.2 Type of balance

The core principle for Net ZEBs is the balance between weighted demand and weighted supply, generically described in **Eq. 1**. Delivered and exported energy quantities can be used to calculate the balance when monitoring a building. Alternatively, estimates of delivered and exported energy may be available in design phase, depending on the ability to estimate self-consumption of energy carriers generated on-site. In these cases an import/export balance is calculated as in **Eq. 2**[i]:

$$\sum_i e_i \cdot w_{e,i} - \sum_i d_i \cdot w_{d,i} = E - D \geq 0 \qquad \text{Eq. 2}$$

where e and d stands for exported and delivered, respectively; w stands for weighting factor and i for energy carrier. E and D stands for weighted exported and delivered energy, respectively; see also Table 1 on nomenclature.

However, most building codes do not require design calculations to estimate self-consumption, consequently lacking the estimations of delivered and exported amounts [10]. Such approaches perform like generation and load systems did not interact, basically because missing normative data on end users temporal consumption patterns (e.g. for lighting, electrical appliances, cooking, hot water use). Thereby, in most common cases only generation and load values are available and a load/generation balance is calculated as in **Eq. 3**:

$$\sum_i g_i \cdot w_{e,i} - \sum_i l_i \cdot w_{d,i} = G - L \geq 0 \qquad \text{Eq. 3}$$

where g and l stands for generation and load, respectively; w stands for weighting factor and i for energy carrier. G and L stands for weighted generation and load, respectively; see also Table 1 on nomenclature. It is worth noting that overlooking the interactions between generation systems and loads as in the generation balance is equivalent to assume that, per each carrier, the load is entirely satisfied by delivered energy while the generation is entirely fed into the grid.

Alternatively, a balance may be calculated based on monthly net values. For each energy carrier, generation and load occurring in the same month are assumed to balance each other off; only the monthly residuals are summed up to form the annual totals. This can be seen either as a load/generation balance performed on monthly values or, equivalently, as a special case of import/export balance where a "virtual monthly self-consumption" pattern is assumed. Such procedure has been proposed in the framework of the German building energy code, see [12] and [14], where it is thought with focus on electricity; the same procedure though may be applied also to thermal carriers. This approach may be regarded as monthly net balance, calculated as in Equation, substituting Equation 4 and Equation 5:

$$g_{m,i} = \sum_m max[0, g_i(m) - l_i(m)] \qquad \textbf{Eq. 4}$$

$$l_{m,i} = \sum_m max[0, l_i(m) - g_i(m)] \qquad \textbf{Eq. 5}$$

---

[i] For simplicity, the weighting factors are the same in **Eq. 2**, **Eq. 3** and Eq. 6, and are implicitly assumed as static yearly values, see 2.3-Weighting system-Time dependent accounting.

$$\sum_i g_{m,i} \cdot w_{e,i} - \sum_i l_{m,i} \cdot w_{d,i} = G_m - L_m \geq 0 \qquad \textbf{Eq. 6}$$

where g and l stands for generation and load, respectively, and m stands for the month; w stands for weighting factor and i for energy carrier. G_m and L_m stands for the total weighted monthly net generation and load, respectively; see also Table 1 on nomenclature.

The three balances are coherent with each other[ii] but differ by the amount of on-site energy generation which is self-consumed, or 'virtually' assumed as self-consumed, as shown in Figure 3. Graphically, the load/generation balance gives the points for weighted demand and supply most far away from the origin; while with import/export balance and monthly net balance the points get closer to the origin as a consequence of the self-consumption and virtual monthly self-consumption, respectively. The import/export balance is expected to be always in between the two other, due to the fact that there usually is some amount of self-consumption but hardly more than the virtual monthly self-consumption, which can be regarded as an upper limit as long as seasonal energy storage is not considered.

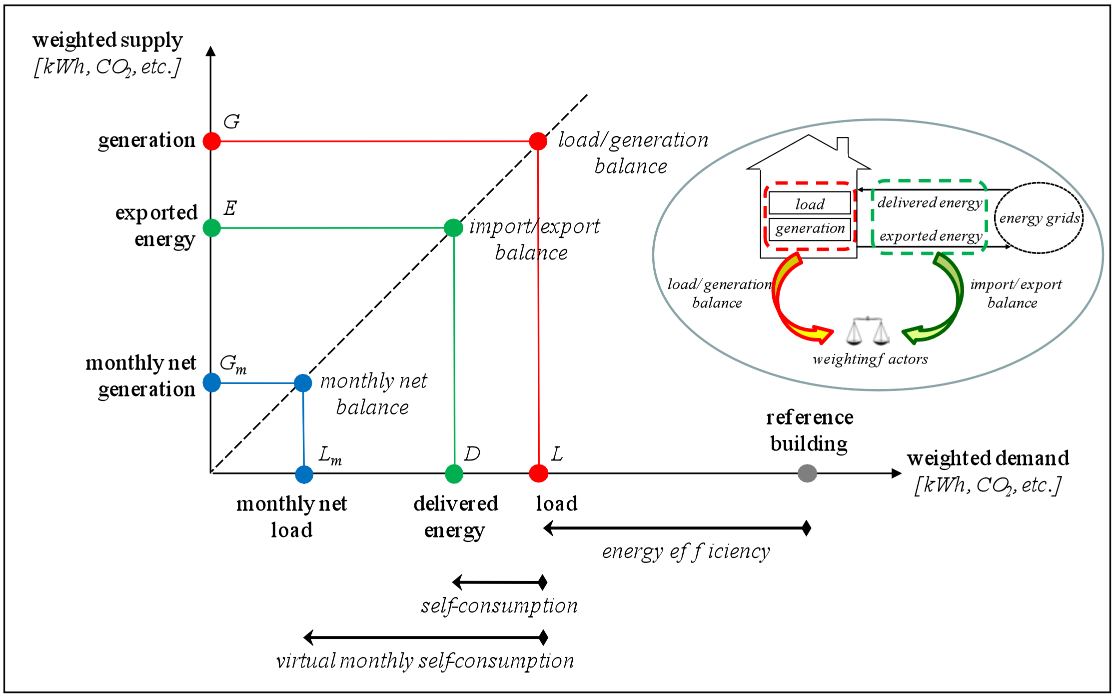


Figure 3. Graphical representation of the three types of balance: import/export balance between weighted exported and delivered energy, load/ generation balance between weighted generation and load, and monthly net balance between weighted monthly net values of generation and load.

It is worth noting that self-consumption of energy generated on-site can be seen as either an efficiency measure or as a supply measure depending on the type of balance adopted. In case of load/generation balance self-consumption is seen as part of the

[ii] Applied to the same case would give the same net balance: the three points lying on a 45° line (not necessarily passing through the origin if the net balance is not zero).

overall generation and is visualized in the graph as moving the weighted supply point up along the y-axis. However, in case of import/export balance self-consumption is seen as a reduction of the load, visualized in the balance graph by moving the weighted demand point closer to the origin, along the x-axis[iii]. This is consistent with the implicit viewpoint of the two balances. In the load/generation balance the building is seen independently, so that energy generated, whether self-consumed or not, does not affect the efficiency of the building as such. In the import/export balance the building is seen in connection with the grids, so that self-consumption does reduce the amount of energy exchanged, in this sense improving the efficiency of the system building-grids.

Each type of balance has pros and cons. The import/export balance gives the most complete information, showing the interaction with the grids but it is the most difficult to obtain in design phase because it requires estimates of self-consumption patterns and detailed simulation (preferably with hourly or sub-hourly resolution). The load/generation balance is the most suit to be seamlessly integrated in existing building codes that are only oriented at calculating the loads. In facts, it is only necessary to add one step: calculation of the generation. The drawback is that it completely overlooks the interaction with the grids. The monthly net balance has the advantage of being simple to implement while not completely overlooking the interaction with the grids. On one hand it only needs monthly values of generation and load and does not require either detailed simulations or self-consumption estimates. On the other hand while the virtual monthly self-consumption is a coarse approximation, it still provides some information on the seasonal interaction with the grids. The higher the monthly net generation (or load), the higher the seasonal unbalance of energy exchanged with the grids.

3.3 Energy efficiency

A Net ZEB definition may set mandatory minimum requirements on energy efficiency. Such requirements may be either prescriptive or performance requirements, or a combination of the two. Prescriptive requirements apply to properties of envelope components (e.g. U-values of walls and windows, air-tightness in pressurization test) and of HVAC systems (e.g. specific fan power, COP of heat pumps), while performance requirements apply to energy needs (e.g. for heating, cooling, lighting) or total (weighted) primary energy demand. See [26] for an overview of prescriptive and performance based energy efficiency requirements adopted in existing national or commercial certification systems.

Mandatory requirements on energy efficiency may be determined on the basis of cost-optimality considerations as in the plans of the EPBD [1]; such methodology is still under development for the time being, see [27], [28] and [29]. Alternatively, mandatory efficiency targets could simply require a demand reduction (e.g. 50%) compared to a reference building of the same category (e.g. detached house, office, school).

In absence of explicit requirements on energy efficiency it is left to the designers to find the cost-optimal balance between energy efficiency measures and supply options, eventually considering embodied energy too, if in the balance boundary. However, the analysis of a large number of already existing Net ZEBs underlines the priority of energy efficiency as the path to success [15].

[iii] Also valid for monthly net generation balance and virtual monthly self-consumption.

Restrictions on the use of some energy carriers, such as oil, can be a direct requirement of a Net ZEB definition or a consequence of the assigned weighting factor, e.g. assigning a ‘politically’ or ‘strategically’ high value to oil would reduce its attractiveness.

3.4 Energy supply

A Net ZEB definition may set mandatory requirements on energy supply. A straightforward requirement is proposed in [30] by setting a threshold for the minimum share of renewable energy that has to be used for covering the building's energy demand. Alternatively, energy supply options may be categorised in different ways and a Net ZEB definition may set a mandatory hierarchy of renewable energy supply options. This prioritization is meant to add an additional dimension to the energy balance itself. Typically, distinction is made at least between ‘on-site’ and ‘off-site’; see [5], [10], [18] and [19]. For using a hierarchy of options a clear and unambiguous definition of what is on-site and off-site (and any further distinction) has to be stated in criterion 1-Building system boundary-Physical boundary.

In [5] the renewable energy supply options are prioritized on the basis of three principles: 1) Emissions-free and reduced transportation, transmission, and conversion losses; 2) Availability over the lifetime of the building; 3) Highly scalable, widely available, and have high replication potential for future Net ZEBs. These principles lead to a hierarchy of supply options where resources within the building footprint or on-site (e.g. PV and CHP) are given priority over off-site supply options, (e.g. import of biofuel for cogeneration or purchase of green electricity). Reasons for supporting such a hierarchy are extensively discussed in the report. In [10] a similar categorisation of supply options is given according to their distance from the building, even though no hierarchy of preferences is expressed. However, it is worth mentioning that the meaning of off-site varies depending on whether the focus is on the origin of the fuel [5] or on the location of the actual generation system [10].

Another example of classification and hierarchy is given by the “Zero Carbon Home” policy under development in the UK (only for new residential buildings), see [18] and [19]. In the Zero Carbon Home approach offsetting carbon emissions is achieved in two steps, named: “carbon compliance” and “allowable solutions”. Carbon compliance is a mix of mandatory energy efficiency measures and a selection of on-site options (e.g. PV and connection to thermal grids) to be implemented as first priority. Allowable solutions is a set of further supply options, including extended on-site options, near-site and off-site options; where the meaning of such words is again different than in [5] and [10].

One of the more contentious topics is likely be how to account for ‘soft’ renewable generation options (‘soft’ as opposed to ‘hard’ = physical generation of energy carriers). For example, the allowable solutions in the Zero Carbon Home definition in the UK include investment (through a national investment fund) in low- and zero-carbon energy projects off-site. These include investments in the local energy infrastructure and financing energy efficient renovation of buildings in the area.

Another area that requires further thought by policy makers, if renewable energy supply is to be prioritized, is defining ‘supply-side’ renewable generation separately from ‘demand-side’ generation. As defined in [5], supply-side renewable energy can be commoditized, exported, and sold like electricity or hot water for district systems, while demand-side renewable are only available in connection with reducing building energy demand on-site. Examples of demand-side generation include CHP systems, ground source heat pumps, and passive solar systems.

Restrictions on the use of some supply option, such crediting of electricity from gas fired CHP, can be a direct requirement of a Net ZEB definition or a consequence of the assigned weighting factor. For example, assigning a 'politically' or 'strategically' low value to electricity generated by gas fired CHP would reduce the attractiveness of such a choice[iv]. However, it should be considered that in areas with poor performance of the grid (high share of fossil fuels and high carbon emission in the generation mix) it may be reasonable to allow solutions that make a very efficient use of natural gas, such as gas fired CHP, especially if the gas grid is already in place.

4. Temporal Energy Match Characteristics

Beside an annual energy or emission balance Net ZEBs are characterized by their different ability to match the load and to work beneficially with respect to the needs of the local grid infrastructure. Suitable indicators can be used to express characteristics of a Net ZEB such as the temporal match between a building's load and its energy generation, load matching, and the temporal match of import/export of energy with respect to the grid needs, grid interaction [30], [32]. Such indicators are useful to show differences and similarities between alternative design solutions. The indicators are intended as assessment tools only: there is no inherent positive or negative value associated with them, e.g. increasing the load match may or may not be appropriate depending on the circumstances on the grid side.

Load matching and grid interaction calculation have to be performed for each energy carrier separately. The calculation of such indicators needs energy data in a time resolution of months for studying the seasonal effects, and hourly or sub-hourly resolution for studying peak load effects. Target groups for this form of Net ZEB characterisation are the building owners and designers, community and urban planners as well as the local grid operators in the context of "smart buildings" and "smart grids".

4.1 Load matching

The temporal match between load and generation for an energy carrier gives a first insight on a building's ability to work in synergy with the grid. When there is a poor correlation between load and generation, e.g. load mainly in winter and generation mainly in summer, the building will more heavily rely on the grid. If load and generation are more correlated, the building will most likely have higher chances for fine tuning self-consumption, storage and export of energy in response to signals from the grid, see criterion 4.2-Grid interaction. Load matching can be addressed in design by separate calculations or simulations on load and generation, without need to know or estimate self-consumption. For this reason indicators of load matching fit well for being used in combination with a load/generation balance, see criterion 3.2-Net ZEB balance-Type of balance.

Suitable indicators for load matching are proposed under different wordings and summarized with a review in [32]. The most common wording for solar systems applied to buildings is the so-called "solar fraction". Generalizing the term to any form of generation leads to the load match index [30] in the form of **Eq. 7**:

$$f_{load,i} = \frac{1}{N} \sum_{year} \min\left[1, \frac{g_i(t)}{l_i(t)}\right] \qquad \text{Eq. 7}$$

[iv] This means adopting an asymmetric weighting system, see 2.2.

where g and l stands for generation and load, respectively; i stands for energy carrier and t is the time interval used, e.g. hour, day or month. N stands for the number of data samples, i.e. 12 for monthly time interval and 8760 for hourly time interval, respectively. See also Table 1 on nomenclature.

Load match calculation is sensitive to the time resolution considered, as investigated in [30] for three existing buildings in Portugal, USA and Germany respectively, and in [33] by simulations for dwellings in high latitude climates. In that study, based on 10 min data resolution not more than 28% of the annual load can be matched although the annual yield fully balances the annual demand. Analyzing the load match at the monthly level, instead, gives a matching of 67%. Also the load considered, naturally, affects load match calculations. Simulations of a Belgian dwelling [34] report that considering 1 min data resolution 42% of the household electrical demand was instantaneously matched, while the fraction decreases to 29% when including the demand for space heating and DHW via heat pump. The reason is that the (electrically driven) heat pump increases the electric load in times with low solar power availability.

When calculated on monthly values the load match index provides basically the same kind of information as the monthly net balance, see criterion 3.2-Net ZEB balance-Type of balance. In this case though, the higher the load match index, the lower the seasonal unbalance of energy exchanged with the grid. The load match index is, however, a finer indicator than the monthly net balance because it looks at one energy carrier at a time and is not distorted by the weighting.

4.2 Grid interaction

To assess the exchange of energy between a Net ZEB and a grid versus the grid's needs one must know at least the import/export profile from the building. The other half information must come from the grid's side, e.g. in terms of base/peak load, hourly price or carbon emission factor; but this is beyond the scope of this paper.

The grid interaction can be addressed based on metering or simulation data of delivered and exported quantities. Therefore, indicators of grid interaction fit well for being used in combination with an import/export balance, see criterion 3.2-Net ZEB balance-Type of balance. Such data have to consider the entire load, including user related loads such as plug loads even if excluded from the balance boundary, as the grid stress can only be addressed by a full balance approach, see criterion 1.2-Building system boundary-Balance boundary.

Several indicators have been proposed to analyze the interaction between buildings and grids, with a viewpoint from either the building or the grid perspective [32]. As an example, an index from the viewpoint of the building is considered here: the grid interaction index [30]. The grid interaction index represents the variability (standard deviation) of the energy flow (net export) within a year, normalized on the highest absolute value. The net export from the building is defined as the difference between exported and delivered energy within a given time interval. The grid interaction index is calculated as in **Eq. 8**:

$$f_{grid,i} = STD\left[\frac{e_i(t) - d_i(t)}{|\max[e_i(t) - d_i(t)]|}\right] \quad \text{Eq. 8}$$

where e and d stands for exported and delivered, respectively; i stands for energy carrier and t is the time interval used, e.g. hour, day or month. See also Table 1 on nomenclature. As for load matching, also the grid interaction index is sensitive to the time resolution considered. Table 2 shows the load match and the grid interaction index calculated for three different time resolutions based on a small all-electric solar home designed for the Solar Decathlon Europe competition in 2010, data presented in [30].

Table 2. Effect of time resolution on the indicator values, data from [30].

Indicator	Time resolution		
	Monthly	Daily	Hourly
Load match index	79%	76%	36%
Grid interaction index	43%	35%	25%

An important characteristic from the viewpoint of the grids is the grid interaction flexibility [32] of a Net ZEB, understood as the ability to respond to signals from the grid (smart grids), e.g. price signals, and consequently adjust load (DSM), generation (e.g. CHP) and storage control strategies in order to serve the grid needs together with the building needs, and/or adjust to favourable market prices for energy exports or imports. Therefore, to be meaningful the grid interaction flexibility has to be evaluated with a time resolution of an hour or preferably even lower.

What is actually in the hands of designers is to design the building and its energy systems to enhance grid interaction flexibility. The flexibility could be quantified using suitable indicator(s) evaluated in two opposite extreme situations. An extreme situation is an export priority strategy (maximum energy export): the generation system export energy to the grids regardless of the building's load or storage possibilities. The opposite extreme situation is a load matching priority strategy (maximum load match): control strategies for storage system, load shifting and generation modulation, where possible, provide maximised self-consumption of the generated energy. The difference between the two values tells how flexible a building is in terms of grid interaction. One important design strategy may be to enhance the grid interaction flexibility: the higher the flexibility, the better the building will be able to adapt to signals from the grid.

It is worth noting that for building designer to design Net ZEBs with high grid interaction flexibility, it is necessary to have data on end users temporal consumption patterns, e.g. for lighting, electrical appliances, cooking, hot water use. Such data should be statistically representative for the type of building in analysis (i.e. residential, office, school, etc.) or better such data should be even normative. In the same way as weather data are standardized to provide designers with a reference climate, user profile data may be standardized to offer designers a reference temporal consumption pattern (with hourly and seasonal variations) for each type of building. Furthermore, evaluation of different strategies for the control of load, generation and storage need the support of advanced dynamic simulations tools.

5. Measurement and Verification

The establishment of building performance targets at policy level necessarily leads to the development of energy rating systems, i.e. methodologies for the evaluation of the building energy performance. Ratings can be calculated ratings when based on calculations, or measured (or operational) ratings when based on actual metering [35]. Within this perspective, it is questioned whether the Net ZEB target should be a calculated or a measured rating. A measured rating would enable the verification of claimed Net ZEBs, the effectiveness and robustness of the design solutions applied, and at last the actual achievement of the energy policy targets.

To check that a building is in compliance with the Net ZEB definition applied, a proper measurement and verification (M&V) process is required [36]. Such process is strictly dependent on the options selected for each criteria of the definition and on the features of the building to be assessed. As a minimum, an M&V protocol for Net ZEBs should enable the assessment of the import/export balance, as this is the core of the Net ZEB concept. Eventually, an M&V process could aim at evaluating also the temporal match characteristics, such as the load match or grid interaction indices. This requires setting the time resolution and selecting the duration of measurements, sampling and recording time.

As comfort is a mandatory requirement in buildings, an M&V protocol should also check the indoor environmental quality (IEQ). The complexity can then increase significantly due to the large number of sensors likely required in several locations within a building. Nevertheless, to warrantee indoor comfort is always the first priority in building design and the risk of designing Net ZEBs with poor IEQ shall be avoided; IEQ measurements would help to this respect. Furthermore it would help explaining possible deviations from the expected energy performance – in relation to the expected operating conditions criterion 1.3-Building system boundary-Boundary conditions – and point out relevant optimization measures.

Clearly, the completeness and complexity of a Net ZEB definition is reflected in the M&V process in terms of feasibility and affordability. It is worth noting that only the energy uses included in the balance boundary, see criterion 1.2-Building system boundary-Balance boundary, contribute to define the Net ZEB balance. As a consequence, the exclusion of an energy use from the balance boundary, e.g. the electricity use for plug-loads, would require the installations of a separate meter – or possibly several – in addition those located at the interface with the grids (on the physical boundaries). This means moving from a whole building monitoring approach to sub-metering [37], [38] and [39], increasing the complexity of the monitoring system and jeopardizing the verifiability of the definition. For an easily verifiable definition, hence, it would be preferable to have all the energy carriers crossing the physical boundary included in the balance boundary as well.

Furthermore, in order to implement a measured rating for Net ZEBs it is necessary to specify the required validity over time and over variable boundary conditions. How long a claimed Net ZEB shall comply with the definition? What happens if in the selected time span, changes in boundary conditions occur, such as variation in the climate, occupancy, building uses? It is therefore necessary to define:

- The time span over which the measured rating shall satisfy the Net ZEB balance;
- Tolerances on the balance and required comfort conditions;
- Parametric analysis approaches to show the relationship between the balance and influencing variables, such as comfort, climate, building use, occupancy, user behaviour.

Conclusions

While the concept of zero energy buildings is generally understood, an internationally agreed definition is still lacking. It is recognised that different definitions are possible, in order to be consistent with the purposes and political targets that lay behind the promotion of Net ZEBs.

A framework for describing the relevant characteristics of Net ZEBs in a series of five criteria and relative sub-criteria has been presented. For each criterion different options are available on how to deal with that specific characteristic. Evaluation of the criteria and selection of the related options becomes a methodology for elaborating Net ZEB definitions in a systematic, comprehensive and consistent way. This can create the basis for legislations and action plans to effectively achieve the political targets.

The common denominator for the different possible Net ZEB definitions in the presented framework is the balance between weighted demand and supply. The balance may be calculated in different ways, depending on the quantities that are of interest and available. An import/export balance focuses on the energy flows exchanged between the building and the grids; it applies in monitoring or in design when estimates of self-consumption are available. A simpler load/generation balance focuses on the gross load and generation quantities disregarding their interplay; it applies in design when estimates of self-consumption are not available. A third type of balance is the monthly net balance that can be seen as a combination of the other two; monthly generation and load (for each energy carrier) are assumed to balance each other off and only the monthly residuals are summed up to form the annual totals.

The choice of a proper balance metrics and weighting system should depend on targets in the political agenda and not being driven solely by feasibility of Net ZEB projects or minimisation of investment cost; even though this may be a major target itself. However, it is important that authorities and competent national bodies and legislators are fully aware of the effect of the weighting factors when deciding upon the metrics to adopt for the Net ZEB definition they want to set in place.

Important aspects in the framework are the criteria on energy efficiency and energy supply. While the pathway to a Net ZEB is given by the balance of the two actions – energy efficiency and energy supply – experience from a large number of already existing Net ZEBs underlines the priority of energy efficiency as the path to success [15]. Minimum energy efficiency requirements may be enforced in a Net ZEB definition. Likewise, a hierarchy of energy supply options may also be enforced.

Net ZEBs are characterized by more than the mere weighted balance over a period of time. In this paper the authors propose a characterization based on two aspects of temporal energy match: load matching, the ability to match the building's own load, and grid interaction, the ability to work beneficially with respect to the needs of the local grid infrastructure. These aspects are evaluated separately per each energy carrier exchanged with the grids, no weighting is applied. For the load matching an indicator is proposed, the load match index, able to express the seasonal unbalance of energy exchanged with a grid. For the grid interaction the concept of grid interaction flexibility is introduced, which may be estimated in design phase by simulating different strategies for the control of load, generation and storage systems. The indicators presented address the topics but need to be further developed. However, there is a need to work with a time resolution of hours or even lower in order to address issues such as energy price fluctuation and grids' peak load. To this respect building designers need information on end users temporal consumption patterns, better if from normative data, and the support of advanced dynamic simulations tools.

Finally, it is argued that only a measured rating would enable the verification of claimed Net ZEBs, the effectiveness and robustness of the design solutions applied, and at last the actual achievement of the energy policy targets. Therefore, a measurement and verification

(M&V) process is required and its completeness and complexity will dependent on the options selected for the definition criteria. It is stressed that for an easily verifiable Net ZEB definition it is preferable to include all operational energy uses in the balance boundary. Specification of other boundary conditions, such as reference climate, comfort, functionality and space effectiveness, are also necessary in order assess possible deviations from the calculated to the measured balance.

References

[1] EPBD recast (2010) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on theenergy performance of buildings (recast), Official Journal of the European Union, 18/06/2010.

[2] US DOE (2008) Building Technologies Program, Planned Program Activities for 2008-2012, Department Of Energy, US, http://www1.eere.energy.gov/buildings/mypp.html (downloaded .01/07/2010)

[3] UK Green Building Council (2011a) http://www.ukgbc.org/site/info-centre/display-category?id=22, accessed 27/10/2011.

[4] UK Green Building Council (2011b) http://www.ukgbc.org/site/news/show-news-details?id=398, accessed 27/10/2011.

[5] Torcellini, P., Pless, S., Deru, M. and Crawley, D. (2006), Zero Energy Buildings: A Critical Look at the Definition, National Renewable Energy Laboratory and Department of Energy, US.

[6] Kilkis, S. (2007), A new metric for net-zero carbon buildings. In the Proceedings of Energy Sustainability 2007, Long Beach, California, pp. 219-224.

[7] Laustsen, J. (2008) Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings, International Energy Agency (IEA).

[8] ECEEE (2009), Net zero energy buildings: definitions, issues and experience, European Council for an Energy Efficient Economy (EU).

[9] Marszal, A. and Heiselberg, P. (2009), A literature review on ZEB definitions, Aalborg University (DK).

[10] Marszal, A. J., Heiselberg, P., Bourrelle, J. S., Musall, E., Voss, K., Sartori, I. and Napolitano, A. (2011) Zero Energy Building – A Review of definitions and calculation methodologies, Energy and Buildings, 43(4): 971-979.

[11] Kurnitzki, J., Allard, F., Braham, D., Goeders, G., Heiselberg, P., Jagemar, L., Kosonen, R., Lebrun, J., Mazzarella, L., Railio, J., Seppänen, O., Schmidt, M. and Virta, M.(2011) How to define nearly zero energy buildings, REHVA Journal, May, p.6-12.

[12] Voss, K., Musall, E., Lichtmeß, M.(2011) From low energy to net zero energy buildings – status and perspectives, Journal of Green Building, vol. 6/1, 2011, p. 46-57.

[13] Sartori, I., Dokka, T. H. and Andresen, I. (2011) Proposal of a Norwegian ZEB definition: Assessing the Implications for Design, Journal of Green buildings, vol. 6/3, in press.

[14] Heinze, M., Voss, K. (2009) Goal: Zero Energy Building – Exemplary Experience Based on the Solar Estate Solarsiedlung Freiburg am Schlierberg, Germany, Journal of Green Building, vol. 4/4.

[15] Voss, K. and Musall, E. (2011) Net Zero Energy Buildings- International Projects on Carbon Neutrality in Buildings, DETAIL, ISBN-978-3-0346-0780-3, Munich.

[16] IEA Task 40/Annex 52 (2008), Towards Net Zero Energy Solar Buildings, IEA SHC Task 40 and ECBCS Annex 52, http://www.iea-shc.org/task40/index.html, accessed 10/12/2009.
[17] EN 15603 (2008) Energy performance of buildings - Overall energy use and definition of energy ratings, European Standard, European Committee for Standardization, Brussels, BE.
[18] Zero Carbon Hub (2011a) Carbon compliance – Setting an appropriate limit for zero carbon new homes, Zero Carbon Hub, February 2011, London, UK.
[19] Zero Carbon Hub (2011b) Allowable solutions for tomorrow's new homes, Zero Carbon Hub, July 2011, London, UK.
[20] Sartori, I. and Hestnes, A.G. (2007) Energy use in the life cycle of conventional and low-energy buildings: a review article, Energy and Buildings, 39(3), 249–257.
[21] Erneuerbare Energien Gesetz, Deutsches Bundesumweltministerium, www.bmu.de/gesetze_verordnungen/doc/2676.php, download date 6.7.2011
[22] Graabak, I. And Feilberg, N. (2011) CO_2 emissions in different scenarios of electricity generation in Europe, SINTEF Energy Research, report TR A7058, Trondheim, NO.
[23] OpenEI (2011) Hourly Energy Emission Factors for Electricity Generation in the United States, http://en.openei.org/datasets/node/488, accessed 22/09/2011.
[24] Red eléctrica de España (2011) Power demand tracking in real time, http://www.ree.es/ingles/operacion/curvas_demanda.asp, accessed 22/09/2011.
[25] TDV (2005) Time-Dependent Valuation, http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/index.html, accessed 22/09/2011.
[26] Sartori, I., Candanedo, J., Geier, S., Lollini, R., Athienitis, A., Garde, F. and Pagliano, L. (2010), Comfort and Energy Performance Recommendations for Net Zero Energy Buildings, In the Proceedings of EuroSun 2010, Graz, AT.
[27] BPIE (2010) Cost Optimality – Discussing methodology and challenges within the recast EPBD, Building Performance Institute Europe, Brussels, BE.
[28] ECEEE (2011) Cost optimal building performance requirements – Calculation methodology for reporting on national energy performance requirements on the basis of cost optimality within the framework of the EPBD, European Council for an Energy Efficient Economy, 2 May 2011.
[29] EPBD-CA (2011) Cost optimal level s for energy performance requirements – Executive summary, Energy Performance of Buildings Concerted Action, July 2011.
[30] BPIE (2011) Principles for nearly zero-energy buildings, Report from the Building Performance Institute of Europe, http://www.bpie.eu/pub_principles_for_n_zeb.html, 2012 (accessed 09/02/2012)
[31] Voss, K., Sartori, I., Musall, E., Napolitano, A., Geier, S., Hall, M., Karlsson, B., Heiselberg, P., Widen, J., Candanedo, J. A. and Torcellini, P. (2010), Load Matching and Grid Interaction of Net Zero Energy Buildings, In the Proceedings of EuroSun 2010, Graz, AT.
[32] Salom, J., Widén, J., Candanedo, J., Sartori, I., Voss, K. and Marszal, A. (2011) Understanding Net Zero Energy Buildings: Evaluation of load matching and grid interaction indicators, Proceedings of Building Simulation, 14-16 Nov., Sydney, AU.
[33] Widén, J., Wäckelgård, E. and Lund, P. (2009) Options for improving the load matching capability of distributed photovoltaics: Methodology and application to high-latitude data, Solar Energy, (83)pp. 1953-1966.
[34] Baetens, R., De Coninck, R., Helsen, L. and Saelens, D. (2010) The impact of domestic load profiles on the grid-interaction of building integrated photovoltaic (BIPV) systems in extremely low-energy dwellings, In Proceedings of the Renewable Energy Research Conference, 7-8 June, Trondheim, Norway.

[35] U.S.Department of Energy, Office of Energy Efficiency and Renewable Energy. (2000). Measurement and Verification Guidelines for Federal Energy Management Projects. Abgerufen am January 2011 von http://www1.eere.energy.gov/femp/pdfs/mv_guidelines.pdf
[36] Napolitano, A. et al. (2011) Measurement and Verification protocol for Net Zero Energy Buildings, Technical report in subtask A of the IEA - SHC/ECBCS - Task40/Annex52 – Towards Net Zero Energy Solar Buildings.
[37] Haberl, J. C. (1990). The design of Field Experiments and Demonstrations. Field Monitoring Workshop. Gothernburg : IEA Proceedings.
[38] EVO Efficiency Valuation Organization. (2010). International Performance Measurement and Verification Protocol - Concepts and Options for Determining Energy and Water Savings Volume 1. Abgerufen am 24. January 2011 von www.evo-world.org.
[39] Australian Government, Energy Efficiency Opportunities Section, Energy and Environment Division. (2008). Energy savings measurement guide: how to estimate, measure, evaluate and track energy efficiency opportunities. Department of Resource, Energy, and Tourism / WorleyParsons Service Pty Ltd .

Appendix A – Conversion factors

		Europe		Austria	Denmark	Finland		Germany		Italy	Norway		Spain		Sweden		Switzerland	
Energy carrier	Metrics	EN 15603 2008	PHPP 2007	Gemis Vers. 4.5	BR 2010 2010	BC 2012 2011	Gemis 2011	DIN V 18599/1 2007	GEMIS Vers. 4 5	UNI-TS-11300/4 draft 9/2009	NS 3700 2009	ZEB centre* 2010-2060	I.D.A.E. 2010	CALENER 2009	average* 2008	pol. factors 2008	SIA 2031 2009	EnDK 2009
Electricity	PEI, n.r.	3,14*	2.70	1,3*		1.70		2.60	2.61	2.18*							2.53	2.00
	PEI, total	3,31*		1.91	2,50*	1.70		3.00	2.96				2.28	2.60	1 50	2.50	2.97	
	$CO_{2\ equiv.}$	617,00*	680.00	389.00		329.62	331.00		633.00	531**	395	132	350*	649			154.00	
Natural gas	PEI, n.r.	1.36	1.10	1.12		1.00		1.10	1.12	1 00							1.10	1.00
	PEI, total	1.36		1.12	1 00	1.00		1.10	1.12				1.07	1.10			1.15	
	$CO_{2\ equiv.}$	277.00	250.00	268.00		202*	315.00		244.00		211		251*	204.00			241.00	-
Oil	PEI, n.r.	1.35	1.10	1.11		1.00		1.10	1.11	1 00							1.15	1.00
	PEI, total	1.35		1.13	1 00	1.00		1.10	1.11				1.12	1.08	1 20	1.20	1.24	
	$CO_{2\ equiv.}$	330.00	310.00	302.00		279*	381.00		302.00		284		342*	287.00			295.00	
Wood, pieces	PEI, n.r.	0,09**	0.20	0.01		0.50		0.20	0.01	0 00							0.05	0.70
	PEI, total	1,09**		1.01	1 00	0.50		1.20	1.01				1.25		1 20	1.20	1.06	
	$CO_{2\ equiv.}$	14**	50.00	6.00		32.40	17.00		6.00		14		0.00	0.00			11.00	
Wood, pellets	PEI, n.r.			0.14		0.50		0.20	0.14	0 00							0.30	0.70
	PEI, total			1.16	1 00	0.50		1.20	1.16					0.00	1 20	1.20	1.22	
	$CO_{2\ equiv.}$			41.00			19.00		41.00		14						36.00	
Disctrict heat	PEI, n.r.		0.80	0.76				0.70	0.76	system specific							0,81*	0.60
70% CHP	PEI, total			0.77	1,00*	0.70		0.70	0.77						0 90	1.00	0,8*	
(fossil)	$CO_{2\ equiv.}$		240.00	219.00			230.00		219.00		231						162*	

PEI = Primary Energy Indicator — $kWh_{Primary}$ / $kWh_{delivered}$
n.r. = non renewable part — $kWh_{Primary}$ / $kWh_{delivered}$
CO_2 equiv. = equivalent CO_2 emissions — g / $kWh_{delivered}$
* see comments for each country

Country	Comments	Sources
Europe	* power according to UCTE mix ** wood in general	EN 15603 (2008)Energy Performance of Buildings – Overall energy use and definition of energy rationgs – Annex E Factors and coefficients, CEN. PHPP (2007) Passive House Planning Package, *The Passive House Institute*, Darmstadt, DE.
Austria	* according to the Austrian Environment Agency	Database of GEMIS, Global Emission Model for Integrated Systems, internet page of the program: http://www.oeko.de/service/gemis/en/
Denmark	* 2015 requirements use 0,8; 2020 requirements use 0,6 for district heating and 1,8 for electricity	The Danish Building Code 2010, BR 2010
Finland	* based on Motiva report, 2004	National Building Code of Finland. Part D3 Energy-Efficiency. Ministry of Environment 2011 Database of GEMIS, Global Emission Model for Integrated Systems, internet page of the program: http://www.oeko.de/service/gemis/en/ Motiva report, 2004, emission factors and calculation of emission factors. Available at: http://www.motiva.fi/files/209/Laskentaohje_CO2_kohde_040622.pdf
Germany	The normative primary energy factors for the national building code are given with DIN V 18599, emission date are not listet; if emission data are applied the most common source is GEMIS	DIN V 18599:2007-02, part 10, Beuth-Verlag, Berlin, 2009 Database of GEMIS, Global Emission Model for Integrated Systems, internet page of the program: http://www.oeko.de/service/gemis/en/
Italy	* EEN3/08 resolution by AEEG - GU n. 100, 29.4.08 - SO n.107 - www.http://www.autorita.energia.it/it/docs/08/003-08een.htm **www.minambiente.it/home_it/menu.html?mp=/menu/menu_attivita/&m=argomenti.html|Fonti_rinnovabili.html|Fotovoltaico.html|Costi__Vantaggi__e_Mercato.html	UNI-TS 11300 Part IV,under review (last draft 2009)-LA NORMATIVA TECNICA DI RIFERIMENTO SUL RISPARMIO ENERGETICO E LA CERTIFICAZIONE ENERGETICA DEGLI EDIFICI
Norway	* EU mix scenario for nearly carbon-free grid towards 2050 (in line with IPCC 450 ppm scenario); average 2010-2060	NS 3700 (2010) Criteria for passive houses and low energy buildings - residential buildings, *Standards Norway.* SINTEF Energy Research (2011) CO2 emissions in different scnarios of electricity generation in Europa, *Report for the Zero Emission Building research centre,* TR A7058.
Spain	* carbon emissions only	I.D.A.E., Institute for Energy Diversification and Saving, http://www.idae.es/index.php/lang.uk CALENER, software for certification of energy efficiency in buildings, http://www.mityc.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/ProgramaCalener/Paginas/DocumentosReconocidos.aspx
Sweden	* calcualted according to EN15316. Electricity calculations are based on Nordic electricity	http://www.sweden.gov.se/content/1/c6/10/01/76/9e6cf104.pdf, download, 27.7.2011
Switzerland	* based on waste combustion	SIA 2031 „Energieausweis für Gebäude“, SIA 2040 „Effizienzpfad Energie“, Schweizer Ingenieur- und Architektenverein, 2009 Gebäudeenergieausweise der Kantone – Nationale Gewichtungsfaktoren, EnDK, Bundesamt für Energie, 2009

Task 36

Solar Resource Knowledge Management

Dave Renné
National Renewable Energy Laboratory (Retired)
Operating Agent for U.S. Department of Energy

TASK DESCRIPTION

Goal and Objectives

The goal of SHC Task 36 "Solar Resource Knowledge Management" was to provide the solar energy industry, the electricity sector, governments, researchers, and renewable energy organizations and institutions with the most suitable and accurate information of the solar radiation resources at the Earth's surface in easily-accessible formats and understandable quality metrics. The scope of solar resource assessment information includes historic and currently derived data products using satellite imagery and other means.

There were three main objectives of this Task to achieve this goal:

- To provide further standardization and benchmarking of international solar resource data sets to insure worldwide Intercomparability and acceptance
- To provide improved data reliability, availability and accessibility in formats that address specific user needs, and
- To develop methods that improve the quality and the spatial and temporal coverage of solar resource products, including reliable long term historical solar radiation databases as well as near-term and long-term irradiance forecasts.

Achieving these objectives would reduce the cost of planning and deploying solar energy systems, improve efficiency of solar energy systems by more accurate and complete solar resource information, and increase the value of the solar energy produced by solar systems.

Scope of the Task

This Task focused on the development, validation, and access to solar resource information derived from surface-based and satellite-based platforms. The Task investigated benchmarking and data quality assessment procedures for data products and validation data sets, examined means by which the data can be made easily available to users through various web-based hosting schemes, and conduct studies on improving the input data sets and algorithms from which satellite-derived products are produced. These studies included the investigation of short-term irradiance forecasting and past and future climatic variability of the solar resource.

The audience for the results of the Task includes the technical laboratories, research institutions and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, solar system operators, architects, engineers, energy consultants, product manufacturers, and building and system owners and managers, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, web sites, handbooks and journal articles.

Means

Task 36 participants addressed the objectives through sharing a co-coordinated work plan encompassing three subtasks:

Subtask A: Standard Qualification for Solar Resource Products

The objective of this Subtask was to provide the user community with benchmarked, standardized, validated worldwide solar resource data sets. Key Subtask activities to meet this objective were:

- Select and Qualify Ground Data Sets (lead: NASA, USA)): this activity will include a survey and documentation of existing data sources, and the production and reporting of high-quality surface data sets with which to use in benchmarking and validating satellite-derived data sets.
- Define Measures of Model Quality for Product Validation (lead: H2 Magdeburg, Germany): besides defining measures of model quality, this activity includes the establishment and documentation of model intercomparison procedures.

- Develop Methodology for Establishing Coherent Benchmarking of Products (lead: NASA, USA)
- Apply Benchmarking Procedures to Subtask C Products (lead: H2Magdeburg, Germany): this activity will provide results of benchmarking studies conducted on data sets provided by Task 36 participants

Subtask B: Common Structure for Archiving and Accessing Data Products

The objective of this Subtask was to provide a user-oriented information system, such as a distributed data system, for archiving and accessing solar resource data. Key subtask activities to meet this objective were:

- Evaluate the Legal Aspects of Accessing Solar Resource Data (lead: Armines, France): this activity focuses on establishing copyright and proprietary rights of data that will be made available through the distributed data system, and to establish appropriate protocols with each participating institution for making the data generally available to the public.
- Identification of User Requirements (lead: SUNY/Albany, USA and JRC, EU): this activity captures and examines needs expressed by users of the data and the outcomes are specifications for the information system, list of customers serving later as testers of the prototypes and guidance to subtask A for selection of algorithms and methods
- Develop Data Exchange Protocols and Metadata (lead: Armines, France): various data exchange protocols will be examined, and one will be selected and documented.
- Develop Prototype (lead: Armines, France): a prototype web-based system will be developed whereby a user can request information of a certain type and format, and the information system provides the response or responses that most closely addresses the request.
- Develop Network of Resource Providers (lead: NASA, USA): a worldwide network of data providers will be established, and the techniques for data exchange among the providers will be investigated.
- Develop Use of Prototype by Users (lead: Armines, France): this activity defines the prototype that can be accessed by users, and raises the awareness of the data exchange system to external users.
- Define Automatic Access by Commercial Applications (lead: NASA, USA): This activity will enable automatic and fast access of resources through the information system by using commercial applications.
- Develop a Test Application (Solar Micrositing) (lead: JRC, EU): a case study in micro sitting of a solar energy system will be developed to demonstrate the benefits of the information system.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

The objective of this Subtask is to conduct essential R&D to improve the accuracy and the spatial and temporal coverage of current techniques, including the introduction of solar resource forecasting products. Key activities to meet this objective were:

- Improve Satellite Retrieval Methods for Solar Radiation Products (lead: SUNY/Albany, USA): This activity will focus on key model input parameters and methodologies, such as cloud indices, radiative transfer schemes, aerosol data retrievals, and treatment of snow and other surface albedo artifacts. The activity also addresses ways of improving the spatial resolution of satellite-derived broadband solar resource products.
- Conduct Climatological Analysis of Solar Resources (lead: NASA, USA): In order to ascertain future impacts on system performance due to climate variations, this activity includes the analysis of long-term surface and satellite-derived data sets and climate models; spe-

- specifically addressing natural long-term fluctuations associated within the ocean-atmosphere system, such as the Southern Oscillation/El Nino.
- Evaluate Solar Radiation Forecasting Procedures (lead: EHF, Germany): This activity investigates different approaches for developing solar resource forecasts based on global numerical weather predictions and extrapolation of cloud motion vectors

Collaboration with other IEA Programmes

Knowledge on solar resources is highly important for all forms of solar energy applications. Therefore Task 36 was conducted as a collaborative Task together with the IEA Implementing Agreements SolarPACES (Solar Power and Chemical Energy Systems), and was designated as Task 5. Task 36 also collaborated with the IEA PVPS (Photovoltaic Power Systems). Both of these Implementing Agreements agreed that SHC coordinates the Task. Cooperation is based on "minimum level" according to the SHC "Guidelines for Coordination with other Programmes."

Task Deliverables

Deliverables included conference papers, journal articles, workshops, and subtask summaries. The major deliverable will be a Handbook on Solar Radiation, summarizing the key results of all subtasks, planned for publication in mid-2012.

Task Duration

The Task was initiated July 1, 2005 and completed June 30, 2011.

Participating Countries

Austria, Canada, European Commission, France, Germany, Spain, Switzerland and the United States

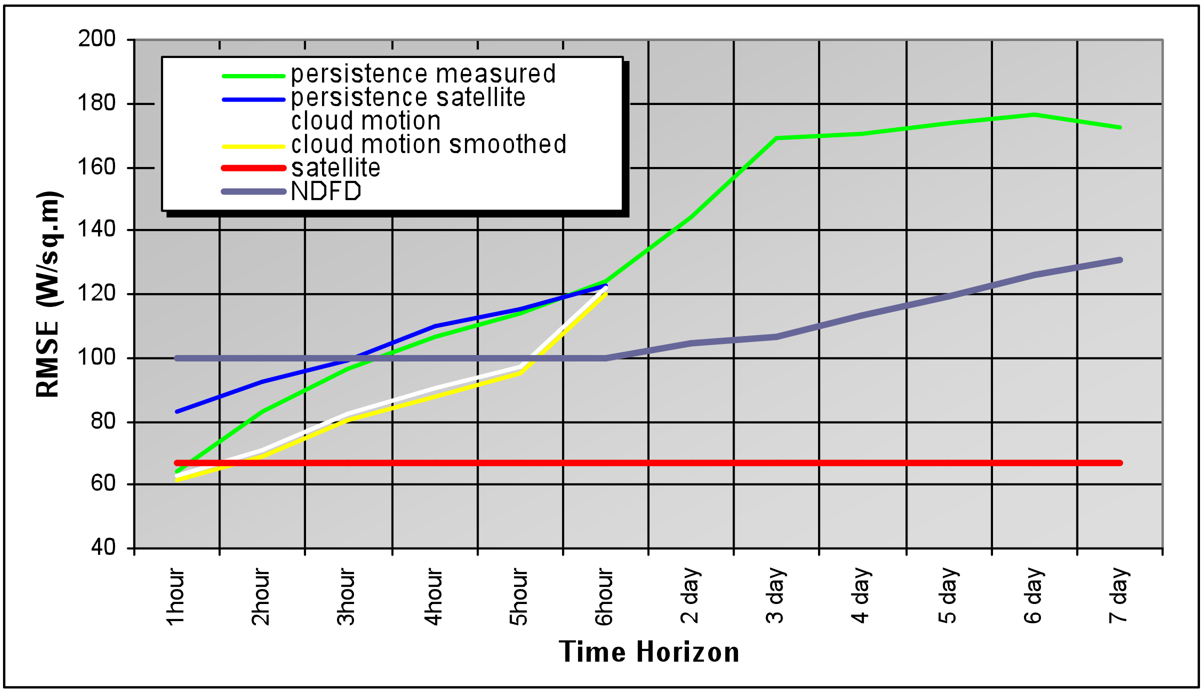


Figure 1. Forecast validation, as measured in Root Mean Square Error (RMSE), at a composite of 7 SurfRad solar monitoring stations around the U.S. NDFD=National Digital Forecast Database, which is based on Numerical Weather Prediction models.

WORK DURING 2011

Summary Task Status

The original work plan for Task 36 called for a 5-year task, ending in July 2010. However, at the 66th ExCo meeting in Nice, France in November 2009 the IEA/SHC ExCo granted a one-year extension of the task. At the time the extension was to allow for additional benchmarking studies and to transition the web portal from the MESoR (Management and Exploitation of Solar Resources) project to Task 36. Additional time was also needed to complete the final deliverable, the Handbook of Solar Radiation. At the same time a concept paper for a new Task titled "Solar Resource Assessment and Forecasting" was submitted to the SHC. This new task was approved by the SHC ExCo as Task 46 at their 68th Meeting in Cape Town in November 2010.

By the start of 2011 the majority of work planned under Task 36 was completed, However one area of work that had a prominent role in Task 36 will continue into Task 46, and this is improving and testing short term solar resource forecasting schemes. Thus, a considerable amount of work continues in this specific area. In addition, the Task Participants have begun focusing their attention on other work areas defined in Task 46, including evaluation of solar resource variability that impacts large penetrations of solar technologies, standardization and integrating procedures for data bankability, and advanced solar resource modeling procedures based on physical principles.

Nevertheless, Task Participants were unable to complete the Handbook on Solar Radiation by July 2011, and as a result Task 36 is still not completed. Current plans are for the Handbook to be submitted at the 71st SHC ExCo meeting in San Francisco in July 2012, and a final workshop for Task 36 to be presented. In addition, Task 46 has not yet been formally initiated since the proposed Operating Agent (to be supported by the U.S.) as well as the U.S. ExCo representative were both unable to attend either of the ExCo meetings in 2011.

Consequently this Annual Report will summarize key areas of technical work that was done under Task 36 and anticipated to continue into Task 46. We also expect to have the issue of the OA for Task 46 as well as country participation lined up by the July 2012 ExCo meeting, when the final Task 36 workshop will be presented.

Overall Task 36 Activities

Task Participants held two Task Expert Meetings in 2011. The 10th (and presumably final) Task 36 Expert Meeting was held in Stuttgart in March 2011. At this meeting one day was focused on presentations of results of work done under Task 36, and the second day was devoted to developing a draft work plan for the newly approved Task 46. At this Expert Meeting there was also considerable discussion as to the scope and content of the final deliverable, the Handbook of Solar Radiation. The original plan of producing a comprehensive document that encompassed all of the work produced under Task 36 was rejected by the Task Participants due to time constraints, and to the fact that so much of the work has already been published elsewhere. A scaled-back version of the Handbook was proposed, but even then there was considerable discussion as to the scope and format of the Handbook. Unfortunately this has resulted in further delays in finalizing the Handbook, although the current plans are for a final version to be completed in time for the Solar Heating and Cooling Conference in San Francisco in July 2012.

Another unique aspect of the 10th Expert Meeting was participation by senior representatives of the International Renewable Energy Agency (IRENA). IRENA has expressed considerable interest in the outcomes of Task 36 since their work plan calls for the development of a renewable energy potentials atlas and database, focusing initially on solar and wind. In fact, some Task 36 participants are involved in the development of a solar and wind atlas, which would ultimately be pulled in to IRENA's activities. This solar and wind atlas is currently supported by Germany, Spain and Denmark through the Major Economies Forum (MEF) Clean Energy Ministerial (CEM). A special meeting of CEM solar and wind atlas team, including the IRENA representatives, was held the day after the Task 36 10th Expert Meeting in Stuttgart.

The first Task 46 Expert Meeting was held in Kassel, Germany in early September 2011 immediately following the Solar World Congress 2011. Many task participants had given technical presentations at the SWC, and therefore there was a large turnout for the Expert Meeting. This one-day meeting focused entirely on developing a draft final work plan for Task 46, which was presented at the 70th ExCo meeting held in Bad Aibling later in 2011.

Task representatives gave presentations at a number of conferences throughout 2011, including the National Solar Conference in Raleigh, North Carolina, USA (18-20 May), the Solar World Congress in Kassel, Germany (29 August - 1 September), PVSec Conference in Hamburg, Germany (5-8 September 2011), the SolarPACES Conference in Granada, Spain, (20-24 September 2011) the 1st International Workshop on Integration of Solar Power into Power Systems (24 October 2011, Aarhus, Denmark), and the International Conference on Energy Meteorology, Gold Coast, Australia (8-11 November).

Denmark is a new participant to the Task and has already joined Task 46. One contribution will be the provision of a solar irradiance database that consists of 10 years of data from the 28 DMI (Danish Meteorological Institute) global solar radiation stations with hourly values from all stations and 10-minute values from selected stations, and, 5 years of 2-minute data from the DTU (Danish Technical University) weather station of both global radiation and scattered irradiances (diffuse radiation). This treatment includes quality control and in a few cases gap filling. In addition a PhD student at DMI, Sisse Camilla Lundholm, is working with comparisons of irradiances from high-resolution ensemble runs including the standard Danish NWP model.

Key Activities in the Individual Subtasks

Subtask A: Standard Qualification of Solar Resource Products

Work on this subtask was completed in 2010. The final results were published in 2009 under the MESoR Project (http://www.mesor.org/docs/MESoR_Benchmarking_of_radiation_products.pdf). Additional benchmarking results were also reported through the MESoR project (http://www.mesor.org/docs/MESoR_Handbook_on_best_practices.pdf).

Reports on benchmarking of satellite-derived data sets using the methods of Subtask A have been published by Dr. Pierre Ineichen at the University of Geneva (Switzerland). The links to these publications are as follows:

http://www.unige.ch/cuepe/pub/ineichen_valid-sat-2011-report.pdf (2.3 Mb)
The annex http://www.unige.ch/cuepe/pub/ineichen_valid-sat-2011-annexe.pdf (60 Mb)
The report + annex http://www.unige.ch/cuepe/pub/ineichen_valid-sat-2011.pdf (62 Mb)

The benchmarking methods are also being applied to the test and evaluation of solar forecasting products, which will continue under Task 46.

Subtask B: Common Structure for Archiving, Processing, and Accessing Resource Data

All work in Subtask B has essentially been completed, and several summary reports regarding web services have been developed under the MESoR Project (http://www.mesor.org/deliverables.html).

Liaison with the Global Earth Observation System of Systems (GEOSS-8) Architecture Implementation Project 3 continues, with a focus on adapting best practices methodologies for web portal design. Instead of a Task 36 web portal, it is likely that some of the results of the work done in Subtask B will be incorporated by IRENA as a means of displaying solar resource products coming out of the solar and wind atlas being developed through the CEM.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

Activity C1: Improve Satellite Retrieval Methods for Solar Radiation Products

A draft final report has been prepared, describing the contributions from the experts who contributed to this activity. These contributions cover the following specific areas of research:

- Combining multiple data sources to optimize the accuracy of a site's solar energy resource assessment.
- Developing simple broad band clear sky models for global and direct irradiance (GHI and DNI), based upon rigorous radiation transfer models
- Determination of atmospheric aerosol content and/or type using either simple radiation transfer models and broadband DNI and/or GHI measurements, or state-of-the-art atmospheric transport models.

Team & abbreviation	Approach	Numerical Weather prediction model with spatial and temporal resolution	
1) University of Oldenburg, Germany, ECMWF-OL	Statistical post processing in combination with a clear sky model	ECMWF* - 0.25°x 0.25° - 3 hours	Global model with post processing
2) Bluesky, Austria a) SYNOP b) BLUE	a) Synoptic cloud cover forecast by meteorologists b) BLUE: statistic forecast tool	for b) GFS+ - 1° x 1° and 0,5°x 0.5° - 3 hours and 6 hours	Global model with post processing
3) Meteocontrol, Germany MM-MOS	MOS (model Output Statistics) by Meteomedia GmbH	ECMWF* - 0.25°x 0.25° - 3 hours	Global model with post processing
4) Cener, Spain CENER	Post processing based on learning machine models	Skiron^x/GFS+ - 0.1°x 0.1° - 1 hour	Mesoscale models with postprocessing
5) Ciemat, Spain HIRLAM-CI	Bias correction	AEMET-HIRLAM^x - 0.2°x 0.2° - 1 hour	Mesoscale models with postprocessing
6) Meteotest, Switzerland, WRF-MT	Direct model output of global horizontal irradiance (GHI) averaging of 10x10 model pixels	WRF^x/GFS+ : - 5 km x 5 km - 1 hour	Mesoscal models
7) University of Jaen, Spain WRF-UJAEN	Direct model output of GHI	WRF^x/GFS+ - 3 km x 3 km - 1 hour	Mesoscal models

Table 1. Solar Resource Forecasting schemes evaluated by Task 36 participants under Activity C3.
(*Table prepared by Dr. Elke Lorenz, University of Oldenburg*)

- Production of enhanced atmospheric aerosol long-term data sets for use by satellite and/or forecast irradiance models
- Assessing the ability of satellite-derived irradiances and of other sources to properly characterize the inter-annual variability of the solar resource.
- Developing enhanced satellite-to irradiance models
- Accuracy improvements of satellite-derived solar resource based on GEMS re-analysis aerosols
- Quality procedures for provision site-specific solar resource information

The report summarizes and contextualizes each contribution and points to source reports and articles produced during the course of the task. The report, when completed, will represent one of the final Task 36 deliverables and will be posted to the IEA-SHC Task 36 web site.

Activity C2: Conduct Climatological Analysis of Solar Resources:

The University of Geneva (Switzerland) has published a comprehensive overview of interannual variability titled "Global Radiation: Average and Typical Year, and Year-to-Year Annual Variability", by Pierre Ineichen. This represents a final deliverable under this task. These and other reports by Dr. Ineichen can be found on his University of Geneva web site: http://www.cuepe.ch/html/pub_ineichen.php?titre=&mjc=2047&ad=&pr=ineichen&sr=auteurs&page=1&line=

Activity C3: Evaluate Solar Radiation Forecasting Procedures:

Results of work under Subtask C3 show that there are three predominant time frames and methodologies for short-term solar resource forecasting: 1) Intra-hour (sub-hourly), where on-site observational tools such as Total Sky Imagers can be deployed, 2) 1 to 6-hour ahead, where methodologies such as satellite cloud motion vectors, perhaps in conjunction with mesoscale numerical weather prediction models, can be used, and 3) 1 to 7-day ahead, where Numerical Weather Prediction models, preferably in ensemble mode, are required. The work in Subtask 3 focused almost entirely on the 1 to 6-hoiur and the 1 to 3-day ahead forecasting methodologies. In a test of forecasting schemes at 7 high-quality SurfRad (Surface Radiation) solar measurement sites operated by the U.S. National Oceanic and Atmospheric Administration, Dr. Richard Perez of the State University of New York at Albany has shown that the use of cloud motion vector analysis is preferable up to about 6-hour ahead forecasts, but then Numerical Weather Prediction models should be used for more extended forecast periods, as shown in Figure 1. The figure also clearly demonstrates that applying either one or the other methods gives superior results to just relying on "persistence-type" forecasts.

A final Subtask C3 deliverable has been prepared under the leadership of the University of Oldenburg (Germany), involving the contributions of many task participants. The report contains information on the following:

- Investigation and development of different approaches for forecasting solar irradiance based on numerical weather prediction models
- Investigation of solar radiation forecasts based on cloud motion vectors
- Comparison of the different forecasting algorithms in two benchmarking exercises (USA, Europe)
- Applications of irradiance forecasting: PV power prediction, use of direct irradiance forecasts for management of CSP, grid integration of solar power, energy management of a solar assisted district heating grid.

A summary of the forecasting methods tested under Activity C3 is given in Table 1. This work was done under the leadership of Dr. Elke Lorenz of the University of Oldenburg.

A contribution with respect to solar and photovoltaic irradiance forecasting based on NWP models was prepared by (CanmetENERGY, Natural Resources Canada) as part of the project "Photovoltaic forecasting in Canada and applications to large-scale grid integration". Hourly solar and photovoltaic (PV) forecasts for horizons between 0 and 48 hours ahead were developed using Environment Canada's Global Environmental Multiscale (GEM) model. The solar and PV forecasts were compared to irradiance data from 10 North American ground stations and to AC power data from 3 Canadian PV systems. A one-year period was used to train the forecasts and the following year was used for testing. Two post-processing methods were applied to the solar forecasts: spatial averaging and bias removal using a Kalman filter. On average, these two methods lead to a 15% reduction in RMSE over the GEM forecasts without post-processing. Bias removal was primarily useful when considering a « regional » forecast for the average irradiance of the 10 ground stations, since bias was a more significant fraction of RMSE in this case. PV forecast accuracy was influenced mainly by the underlying (horizontal) solar forecast accuracy, with RMSE ranging from 6.4% to 9.2% of rated power for the individual PV systems. About 76% of the PV forecast errors were within +-5% of the rated power for the individual systems, but the largest errors reached up to 44 to 57% of rated power. The results of this project have been described in a scientific paper [Pelland et al, 2011] that has been submitted by **Sophie Pelland, George Galanis and George Kallos** the journal Progress in Photovoltaics: Research and Applications in April 2011.

Although Task 36 participants did not consider the sub-hourly time frame in their work, a recent contribution that will be given further consideration in Task 46 is presented here, demonstrating how a Total Sky Imager can be used to provide short-term irradiance forecasts to utility operators is being developed by the University of California San Diego (Dr. Jan Kleissl). Sky images taken every 30-s were processed to determine sky cover using a clear sky library and sunshine parameter. From a two-dimensional cloud map generated from coordinate-transformed sky cover, cloud shadows at the surface were estimated. Limited validation on four partly cloudy days showed that (binary) cloud conditions were correctly nowcast 70% of the time for a network of six pyranometer ground stations spread out over an area of 2 km2. Cloud motion vectors were generated by cross-correlating two consecutive sky images. Cloud locations up to 5 min ahead were forecasted by advection of the two-dimensional cloud map. Results are shown in Figure 2 (Chow et al., 2011).

WORK PLANNED FOR 2012

The final deliverable, *Handbook on Solar Radiation*, was stalled and will now be completed in 2012. In the meantime, Task participants will begin preliminary work on Task 46, which started on 1 July 2011.

LINKS WITH INDUSTRY

Several small companies directly participated in the Task: Suntrace GmbH, Meteotest, Blue Sky Wetteranalyzen, irSO-Lav, and GeoModel Solar s.r.o. Another task participant formed a cooperative arrangement with Clean Power Research in the U.S. to market satellite-derive data.

The audience for the results of Task 36 includes the technical laboratories, research institutions, and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, building and system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, web sites, handbooks and journal articles.

REPORTS/PAPERS PUBLISHED IN 2011

Journal Articles

Chow, Chi Wai, Bryan Urquhart, Matthew Lave, Anthony Dominguez, Jan Kleissl, Janet Shields, and Byron Washom, 2011: Intra-hour forecasting with a total sky imager at the UC San Diego solar energy testbed. Solar Energy Journal (in press).

Dominguez A, Kleissl J, Luvall JC, 2011: Effects of Solar Photovoltaic Panels on Roof Heat Transfer, Solar Energy, 10, 85(9): 2244-2255.

Lave, M., J. Kleissl, Arias-Castro, E., 2011: High-frequency fluctuations in clear-sky index, Solar Energy.

Lave M, Kleissl J, 2011: Optimum fixed orientations and benefits of tracking for capturing solar radiation in the continental United States, Renewable Energy, 36:1145-1152.

Lara-Fanego, V., J.A. Ruiz-Arias, D. Pozo-Vázquez, F.J. Santos-Alamillos, J. Tovar-Pescador. Evaluation of the WRF model solar irradiance forecasts in Andalusia (southern Spain), Solar Energy, *In press*.

Mathiesen P, Kleissl J, 2011: Evaluation of numerical weather prediction for intra-day hourly solar irradiance forecasting in the CONUS, Solar Energy, 85(5): 967-977.

Polo, J, Zarzalejo L.F., Cony M, Navarro A.A., Marchante R., Martín L., Romero M. (2011). Solar Radiation estimations over India using meteosat satellite images, Solar Energy 85, 2395-2406.

Ruiz-Arias, J. A., Pozo-Vázquez, D., Lara-Fanego, V. and Tovar-Pescador, J. (2011), A high-resolution topographic correction method for clear-sky solar irradiance derived with a numerical weather prediction model. Journal of Applied Meteorology and Climatology, Vol. 50, pp 2460-2472.

Ruiz-Arias, J.A., Pozo-Vázquez, D., Santos-Alamillos, F.J., Lara-Fanego, V., Tovar-Pescador, J. (2011). A topographic geostatistical approach for mapping monthly mean values of daily global solar radiation: A case study in southern Spain. Agricultural and Forest Meteorology, Vol. 151, pp 1812-1822.

IEA SHC Task 36 Reports

Ineichen, Pierre, 2011: Global Irradiation: average and typical year, and year-to-year variation. University of Geneva, March 2011.
http://www.cuepe.ch/html/pub_ineichen.php?titre=&mjc=2047&ad=&pr=ineichen&sr=auteurs&page=1&line=

SolarPACES 2011, Granada, Spain

Kraas, Birk, Reinhard Madlener, Benedikt Pulvermuller, and Marion Schroedter-Homscheidt. Variability of a Concentrating Solar Power Forecasting System for Participation in the Spanish Electricity Market.

Pozo Vazquez, D., S. Wilbert, C.A. Gueymard, L. Alados-Arboledas, F. J. Santos-Alamillos, M. J. Granados-Munoz. Interanjnual Variability of Long Time Series of DNI and GHI at PSA, Spain. University of Jaén.

V. Lara-Fanego, J. A. Ruiz-Arias, D. Pozo Vázquez, F. J. Santos-Alamillos, J. Tovar Pescado, S. Quesada-Ruiz, J. Martínez-Valenzuela, A. Linares-Rodríguez and A. Molina. The Role oft he Spatial Resolution in the Reliability of WRF-Based DNI Forecast: A Case Study at the Andasol STPP. University of Jaén.

Schroedter-Homscheidt, Marion and Benedikt Pulvermuller. Verification of Direct Normal Irradiance Forecasts fort he Concentrating Solar Thermal Power Plan Andasol-3 Location.

Schroedter-Homscheidt, Marion, Armel Oumbe, and Carsten Hoyer-Klick, Aerosol Load and Dust Event Mapping Based on Chemical Transport Modeling.

1st International Workshop on Integration of Solar Power into Power Systems, Aarhus, Denmark

Lara-Fanego, V., J.A. Ruiz-Arias, D. Pozo-Vázquez, F.J. Santos-Alamillos, J. Tovar-Pescador and S. Quesada-Ruiz. The role of the spatial resolution in the reliability of WRF-based DNI forecasts: a case study at the Andasol STPP

REPORTS PLANNED IN 2012

Handbook on Solar Radiation

MEETINGS IN 2011

9th Experts Meeting
March 1-2, 2010
Stuttgart, Germany

This meeting focused on a review of Task activities and results in preparation for developing the final task deliverables; a draft workplan for Task 46 "Solar Resource Assessment and Forecasting" was prepared; a liaison meeting with the CEM solar and wind atlas team and IRENA representatives was held.

10th Experts Meeting
September 2, 2011
Kassel, Germany

A final draft work plan for Task 46 was prepared. The work plan was subsquently presented at the 70th Executive Committee Meeting in Bad Aibling, Germany on 8 November 2011. However, because the designated OA and U.S. ExCo representative were unable to attend the meeting no final determination of country participation and support of the OA could be made.

MEETINGS PLANNED FOR 2012

2nd Task 46 Experts Meeting
May 18, 2012
Denver, Colorado, USA

Final Task 36 Workshop
July 2012
San Francisco, California, USA

(in conjunction with the SHC Programme's first Solar Heating and Cooling Conference)

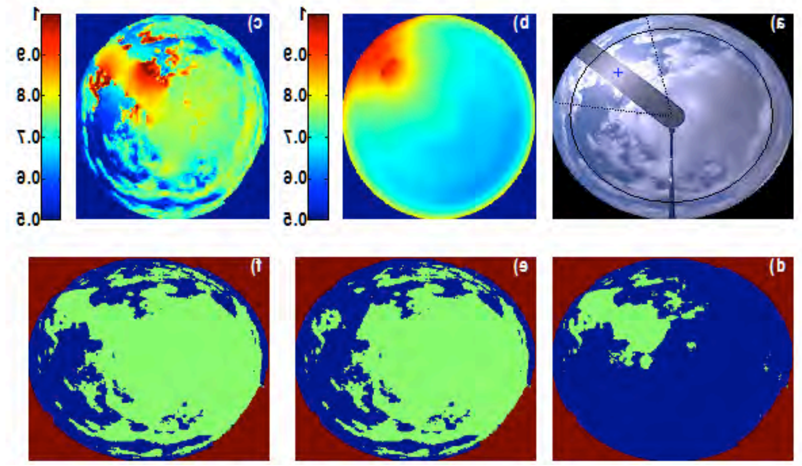


Figure 2. Processing chain of a sky image on October 4, 2009 15:45:30 PST (a) to obtain the cloud decision image. The sunshine parameter is 0.85 and is evaluated around the sun position indicated by the blue cross. The dotted black lines show the borders of the circumsolar region defined as solar azimuth ±35° and the solid black line shows zenith angle (ZA) at 65°. (b) Clear sky red-blue-ratio (RBR, colorbar) background image plus the threshold. (c) RBR (colorbar) image. (d) Pixels in (c) with RBR > sunshine parameter or (e) RBR > clear sky library are assumed to be cloudy. (f) Shows the final cloud decision image. Green areas are clouds and blue areas are clear skies.

TASK 36 NATIONAL CONTACTS

Operating Agent
Dave Renné
National Renewable Energy Laboratory (Retired)
1617 Cole Boulevard
Golden, Colorado 80401-3393 USA
drenne@mac.com

Austria
Klaus Reingruber and Wolfgang Traunmuller
Bluesky Wetteranalyzen
Steinhüblstr. 1, 4800 Attang-Puchheim
klaus.reingruber@blueskywetter.at
wolfgang.traunmueller@blueskywetter.at

Gerald Steinmaurer
Austria Solar Innovation Center
Roseggerstrasse 12, 4600 Wels
steinmaurer.gerald@asic.at

Canada

Sophie Pelland and Yves Poissant
Natural Resources Canada
CanmetENERGY
1615 Lionel-Boulet Boulevard
Varennes/J3X 1S6
spelland@nrcan.gc.ca
ypoissant@nrcan.gc.ca

European Commission
Thomas Huld and Attilio Gambardella
European Commission - DG Joint Research Centre
Institute for Energy - Renewable Energy Unit
I-21020 Ispra (VA), Italy
thomas.huld@jrc.ec.europa.eu
attilio.gambardella@irc.ec.europa.eu

France
Lucien Wald (*Subtask B Leader)* and Lionel Ménard
Centre Energetique et Procedes
MINES ParisTech / Armines
BP 207
F-06904 Sophia Antipolis cedex
lucien.wald@mines-paristech.fr
lionel.menard@mines-paristech.fr

Dominique Dumortier
LASH-ENTPE
Rue Maurice Audin
F-69518 Vaulx-en-Velin
dominique.dumortier@entpe.fr

Germany
Prof. Dr. Hans Georg BEYER
University of Agder
Department of Engineering Sciences
Grimstad, Norway
hans-georg.beyer@uia.no

Richard Meyer
(Task Representative, SolarPACES)
Suntrace GmbH
Brandstwiete 46
20457 Hamburg
Richard.Meyer@suntrace.de

Detlev Heinemann *(Subtask C Leader)* and Elke Lorenz
Carl von Ossietzky Universität Oldenburg
D-26111 Oldenburg
detlev.heinemann@uni-oldenburg.de
elke.lorenz@uni-oldenburg.de

Gerd Heilscher
University of Applied Sciences
Hochschule Ulm
Eberhard Frinckh Str. 11
D-89075 Ulm
heilscher@hs-ulm.de

Carsten Hoyer-Klick and Christoph Schillings
DLR Institut für Technische Thermodanamik
Pfaffenwaldring 38-40
D-70503 Stuttgart
carsten.hoyer@dlr.de
christoph.schillings@dlr.de

Marion Schroedter-Homscheidt
DLR-DFD
Oberpfaffenhofen
D-82234 Wessling
marion.schroedter-homscheidt@dlr.de)

Spain
Martín Gastón, Lourdes Ramirez
(Deputy Task Representative, Solar-PACES)
CENER
C/Ciudad de la Innovación 7, 31.621
Sarriguren
mgaston@cener.com
lramirez@cener.com

Jesús Polo and Luis F. Zarzalejo
CIEMAT
División de Energías Renovables
Departamento de Energía
Avda. Complutense, 22
E-28040 Madrid
jesus.polo@ciemat.es
lf.zarzalejo@ciemat.es

Luis Martín
IrSOLaV
C/ Santiago Grisolía, 2
E-28760 Tres Cantos (PTM)
luis.martin@irsolav.com

José Louis Torres, Marian de Blas and Ana Maria Gracia
Public University of Navarro
Dpto. Proyectos e Ingeniería Rural
Edificio Los Olivos
UPNA 31006 Pampiona
jlte@unavarra.es
mblas@unavarra.es
ana.gracia@unavarra.es

David Pozo Vazquez, Jose Antonio Ruiz Arias and Vicente Lara Fanego
University of Jaen
Campus Lagunillas, A3, 23071 Jaen
dpozo@ujaen.es
jararias@ujaen.es
vlara@ujaen.es

Slovakia
Marcel Suri and Tomas Cebecauer
GeoModel Solar, s.r.o.
M. Marecka 3
SK-841 07 Bratislava
marcel.suri@geomodel.eu
tomas.cebecauer@geomodel.eu

Switzerland
Pierre Ineichen
University of Geneva, CUEPE
7 rte de Drize
CH-1227 Carouge Geneva
pierre.ineichen@unige.ch

Jan Remund
Meteotest
Fabrikstr. 14
CH-3012 Bern
remund@meteotest.ch

United States
Paul Stackhouse and Taiping Zhang
NASA Langley Research Center
MS 420
Hampton, VA 23681
Paul.w.stackhouse@nasa.gov
t-zhang@larc.nasa.gov

Richard Perez
State University of New York/Albany
Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203
perez@asrc.cestm.albany.edu

Manajit Sengupta
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393
Manajit.Sengupta@nrel.gov
Daryl.myers@nrel.gov

Task 39

Polymeric Materials for Solar Thermal Applications

Michael Köhl
Fraunhofer ISE
Operating Agent for the Projektträger Jülich

TASK DESCRIPTION

The objective of Task 39 is the assessment of the applicability and the cost-reduction potential by using polymeric materials and polymer based novel designs of suitable solar thermal systems and to promote increased confidence in the use of these products by developing and applying appropriate methods for assessment of durability and reliability. These goals will be achieved by either less expensive materials or less expensive manufacturing processes.

The Task's objectives will be achieved in the following Subtasks:

Subtask A: Information (Norway)
Subtask B: Collectors
Subtask C: Materials (Austria)

Subtask A: Information

The objective of Subtask A is to collect, create and disseminate information about the application of polymeric materials in solar thermal systems and their figures or merits, especially in terms of cost/performance ratios for an acceptable lifetime, in order to increase the penetration of good applications into the market.

The production of a periodical newsletter, targeted at the solar- and polymer industry, and the preparation and revision of an electronic or printed handbook on polymeric materials in solar thermal applications are to be main results of this Subtask.

Activities

- Updating of the state-of-the-art overview of existing applications of polymeric materials in solar thermal systems and other relevant industry sectors.
- Performance of two case studies, where a total cost accounting approach is adopted, for assessment of suitability of using polymeric materials in solar thermal applications.
- Investigation of standards, regulations and guidelines with regard to the applications of polymeric materials in solar thermal systems and building integration.
- Extension of the database consisting of showcases where solar collectors using mostly polymeric materials have been successfully integrated into the architecture.
- Dissemination of information of the work and results in all Subtasks to a wide audience.

These activities will be carried out in five projects:

A1: State of the art: polymeric materials in solar thermal applications
A2: Task force on total cost accounting approach
A3: Task force on standards, regulations and guidelines
A4: Database of successful architectural integration
A5: Dissemination of information

Subtask B: Collectors

Objectives

Based on the results of the first phase of this subtask, the objectives for the extension phase are focused on the development of:

- new collectors, made completely or partly with polymeric materials, with a profitable cost of ownerships,
- innovative concepts based on polymeric materials (integrated collector storage, thermo-syphon systems) or adapted to specific requirements of polymeric collectors (overheating protection, pressure, etc.), and
- other components of a solar thermal system (piping, fitting, storage, drain back vessel, etc) that could benefit from polymeric materials or processes.

Activities
Based on the updated state-of-the-art from Subtask A, studies and development of new collectors, systems and components will be produced in order to show the feasibility, performance, durability and cost savings.

Subtask C: Materials

As shown in Phase I of Task 39, polymer engineering and science offer great potential for new products in solar thermal systems, which simultaneously fulfill technological and environmental objectives as well as social needs. The major achievements within Phase I of task 39 concerned the significant improvement in the long-term stability of an extruded polymer collector as well as the realization of a polypropylene based modular storage tank. Furthermore, a variety of novel polymeric material grades and components for solar-thermal systems (e.g., spectrally selective coatings with improved performance and commercial availability, injection-molded installation board, extruded spacers for the fixing of an absorber in the collector frame, thermoformed casings for collectors based on polycarbonate blends, polymeric foams with enhanced service temperature) were realized.

The final product performance, functionality, durability and costs not only depend on the type of the polymeric material used, but also on many other factors related to product design, processing and production. As evidenced in Phase I of Task 39, the different components in solar thermal systems have to fulfill a complex material property profile which can be provided only by multi-functional polymer compounds. The classical differentiation between structural (load-carrying) and functional polymeric materials is therefore not suitable in context with the application of plastics in solar thermal systems.

Objectives

- Further development and investigation of multi-functional polymeric materials for various components in solar thermal systems considering different plant types and climate zones.
- Evaluation of polymer processing methods for the production of specimen and components with special focus up to the sub-component level (e.g., multi-layer films and sheets). Full components will be developed in Subtask B.
- Development of testing and characterization methods and modeling tools for the application-oriented assessment of the performance and durability.

SHC database of successful architectural integration
http://www.iea-shc.org/task39/projects/default.aspx

Activities

- Formulation of multi-functional polymeric materials for various components of solar thermal systems (e.g., absorber, insulation and frame of a collector, storage tank components). The considered polymeric material classes will include thermoplastics (i.e., melt processable materials), elastomers (i.e., chemically cross-linked soft materials) and thermosets (i.e., chemically cross-linked stiff materials).
- Compounding of polymeric materials considering a variety of functional fillers and additives allowing for improved processability and enhanced performance.
- Production of specimen and sub-components by applying various mass production processing technologies (e.g., injection molding, compression molding, extrusion, coating technologies, lamination and joining technologies).
- Establishment of a toolbox for the quality testing of polymeric materials for specific applications in solar thermal systems considering the various material states along the value creation chain.
- Implementation and application of analytical and technical methods for the characterization of properties, long-term behaviour and relevant aging and degradation phenomena.
- Establishment of micro-structure/ property/processing/performance relationships.

Duration

The SHC Executive Committee agreed on a 4-year Task extension. The Task was initiated on October 1, 2006 and will be completed on September 30, 2014.

Participating Countries

Austria, France, Germany, Norway, Portugal, Sweden, Switzerland, United States

ACTIVITIES DURING 2011

Subtask A

Project A4: Database of Successful Architectural Integration

A first version of the database showcasing the successful integration of solar thermal energy systems into building architecture is now available on online, http://www.iea-shc.org/. To ensure that the database will be extended with more showcases over time, responsible national contacts were assigned from Austria, Canada, France, Germany, Israel, Norway, Portugal, Slovenia, Sweden. The work is coordinated by I. Skjelland of Aventa AS, Norway.

Project A5: Dissemination of Information

The dissemination of information and results from Task 39 is an important part of Subtask A. It includes also a better dialog with new partners from industry and research, for example through open workshops and excursions during the Task meetings.

The following were the dissemination activities in 2011:

- General article on Task 39: M.Köhl, M. Meir, 2011. Polymere Materialien für Solarthermische Systeme, EE-Erneuerbare Energie 01/2011, pp. 4-5, AEE Dachverband, Gleisdorf, Austria.
- Task 39 Newsletter, Nr. 8. June 2011: http://www.iea-shc.org/task39/newsletters/index.html.
- Task 39 Newsletter, Nr. 9, November 2011: http://www.iea-shc.org/task39/newsletters/index.html.
- Guided tour of the National Institute of Chemistry laboratories, 11th Experts Meeting, Ljubljana, Slovenia, May 2011.
- Guided factory visit of Bosch Termotecnologia's solar thermal collector production facility in Cacia – Task

Experts Meeting, Aveiro, Portugal, September 2011.

- Abstract on Task 39 activities submitted to 22nd Symposium Thermische Solarenergie, Bad Staffelstein, Germany, May 2012.

Although the deliverable is delayed, significant effort was made related to negotiations for the Task 39 Handbook from Phase I (2006-2010). The final table of content was defined:

PART I: "Solar Thermal Market" for Polymer Experts

1 Principles
2 Solar Thermal Market
3 Solar Thermal Systems and Technical Requirements
4 Conventional Collectors, Heat Stores, and Coating
5 Thermal Loads on Collectors
6 Standards, Performance Tests of Solar Thermal Systems

PART II: "Polymers" for Solar Thermal Experts

7 Market
8 Polymeric Materials
9 Processing
9.1. Structural Polymeric Materials
9.2 Paint Coatings for Polymeric Sola Absorbers and their Applications
10 Durablity for Solar Thermal Application
11 Properties (campus database) and material selection

PART III: Polymeric Materials for Solar Thermal Applications

12 State of the Art: Polymeric Materials in Solar Thermal Applications
13 Specific Materials for Solar Thermal Application
13.1 Multifunctional Structural Materials
13.2 Thermotropic Layers
13.3 Application of POSS Compounds
14 Conceptual Design of Collectors
15 Novel Collectors and Heat Stores
16 Durability Tests of Polymeric

Top: **Architecture Meets Sustainability (Norway): Aventa's polymeric collector was presented at The National Museum – Architecture, May 6 – August 21, 2011, as part of the exhibition "SPOR Norwegian architecture 2005-2010."**

The aim of the exhibition was to communicate developing architectural qualities in Norway today, and to point out new trends of architecture making social impact.

Bottom: **The AventaSolar collector is part of the "Bjørnveien 119 Dahle/Dahle/Breitenstein" presentation.**

Components
17 Architecturally Appealing Solar Thermal Systems
18 Obstacles for the Application of Current Standards

Subtask B

Project B1: Collector

Information on funded research projects during Phase II of Task 39 (2010-2014) is displayed in the Table in the Section *Funded Projects*. These activities will strengthen the activities of Subtask B.
In addition to the polymeric collector concept by Aventa AS three new polymeric collector concepts and experiences were presented by new partners at the Task 39 Meetings in Ljubljana and in Aveiro:

- Aventa AS (Norway): All-plastics collectors with liquid-cooled absorber of high-temperature performance polymers
- Magen Eco Energy (Israel): All-plastics collectors with liquid-cooled absorber of commoditive polymers and overheat protection (might not continue participation in Task 39)
- Enerconcept (Canada): Air-collector; perforated façadecovers for building integration
- Polysolair (Germany): Air-collector; modular unit, still in development phase;
- Design concepts and suitable production processes for a new generation of polymeric collectors have been studied in Subtask B.

Project B2: System

Comparative energy monitoring of pressure-less drain-back systems with polymeric collectors and conventional collectors were tested at the outdoor facilities of AEE INTEC in Gleisdorf, Austria.

Source: Milennium Energy Industries/AEE-INTEC

Subtask C

Project C1: Multi-Functional Polymeric Materials

In Project C1 multi-functional polymeric materials for different components in polymeric solar thermal systems are assessed and evaluated. Special attention is given to absorber materials for various stagnation temperature ranges, switchable glazing materials or absorber coatings, polymeric foams or polymeric liner materials for storage tanks.

Different collector concepts presented at the May 2011 Task 39 Meeting in Ljubljana, Slovenia and in the Task 39 Newsletter No. 9, June 2011 (Magen Eco Energy, Aventa, Enerconcept, Polysolair).

The following were the activities in 2011:

- Development of novel black polyolefin grades for solar absorber applications as part of the project SolPol coordinated by JKU Linz (Austria). In this work the effect of various black pigments on optical and thermal properties of a PP copolymer have been investigated (Figure 1a).
- New thermal insulation materials for solar thermal components are evaluated at the Austrian Institute of Technology (Vienna) and the potential for solar thermal collectors and storages is studied. A thorough screening of existing and new materials is the basis for a detailed analysis of the behaviour of insulations in real components (Figure 1b);
- Smart Materials: Thermotropic glazings for overheating protection of polymeric collectors were investigated by PCCL and the University of Leoben. The novel produced mterial formulations yield promising results for efficient overheating protection of solar thermal collectors (Figure 1c).
- Multifunctional coatings: The material aspects of coloured cool TISS paint coatings are reviewed by NIC (Ljubljana, Slovenia), focusing on cool pigments, metallic and metallised flake pigments and polymeric resin binders used for the production of solar paint coatings on polymeric substrate (Figure 1d).

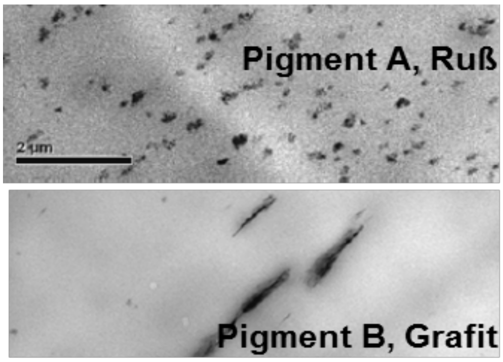


Figure 1a. Micrograph of black-pigmented polyolefin compounds developed within the project SolPol-2 at JKU Linz, Austria.

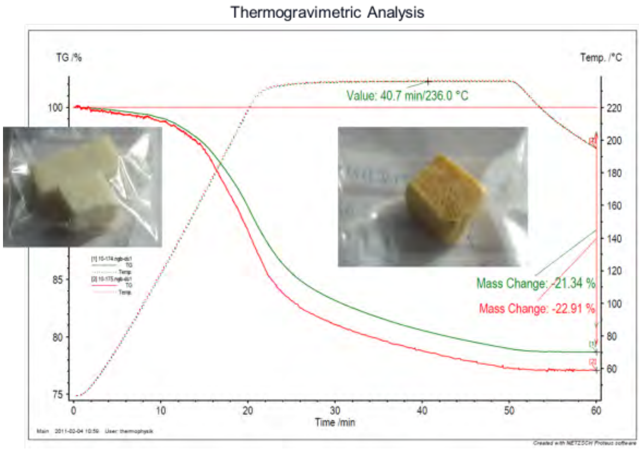


Figure 1b. Thermogravimetric analysis of polyurethane foam thermal insulation at AIT, Vienna, Austria.

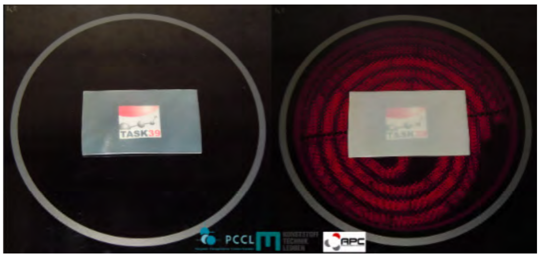


Figure 1c. Thermotropic layer in transparent and opaque state (PCCL, Leoben, Austria.

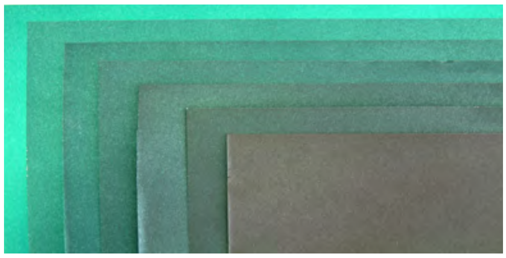


Figure 1d. Spectrally selective coloured TISS paint coatings, National Institute of Chemistry, Slovenia.

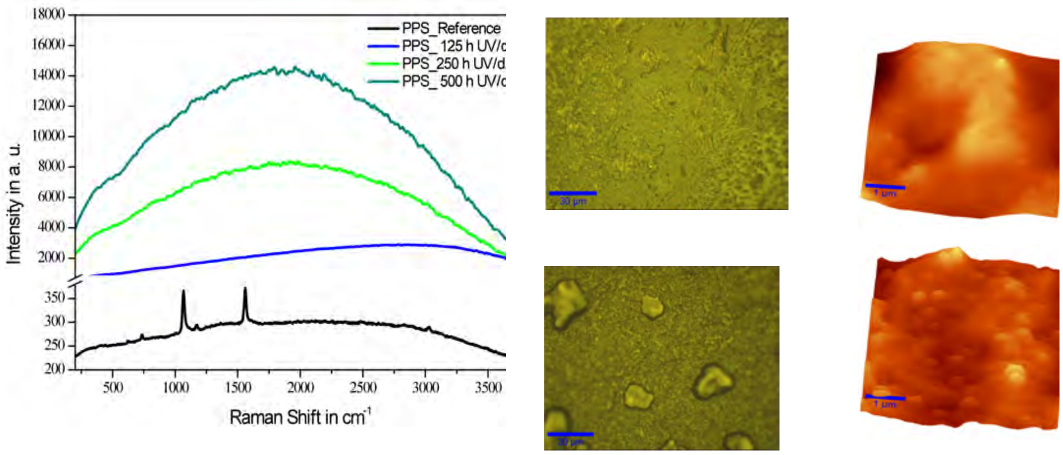


Figure 2: Non-destructive analysis methods, performed at Fraunhofer ISE:
A) Raman spectra of PPS before and after UV/damp heat aging
B) Raman micrographs of PPS-samples before (top) and after (bottom) 500 h UV exposure.
C) AFM measurements: PPS-samples before (top) and after 500 h at 85 °C, 85% r.h. (bottom)

Project C3: Methods for Testing and Characterization of Polymeric Materials

The properties and performance of polymeric materials and components are determined by their material structure and formulation, the processing routes and the loading conditions in the use phase. For the assessment of the material quality and performance in solar thermal applications adapted and novel methods for quality assurance testing and long-term performance and durability testing will be developed and evaluated in Project C3.

- Non-destructive methods for testing polymeric samples after exposure to accelerated aging were developed at Fraunhofer ISE (Freiburg Germany): Raman spectroscopy, Raman microscopy and AFM measurements (Figure 2);
- Accelerated aging of liner materials for storage tanks: The approach examined is based on micro-sized specimens with significantly reduced thickness and the exposure in heat carrier fluids and air at application-relevant temperatures (SolPol project; JKU Linz, Austria; Figure 3).

PUBLICATIONS & PRESENTATIONS IN 2011

Conferences and Seminars with contributions from Task 39

ESTEC 2011, 5th European Solar Thermal Energy Conference, 20-21 October 2011, Marseille (France)

Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

21st Symposium Thermische Solarenergie, Bad Staffelstein, Germany, May 11 - 13, 2011.

Solar Energy & Architecture - Knowledge and Inspiration (IEA-SHC Task 41), NHO Conference Center, Oslo, Norway, April 01, 2011.

SMEThermal 2011 - Solar Thermal Materials, Equipment and Technology Conference, Beletage - Conference Center Heinrich-Böll-Stiftung, Berlin, Germany, February 10, 2011.

Articles about Task 39

B. Epp, Fantastic plastics: revolution or devolution? Sun & Wind Energy Magazine, 4/2011, pp. 84-89, ISSN: 1861-2741 74714. (article with interview)

A. Lee, Solar Heating and Cooling Needs New Materials, Renewable Energy World Magazine, 25.02.2011, ISSN 1462-6381, online article. (article with interview)

Publications in journals or conference proceedings

Andreas Weber and Katharina Resch, 2011. Thermotropic glazings for overheating protection applications, 6th Energy Forum "Solar Building Skins", December 2011, pp. 73 - 77.

Katharina Resch, Andreas Weber, 2011. Smart Windows - Smart Collectors. Entwicklung und Charakterisierung von Überhitzungsschutzverglasungen für Gebäudeverglasungen und thermische Solarkollektoren. Berg- und hüttenmännische Monatshefte BHM 156 (2011) 11, S. 429 - 433.

Christian Vachon, 2011. Perforated glazing technology for solar air heating and heat recovery applications: A new option for architects and builders, ESTEC 2011, 5th European Solar Thermal Energy Conference, 20-21 October 2011, Marseille (France).

Stephan Fischer, 2011. Performance measurements on a parabolic trough collector mainly made out of polymeric materials, ESTEC 2011, 5th European Solar Thermal Energy Conference, 20-21 October 2011, Marseille (France).

Karl-Anders Weiß, 2011. Alterungsbeständigkeit von Kollektoren und Komponenten: Prüfungen in verschiedenen Klimaregionen, 21st Symposium Thermische Solarenergie, Bad Staffelstein, Germany, May 11 - 13, 2011.

Christoph Zauner, 2011. Thermophysikalische und spektroskopische Methoden zur Analyse von Isolationsmaterialien für solarthermische Anwendungen, 21st Symposium Thermische Solarenergie, Bad Staffelstein, Germany, May 11 - 13, 2011.

Christoph Reiter, 2011. Simulationsgestützte Analyse der Bauteiltemperaturen für den Kunststoffeinsatz in Flachkollektoren, 21st Symposium Thermische Solarenergie, Bad Staffelstein, Germany, May 11 - 13, 2011.

R.W. Lang, G.M. Wallner, J. Fischer, H. Schobermayr, H. Kicker, M. Kurzböck, K. Grabmayer, 2011. Research on polymeric materials for solar energy technologies, Colloquium of Optical Spectrometry 2011, Berlin, Germany.

I. Jerman, M. Mihelčič, D. Verhovšek, J. Kovač, B. Orel, 2011. Polyhedral oligomeric silsesquioxane trisilanols as pigment surface modifiers for fluoro polymer based Thickness Sensitive Spectrally Selective (TSSS) paint coatings. Solar Energy Materials and Solar Cells (95) 2, pp. 423–431.

Reinhold Lang, Gernot Wallner, Jörg Fischer, 2011. Solarthermische Systeme aus Polymerwerkstoffen, Erneuerbare Energie 2011-1, Ed. AEE-INTEC, Gleisdorf Austria.

Michael Köhl, Michaela Meir, 2011. Polymere Materialien für Solarthermische Systeme, EE-Erneuerbare Energie 01/2011, pp. 4-5, AEE Dachverband, Gleisdorf, Austria

Presentations at conferences and seminars (from Task 39 Partners)

Reinhold W. Lang, 2011. SolPol – eine wissenschaftsgetriebene österreichische Forschungsinitiative zu Polymerwerkstoffen für die Solartechnik, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Katrin Zaß, 2011. Modulare Speicher aus Kunststoffen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Christian Fink, 2011. Betriebserfahrungen mit drucklosen Solarthermie-Systemen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

David Nitsche, 2011. Entwicklung von Speichermaterialen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Michael Köhl, 2011. Task 39 – Polymermaterialien für solarthermische Anwendungen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Robert Hausner, 2011. Berechnung von Kunststoffkollektoren mit Überhitzungsschutz, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Katharina Resch, 2011. Thermotrope Materialien für den Überhitzungsschutz, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Michael Monsberger, 2011. Leistungstests an Kunststoffkollektoren, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Gernot Wallner, 2011. Kunststoffe für Solarabsorber, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Susanne Kahlen, 2011. Alterungsverhalten von Kunststoffen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Michaela Meir, Entwicklung von Kunststoffkollektoren in Norwegen, Symposium "Kunststoff als Wachstumsmotor für die Solarthermie", Johannes Kepler University, Linz, Austria, July 06, 2011.

Ingvild Skjelland, Termisk solenergi integrert i arkitekturen - Eksempler fra IEA-SHC Task 39, Solenergidagen May 06, 2011, Norsk Solenergiforening, Universitetet, Oslo, Norway

John Rekstad, "Prosjekter: Bjørnveien / OBOS / Fremtidsvisjoner", Solar Energy & Architecture - Knowledge and Inspiration (IEA-SHC Task 41), NHO Conference Center, Oslo, Norway, April 1, 2011.

John Rekstad, Els de Meersman et al., "Round table: Polymers for the solar thermal industry?", SMEThermal 2011 - Solar Thermal Materials, Equipment and Technology Conference,
Beletage - Conference Center Heinrich-Böll-Stiftung, Berlin, Germany, February 10, 2011.

MEETINGS IN 2011

11th Experts Meeting
May 19 - 20
Ljubljana, Slovenia

32 experts participated in the meeting, among them experts from two new industrial companies from Canada and Israel.

12th Experts Meeting
September 19 - 21
Aveiro, Portugal

23 experts participated in the meeting, among them new industry participants from Brasil. Meeting included a guided factory visit of Bosch Termotecnologia's solar thermal collector production facility in Cacia – Aveiro. Representatives from Bosch Termotecnologia S.A. participated also in the Experts meeting.

MEETINGS PLANNED FOR 2012

13th Experts Meeting
May 14
Berlin, Germany
Slovenia

14th Experts Meeting
October 15-17
Gran Canaria, Spain (hosted by Fraunhofer ISE)

Funded Projects

The table below shows an overview of funded projects of Task 39 Partners (status: March 2012, http://www.iea-shc.org/task39/fundedprojects/). Results, which are open for dissemination will be presented in phase 2 of Task 39.

	Project	Period	Funding agency	Partner countries
1	Poly2Facade – Innovative thermal self-regulating solar facades by means of functional polymers Coordinator: University of Leoben; Partners: PCCL, ÖFPZ Arsenal GesmbH, Forschungszentrum für integrales Bauwesen AG	2012-15	Forschungsförderungsgesell-schaft (FFG), Programmlinie Haus der Zukunft	AT
2	Untersuchungen zur Fertigungstechnik und Kollektorkonstruktion für Vollkunststoff-Kollektoren Partners: HAW Ingolstadt, Roth Werke GmbH	2012-15	Bundesministerium für Um-welt, Naturschutz und Reak-torsicherheit	DE
3	SCOOP - Solar Collectors of Polymers Coordinator: Fraunhofer Institute for Solar Energy Systems - ISE Partners: http://eu-scoop.org/partners.html Website: http://eu-scoop.org/	2011-15	EU FP7-ENERGY-2011-1	DE, AT, FR, NO, CH
4	Participation in Phase II of IEA-SHC Task 39 Coordinator: JKU-Linz; Partner: AEE-INTEC Subcontractors: AIT, PCCL, UIBK-EGEE	2011-14	Bundesministerium für Ver-kehr, Innovation und Techno-logie; FFG	AT
5	ISOlar - Screening of insulation materials for solar thermal collectors and thermal storages and analysis of their long-term-properties Coordinator: Austrian Institute of Technology Partners: TiSUN GmbH, EuroFoam GmbH Website: http://www.ait.ac.at/~isolar	2011-14	Österreichische Forschungs-förderungsgesellschaft (Neue Energien 2020 - Programm)	AT
6	SILVER - Solar Energy in Living Environments Coordinator: Aventa AS; Partners: OBOS, University of Oslo, Linnæus University, CHCP, DSSK Website: http://www.forskningsradet.no/~silver	2011-14	Research Council of Norway	NO, SE, BE, FR
7	PISA - Polymers in solar thermal applications University of Oslo: Leitung, Subtask A	2011-14	Enova	NO
8	UNISOL - Sistema Solar Termico Universal Coordinator: Fabrica de Plasticos, Lda (Pt) Partners: Aveiro University, Oslo University, Aventa AS; Website: http://projectos.adi.pt/actions/project?id=C16/2011/21507&search=global &actionbean=actions/project	2011-14	Portuguese Agency for De-velopment and Innovation	PT, NO
9	POLYSOL - Development of a modular, all-POLYmer SOLarthermal collector for DHW preparation and space heating Coordinator: Energias Renovables Aplicadas S.L. Website and Partners: http://cordis.europa.eu/projects/rcn/98108_en.html	2011-12	EU FP7-SME Research area: SME-1	UK, DE, MK, ES

10	Smart Windows-Smart Collectors Partners: PCCL, University of Leoben, A-P-C	2010-13	Land Steiermark, Zukunftsfonds Partners	AT
11	SOLPOL-1/2 - Solar Thermal Systems based on Polymeric Materials Coordinator: Johannes Kepler University - JKU Partners: http://www.solpol.at/partners Website: http://www.solpol.at/	2009-13	Klima- und Energiefonds. Management: Österreichische Forschungsförderungsgesellschaft	AT
12	Use of polymeric materials in solar collectors studied from a total cost perspective - Participation in IEA SHC Task 39 Coordinator: Linnæus University; Partners: Aventa AS, University of Oslo	2009-12	Swedish Energy Agency	SE, NO
13	PolySol2 – Polymeric materials for solar thermal applications Coordinator: CEA-INES	2008-11	ADEME	FR
14	SolaireDuo – WP 1.2. Polymeric collectors Coordinator: Jacques Giordano Industries Partners: CEA-INES, Clipsol, Pôle Européen de Plasturgie, LPMM	2009-11	ADEME, OSEO	FR
15	MULTIFUNCOAT-Multifunctional paint coatings for all-polymeric solar collectors Coordinator: National Institute of Chemistry ; Partners: Aventa, COLOR/HELIOS	2007-11	Ministry Higher Education, Science and Technology; Research Council of Norway	SI, NO
16	Polymers in solar thermal systems Partners: HSR - SPF, EMS Chemie Website: http://www.bfe.admin.ch/forschungsolarwaerme/	2006-11	Bundesamt für Energie BFE	CH

TASK 39 NATIONAL CONTACTS

Operating Agent
Michael Köhl
Fraunhofer Institute for Solar Energy Systems ISE
Dept. Thermal Systems and Buildings
Heidenhofstr. 2,
79110 Freiburg, GERMANY
michael.koehl@ise.fraunhofer.de

Austria
Robert Hausner
AEE - Institut für Nachhaltige Technologien
Feldgasse 19
A-8200 Gleisdorf
r.hausner@aee.at
http://www.aee-intec.at

Christoph Zauner
Austrian Institute for Technology
Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H.
Giefinggasse 2
A-1210 Wien
christoph.zauner@ ait.ac.at

Katharina Resch
Institute of Materials Science and Testing of Plastics at University of Leoben
Franz-Josef-Straße 18
A-8700 Leoben
katharina.resch@unileoben.ac.at

Gernot Wallner
Johannes Kepler University Linz (JKU)
Institute of Polymeric Materials and Testing
Science Park, Altenberger Strasse 69
A-4040 Linz
gernot.wallner@jku.at

France
Philippe Papillon
CEA INES
Recherche, Développement et Innovation Industrielle, BP 332
50, avenue du Lac Léman
73377 Le Bourget du Lac
philippe.papillon@cea.fr
http://www.cea.fr/
http://www.ines-solaire.fr/

Germany
Trinkl Christoph
Fachhochschule Ingolstadt
Kompetenzzentrum Solartechnik
Esplanade 10
D-85049 Ingolstadt
trinkl@fh-ingolstadt.de>
http://www.solartechnik-ingolstadt.de

Helmut Vogel
University of Applied Sciences Osnabrück
P.O. Box 1940
D-49009 Osnabrück
h.vogel@fh-osnabrück.de
http://www.fh-osnabrueck.de/

Karl-Anders Weiss and Markus Heck
Fraunhofer Institute ISE
Dept. Thermal Systems and Buildings
Heidenhofstr. 2,
79110 Freiburg
karl-anders.weiss@ise.fraunhofer.de
markus.heck@ise.fraunhofer.de
http://www.ise.fraunhofer.de

Claudius Wilhelms and Klaus Vajen
Universität Kassel
Mönchebergstraße 19
34109 Kassel
wilhelms@uni-kassel.de
vajen@uni-kassel.de
www.uni-kassel.de

Stephan Fischer
University Stuttgart, ITW
Pfaffenwaldring 6
D-70550 Stuttgart, GERMANY
fischer@itw-stuttgart.de
ochs@uni.itw-stuttgart.de
http://www.itw.uni-stuttgart.de

Norway
Michaela Meir and John Rekstad
University of Oslo
Department of Physics
PO Box 1048, Blindern
N-0316 Oslo
mmeir@fys.uio.no
john.rekstad@fys.uio.no
http://www.physics.uio.no/energy

Portugal
Clarisse Nunes and
Manuel Lopes Prates
Instituto de Technologias Energeticas
Department de Energias Renovavaeis
Estrada do Paço do Lumiar 22
1649-038 Lisboa
lopes.prates@ineti.pt
http://www.ineti.pt

Slovenia (observer)
Boris Orel
National Institute of Chemistry Slovenia
Hajdrihova 19
PO Box 660
SI-1001 Ljubljana
boris.orel@ki.si
http://www.ki.si/

Sweden
Kenneth Moeller
SP Swedish National Testing and
Research Institute
Box 857
SE-501 15 Borås
kenneth.moller@sp.se
http://www.sp.se

Bo Carlsson
Linnaeus University
School of Natural Science
39182 Kalmar
Bo.Carlsson@lnu.se

Switzerland
Stefan Brunold
Institut für Solartechnik SPF
Hochschule für Technik Rapperswil HSR
Oberseestrasse 10
CH-8640 Rapperswil
stefan.brunold@solarenergy.ch
http://www.solarenergy.ch

United States
Jay Burch
NRELNational Center for Photovoltaics
National Renewable Energy Laboratory
1617 Cole Boulevard, MS-3214
Golden, CO 80401
jay.burch@nrel.gov

Mike Rubio
FAFCO
435 Otterson Drive
Chico, CA 95928-8207
mrubio@fafco.com
http://www.fafco.com/

Susan Mantell
Department of Mechanical Engineering
University of Minnesota
111 Church St.SE, Rm 1100
Minneapolis, MN 55455
smantell@me.umn.edu

Task 40

Towards Net Zero Energy Solar Buildings

Josef Ayoub
CanmetENERGY
Operating Agent for Natural Resources Canada

TASK DESCRIPTION

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions. Energy use and emissions include both direct, on site use of fossil-fuels and indirect use from electricity, district heating / cooling systems and embodied energy in construction materials. Several International Energy Agency (IEA) countries have adopted a vision of so-called 'net zero energy buildings' as long-term goal of their energy policies. However, what is missing is a clear definition and international agreement on the measures of building performance that could inform 'zero energy' building policies, programmes and industry adoption around the world.

Objective

The objective of this joint Task with the IEA ECBCS Programme (Annex 52) is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical NZEB demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption. These projects aim to equalize their small annual energy needs, cost-effectively, through building integrated heating/cooling systems, power generation and interactions with utilities.

The Task will build upon recent industry experiences with net-zero and low energy solar buildings and the most recent developments in whole building integrated design and operation. The joint international research and demonstration activity will address concerns of comparability of performance calculations between building types and communities for different climates in participating countries. The goal is solution sets that are attractive for broad industry adoption.

Scope

The scope includes major building types (residential and non-residential), new and existing, for the climatic zones represented by the participating countries. The work will be linked to national activities and will focus on individual buildings, clusters of buildings and small settlements. The work will be based on analysis of existing examples that leads to the development of innovative solutions to be incorporated into national demonstration buildings.

The objectives shall be achieved in the following Subtasks.

Subtask A: Definitions & Implications

(Subtask Leaders: Karsten Voss, Germany and Assunta Napolitano, Italy)

SHC Task 40 / ECBCS Annex 52 National Experts and observers attending the 6th Experts Group Meeting, October 5-7, 2011, Basel, Switzerland.

Activity A1: NZEB definitions framework
Activity A2: Monitoring, verification and compliance guide
Activity A3: Grid interactions

The objective of Subtask A is to establish an internationally agreed understanding on NZEBs based on a common methodology. The Participants shall achieve this objective by the following activities:

- The review and analysis of existing NZEB definitions and data (site/source energy, emissions, exergy, costs, etc.) with respect to the demand and the supply side;
- A study of grid interaction (power/heating/cooling) and time dependent energy mismatch analysis.
- The development of a harmonized international definition framework for the NZEB concept considering large-scale implications, exergy and credits for grid interaction (power/heating /cooling).
- The development of a monitoring, verification and compliance guide for checking the annual balance in practice (energy, emissions and costs) harmonized with the definition.

Subtask B: Design Processes & Tools
(Subtask Leaders: Adam Hirsch, Paul Torcellini USA and Andreas Athienitis, Canada)

Activity B1: Processes and tools
Activity B2: Pre-concept design, feasibility tools
Activity B3: Tools guide and worked examples

Subtask B aims to identify and refine design approaches and tools to support industry adoption. The Participants shall achieve this objective by the following activities:

- Documenting processes and tools currently being used to design NZEBs and under development by participating countries.
- Assessing gaps, needs and problems, considering the work of Subtask A and Subtask C, and inform simulation engine and detailed design tools developers of priorities for NZEBs.
- The development and testing of design approaches and simplified NZEB tools or interfaces (e.g., spreadsheet or web-based method) linked to Subtask C Solution Sets to support integration of NZEB technologies and architecture at the early design stage.

Subtask C: Solution Sets (Design, Engineering, Technologies)
(Subtask Leaders: Michael Donn, New Zealand and François Garde, France)

Activity C1: NZEB STC Database
Activity C2: Analysis Matrix
Activity C3: Research Analysis of Themes Undertaken
Activity C4: Subtask C Source Book

The objectives of this Subtask are to develop and test innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration. The Participants shall achieve these objectives by the following activities:

- Documenting and analyzing current NZEBs designs and technologies, benchmarking with near NZEBs and other very low energy buildings (new and existing), for cold, moderate and hot climates considering sustainability, economy and future prospects using a projects database, literature review and practitioner input (workshops).
- Developing and assessing case studies and demonstration projects in close cooperation with practitioners.
- Investigating advanced integrated design concepts and technologies in support of the case studies, demonstration projects and solution sets .
- Developing NZEB solution sets and guidelines with respect to building types and climate and to document design options in terms of market application and CO2 implications.

Subtask D: Dissemination & Outreach
(Operating Agent and Subtask Leaders)

Activity D1: NZEB web page
Activity D2: Reports production, Source

book(s): Vols. 1, 2 and 3

Activity D3: Education network for PhD students and summer schools

Activity D4: Outreach (conferences, seminars, workshops etc.)

The objective of the dissemination activity is to support knowledge transfer and market adoption of NZEBs on a national and international level. Subtask leaders will be responsible for the coordination of the individual contributions of Subtask participants and for coordination with the other Subtasks where a combined output is planned. The Participants shall achieve the objectives by the following activities:

- Establishing an NZEB web page, within the IEA SHC/ECBCS Programmes' framework, and a database that can be expanded and updated with the latest projects and experiences.
- Producing a NZEB source book including example buildings for investigated building types and climates.
- Transferring the Task outputs to national policy groups, industry associations, utilities, academia and funding programs.
- Establishing an education network, summer school and contributions to the Solar Decathlon and similar student activities.
- Workshops, articles and features in magazines to stimulate market adoption.

Duration

This Task was initiated on October 1, 2008 and remains in force until September 30, 2013.

Participating Countries

Austria, Belgium, Canada, Finland, France, Germany, Italy, South Korea, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, United States

WORK DURING 2011

Completed 13 technical Task papers several of which were presented (oral and/or poster) at ASHARE conference in Las Vegas and others submitted to refereed journals. Volume 1 of the source book, a deliverable of Subtask A on definitions work was published in German and an English translation of it was undertaken in 2011. An English version was subsequently published in 2011.
Subtasks work proceeding as per work plans.

The PhD summer workshop on net-zero energy solar buildings (theory, modeling and design) was conducted in June 2011 in Montreal, Canada,

Initiated planning fort a 2nd PhD workshop to be hosted by France in the fall of 2012.

Finalized Table of Contents for Volume 2 and 3 of the source book.

Held two-industry/public workshops in conjunction with SHC and ECBCS Executive Committee meetings.

Continuing to strengthen links to industry by participating in the Buildings and initiated discussions with Johnson Controls, potential new member.

19 countries confirmed participation and National Experts seeded by both the ECBCS and SHC. Singapore is the newest member to join in 2011.

Continually upgrading the Task File Sharing System and the Task public website.

WORK PLANNED FOR 2012

2nd PhD summer workshop to be hosted by France at the l'Institut des Rechereches Scientifique des Carsege, in conjunction with the 8th Task Experts Meeting in the 3rd quarter of 2012.

Finalize final drafts of the two technical reports from Subtask A.

Complete the drafts of some chapters of Volumes 2 and 3 of the Source Book.

Continue to participate in public dissemination activities as opportunities arise. Conduct at least one Industry/public meetings in conjunction with the 7th Experts Group Meeting in Naples in May.

Continue the work on NetZEB definitions evaluation tool.

Finalize the Task /Annex database display.

Complete the technical report on Design Tools Benchmarking.

Continue to update Task website.

REPORTS PUBLISHED IN 2011

There were 13 (#1-13) technical papers published delineating the work accomplished to date within the Task/Annex submitted to various sources (technical journals, referred conference papers, other)

Subtask A

1. "Load matching and grid interaction" (J. Salome et.al.)

Subtask B

2. "Strategies for reducing peak demand in net-zero energy solar homes" (J. Candanedo et. Al.)
3. "Optimization of net-zero energy solar communities: effect of uncertainty due to occupant factors" (S. Bucking et. al.)
4. "Energy performance, comfort and lessons learned from a near-net zero energy solar house" (M. Dorion et.al.)
5. "The redesign of an Italian building to reach net-zero energy performance: a cse study of the SHc Task 40 – ECBCS Annex 52" (M. cellura et. al.)

Subtask C

6. "Towards net-zero energy buildings in hot climates: Part 1, new tools an methods" (F. Garde et. al.)
7. "Towards net-zero energy buildings in hot climates: Part 2, Experimental feedback" (A. Lenoir et. al.)
8. "Formulating a building climate classification method" (S. Corey et. al.)
9. "User behaviour and energy performances of net-zero energy buildings" (A. Lenoir et. al.)
10. "Passive cooling approaches in net-0zero energy solar buildings: Lessons learned from demonstration buildings" (L. Aelenei et. al.)
11. "Zero-energy buildings in France Overview and Feedback" (A. Lenoir et. al)
12. "Environmental design and performance of the ENERPOS building, Reunion Island, France (M. Franco et. al.)
13. "Calibrating the impact of a photovoltaic thermal mechanical ventilation heat recovery system on the delivery of net-zero energy housing in Scotland" (M. Noguchi et. al.)

All of these papers are posted for free downloading from the Task website. http://www.iea-shc.org/task40/

Technical Reports in progress:

1. "Survey of Current Practices for checking balances in Net ZEB Projects" by Assunta Napolitano and Roberto Lollini. A Report of Subtask A (A2). Draft form.
2. "Zero Energy Building definition - A Literature Review" by Anna Joanna Marszal and Per Heiselberg. A Report of Subtask A (A1).). Final Draft form.

MEETINGS IN 2011

5th Experts Meeting
April 4-6
Golden, Colorado, USA

6th Experts Meeting
October 5-7
Basel, Switzerland

MEETINGS PLANNED FOR 2012

7th Experts Meeting
May 8-11
Naples, Italy

8th Experts Meeting
October 1-3
Barcelona, Spain

In conjunction with 2nd PhD Workshop
September 25-29
Carsège, Corsica, France

SHC TASK 40/ECBCS ANNEX 52
NATIONAL CONTACTS

Operating Agent
Josef Ayoub
Senior Planning Advisor, Energy S&T
CanmetENERGY/Natural Resources
Canada/ Government of Canada
1615 Lionel-Boulet Blvd, P.O. Box 4800
Varennes, Québec
Canada J3X 1S6
Phone: + (1) 450-652-1981
Fax: + (1) 450- 652-5177
josef.ayoub@rncan-nrcan.gc.ca
Web:
http://www.canmetenergy.nrcan.gc.ca

Subtask A Leaders
Assunta Napolitano
EURAC Research
Insitute for Renewable Energy
Viale Druso n°1,
39100 Bozen/Bolzano
Italy
Phone: +39 0471 055 651
Fax +39 0471 055 699
assunta.napolitano@eurac.edu

Karsten Voss
Bergische Universität Wuppertal
Haspeler Straße 27
42285 Wuppertal
Germany
Phone: 0049 (0)202 439 4094
Fax: 0049 (0)202 439 4296
kvoss@uni-wuppertal.de

Subtask B Leaders
Andreas Athienitis
Concordia University (Solar Buildings Research Network)
1455 Maisonneuve W., Montreal
Quebec, H3G1M8
Canada
Phone: +1 514-848-2424 Ext. 8791
Fax: +1 514-848-7965
aathieni@encs.concordia.ca

Paul Torcellini
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401 -3305
United States
Phone: +1 303-384-7528
Fax: +1 303-384-7540
paul_torcellini@nrel.gov

Adam Hirsch
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401-3305
United States
Phone: + 303-384-7874fax
Fax +: 303-384-7540
adam.hirsch@nrel.gov

Subtask C Leaders
Michael Donn
Centre for Building Performance Research
Victoria University
PO Box 600
Wellington
New Zealand
Phone: +6444636221
Mobile: +6421611280
michael.donn@vuw.ac.nz

François Garde
Université de la Réunion
Faculty of Humanities and the Environment
Sciences Building and Environment
15, avenue René Cassin
Saint Denis, Ile de la Réunion, 97715
France
Phone: +262 (0)262 96 28 90
Fax: +262 (0)262 96 28 99
garde@univ-reunion.fr

Austria
Karl Höfler and Sonja Geier
Department for Sustainable Buildings
AEE INTEC
AEE Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf
k.hoefler@aee.at
s.geier@aee.at
http://www.aee-intec.at/index.php?lang=en

Werner Nussmüller
Nussmüller Architekten ZT GmbH
Zinzendorfg. 1
8010 Graz
buero@nussmueller.at
http://www.nussmueller.at/aktuelles.php

Belgium
Roel De Coninck
3E
Quai à la Chaux 6 Kalkkaai,
1000 Brussels
roel.deconinck@3e.eu
http://www.3e.be/index.php

André De Herde
Université Catholique de Louvain
Place du Levant, 1
1348 Louvain-la-Neuve
deherde@arch.ucl.ac.be
http://www-climat.arch.ucl.ac.be

Ralf Klein
KaHo Sint-Lieven
Gebroeders Desmetstraat 1
9000 GENT
ralf.klein@bwk.kuleuven.be
http://www.kahosl.be/site/index.php?p=/en/page/11/welcome-to-kaho-sintlieven/

Erwin Mlecnik
Passiefhuis-Platform vzw
Gitschotellei 138
2600 Berchem
erwin.mlecnik@passiefhuisplatform.be
http://www.passiefhuisplatform.be/

Canada
Andreas Athienitis
Scientific Director
NSERC Solar Buildings Research Network Professor and Concordia Research Chair Tier I
Dept. of Building, Civil and Environmental Engineering
Concordia University
1455 Maisonneuve W.
Montreal, Québec H3G 1M8
aathieni@encs.concordia.ca
http://www.solarbuildings.ca

Véronique Delisle
CanmetENERGY/Natural Resources Canada/Government of Canada
1615 Lionel-Boulet Blvd, P.O. Box 4800
Varennes, Québec J3X 1S6
veronique.delisle@rncan-nrcan.gc.ca
www.canmetenergy.nrcan.gc.ca

Michel Tardif
CanmetENERGY/Natural Resources Canada/Government of Canada
580 Booth Street
Ottawa, Ontario K1A 0E4
michel.tardif@rncan-nrcan.gc.ca
http://www.canmetenergy.nrcan.gc.ca

Denmark
Per Heiselberg and Anna Marszal
Aalborg University
Department 6 - Department of Civil Engineering
Sohngårdsholms Vej 57
9000 Aalborg
ph@civil.aau.dk
ajm@civil.aau.dk
http://en.aau.dk/
http://www.zeb.aau.dk

Søren Østergaard Jensen
Danish Technological Institute
Gregersen Vej
2630 Taastrup
soren.o.jensen@teknologisk.dk
http://www.teknologik.dk/

Kim B. Wittchen
Danish Building Research Institute
Aalborg University
Dr. Neergaards Vej 15
2970 Hørshom
KBW@SBi.dk
http://www.en.sbi.dk/

Finland

Riikka Holopainen, Jyri Nieminen and Sirje Vares
VTT Technical Research Centre of Finland
P.O. Box 1000
02044 Espoo
jyri.nieminen@vtt.fi
http://www.vtt.fi/index.jsp

Ala Hasan and Mohamed H. Hamdy
Department of Energy Technology
School of Science and Technology
Aalto University
PO Box 14400
FI-00076 Aalto
ala.hasan@tkk.fi
Mohamed.Hassan@tkk.fi
http://hvac.tkk.fi/index_uk.html

France

François Garde
Campus universitaire Sud
Université de la Réunion
15 avenue René Cassin, BP 7151
97715 Saint Denis Messag, Cedex 9
garde@univ-reunion.fr
http://www.univ-reunion.fr/index.html

Germany

Karsten Voss
Bergische Universität Wuppertal
Haspeler Straße 27
42285 Wuppertal
kvoss@uni-wuppertal.de
http://www.btga.uni-wuppertal.de

Italy

Stefano Avesani, Roberto Lollini, and Assunta Napolitano
EURAC Research
Insitute for Renewable Energy
Viale Druso n°1,
39100 Bozen/Bolzano
stefano.avesani@eurac.edu
roberto.lollini@eurac.edu
assunta.napolitano@eurac.edu
http://www.eurac.edu

Alessandra Scognamiglio
ENEA CR Portici
P.le E. Fermi - 80055 Portici (Napoli)
alessandra.scognamiglio@enea.it
http://www.portici.enea.it/index2.html

Valerio Calderaro
Università degli Studi di Roma "La Sapienza"
Piazzale Aldo Moro 5, 00185 Roma
valerio.calderaro@uniroma1.it
http://www.uniroma1.it/default_e.php

Salvatore Carlucci, Lorenzo Pagliano and Paolo Zangheri
Politecnico di Milano
Energy Department - eERG end-use Efficiency Research Group
Via Lambruschini 4, 20156 Milano
salvatore.carlucci@polimi.it
lorenzo.pagliano@polimi.it
http://www.energia.polimi.it/english/research/scheda_gruppo.php?id=14

Maurizio Cellura
Universitá degli di studi Palermo
Dipartimento di Ricerche Energetiche ed Ambientali (DREAM)
V.le delle Scienze - Ed. 9 - 90128 Palermo
mcellura@dream.unipa.it
http://portale.unipa.it/home/dipartimenti/dip_energetic

South Korea

Gi Young Yang and Seungho Shin
Research Institute of Construction Technology
Samsung C&T Corporation
1321-20, Seocho2-dong, Seocho-Gu, Seoul
pius.yang@samsung.com
seungho.shin@samsung.com
http://www.secc.co.kr/

Jun Tae Kim
Dept. Architectural Engineering
Kongju National University
275 Budae-dong, Cheonan, Chungnam Province
jtkim@kongju.ac.kr
http://www.kongju.ac.kr/index.jsp

New Zealand
Michael Donn
Victoria University of Wellington School of Architecture
PO Box 600, 139 Vivian St., Wellington
michael.donn@vuw.ac.nz
http://www.victoria.ac.nz/home/

Norway
Anna Grete Hestnes
The Research Centre on Zero Emission Buildings
Faculty of Architecture and Fine Art
Norwegian University of Science and Technology - NTNU
NO-7491 Trondheim
annegrete.hestnes@ntnu.no
http://www.sintef.no/projectweb/zeb

Tor Helge Dokka and Igor Sartori
NTNU/ SINTEF Building and Infrastructure
Forskningsveien 3 b
P.O.Box 124 Blindern
N-0314 Oslo
torhelge.h.dokka@sintef.no
igor.sartori@sintef.no
http://www.sintef.no/Home/Building-and-Infrastructure/

Harald N Røstvik
Sivilarkitekt Harald N. Røstvik AS
PB 806, 4004 Stavanger
hnr@telnett.no
http://www.sunlab.no/default.aspx

Portugal
Daniel Aelenei
Campus da Caparica
Department of Civil Engineering
Faculty of Science and Technology
Universidade Nova de Lisboa
2829-516 Caparica
aelenei@fct.unl.pt
http://www.fct.unl.pt/

Laura Aelenei
Unidade de Energia no Ambiente Construído - UEAC
Laboratório Nacional de Energia e Geologia - LNEG
Estrada do Paço do Lumiar, Edifício Solar XXI
1649-038 Lisboa
laura.aelenei@ineti.pt
http://www.ineti.pt

Helder Gonçalves
Laboratório Nacional de Energia e Geologia - LNEG
Estrada do Paço do Lumiar, Edifício Solar XXI
1649-038 Lisboa
helder.goncalves@LNEG.pt
http://www.lneg.pt

Singapore
Stephen Wittkopf
Solar and Energy Efficient Buildings Cluster
Solar Energy Research Institute of Singapore (SERIS)
National un iversity of Singapore
7 Engineering Drive 1
Block E3A, #06-01
Singapore 117574
Stephen.wittkopf@nus.edu.sg
http://www.seris.sg

Spain
Jaume Salom and Eduard Cubi
Thermal Energy and Building Performance Group
IREC – Institut de Recerca en Energia de Catalunya
Josep Pla 2, B2, Ground floor
08019 Barcelona
jsalom@irec.cat
ecubi@irec.cat
http://www.irec.cat

Sweden
Joakim Widén
Energy Systems Programme
Department of Engineering Sciences, Solid State Physics
Uppsala University
P.O. Box 534
SE-751 21, Uppsala
joakim.widen@angstrom.uu.se
Personal website:
http://www.anst.uu.se/jowid957/

Björn Karlsson
Energy & Building Design
Lund University
Box 118
221 00, Lund
Bjorn.karlsson@ebd.lth.se
http://www.lu.se/lund-university

Switzerland
Armin Binz and Monika Hall
Fachhochschule Nordwestschweiz
Hochschule für Architektur, Bau und Geomatik
Institut Energie am Bau
St. Jakobs-Strasse 84
CH-4132 Muttenz
monika.hall@fhnw.ch
Armin.Binz@fhnw.ch
http://www.fhnw.ch/habg/iebau/

United States
Adam Hirsch, Shanti Pless, Paul Torcellini,
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401-3305
adam.hirsch@nrel.gov
shanti.pless@nrel.gov
paul.torcellini@nrel.gov
http://www.nrel.gov/about/

Regular Participants

Attia, Shady
Université Catholique de Louvain, BELGIUM
shady.attia@uclouvain.be

Biesbroek, Katrien
Katholieke Hogeschool (KaHo) Sint-Lieven, BELGIUM
katrien.biesbroeck@kahosl.be

Bourrelle, Julien S.
Norwegian University of Science and Technology - NTNU, NORWAY
julien.bourrelle@ntnu.no

Bourdoukan, Paul
FRANCE
paul.bourdoukan@gmail.com

Calderaro, Isabella
Università degli Studi di Roma "La Sapienza" , ITALY
isabella.calderaro@alice.it

Candanedo, José A. and O'Brien, William
Concordia University, CANADA
j_candan@encs.concordia.ca
w_obrie@encs.concordia.ca

Corey, Shaan
Victoria University of Wellington School of Architecture

Davidsson, Henrik
Lund University, SWEDEN
henrik.davidsson@ebd.lth.se

Lenoir, Aurélie
Université de la Réunion, FRANCE
aurelie.lenoir@univ-reunion.fr

Musall, Eike
Bergische Universität Wuppertal, GERMANY
emusall@uni-wuppertal.de

Nardi Cesarini, David and Spallacci, Maddalena
The Loccioni Group, ITALY
d.nardicesarini@loccioni.com
m.spallacci@loccioni.com

Noguchi, Masa
MEARU, Mackintosh School of Architecture, Glasgow, UK
m.noguchi@gsa.ac.uk

Prasad, Deo
Built Environment, University of New South Wales, AUSTRALIA
d.prasad@unsw.edu.au

Thyholt, Marit
NTNU/SINTEF Building and Infrastructure, NORWAY
marit.thyholt@sintef.no

Weiss, Tobias
Nussmüller Architekten ZT GmbH, AUSTRIA
tobias.weiss@nussmueller.at

Task 41

Solar Energy & Architecture

Maria Wall
Energy and Building Design, Lund University
Operating Agent for the Swedish Energy Agency, the Danish Energy Agency and Enova of Norway

TASK DESCRIPTION

The main goals of the Task are to help achieving high quality architecture for buildings integrating solar energy systems, as well as improving the qualifications of the architects, their communications and interactions with engineers, manufactures and clients. Increased user acceptance of solar designs and technologies will accelerate the market penetration. The overall benefit will be an increased use of solar energy in buildings, thus reducing the non-renewable energy demand and greenhouse gas emissions.

To achieve these goals, work is needed in three main topics:

A. Architectural quality criteria; guidelines for architects by technology and application for new products development.
B. Methods and tools for early stage evaluations and balancing of various solar technologies integration.
C. Integration concepts and examples, and derived guidelines for architects.

The first objective is to define general architectural quality criteria and extract recommendations for solar components and systems, to support manufacturers in developing existing products as well as new products. Specific criteria for the architectural integration of different solar energy components/systems will be developed in cooperation between architects, manufacturers, and other actors. New adapted products should result from this activity as well as appropriate ways to use them.

The second objective concerns methods and tools to be used by architects at an early design stage, which need to be developed or improved. An example of such a tool can be how to visualize the solar energy concepts to show e.g. clients. Other examples can be tools needed to quantify and clearly illustrate the solar energy contribution and help balance the use of different active and passive solar technologies on the building envelope.

The last objective is to provide good examples of architectural integration, in

both existing projects that can be analysed and proposals for new projects. Buildings, installations and products will be included. Case studies will be an important basis to gain experience regarding the level of successful building integration, achieved solar energy contribution and to identify barriers related to e.g. technical and economical aspects and attitudes.

Communication guidelines with facts and arguments for architects to help convince their clients to include solar energy systems will be produced. Arguments and facts related to architectural value, energy performance and life cycle costs are essential. Here, the arguments and facts need to be tailored for different building types and owner/user structures. The results from the Task will also serve as a basis for teaching material that could be used in e.g. architecture schools. To communicate the value of solar energy designs and technologies, the Task will carry out seminars, workshops and produce articles in architectural magazines, etc.

Scope

The scope of the Task includes residential and non-residential buildings. Both new and existing buildings will be included, for the climatic zones represented by the participating countries. Individual buildings as well as urban areas will be studied. In this way the potential impact of the Task can be large. Already cost-effective systems can, with a successful architectural integration, accelerate the market penetration. But also technologies not yet fully cost-effective can benefit from the work to pave the way to successful integration and user/client acceptance, and make the coming market penetration smoother. The work will build upon past IEA Tasks and other research projects related to building integration of solar systems and development of sustainable buildings.

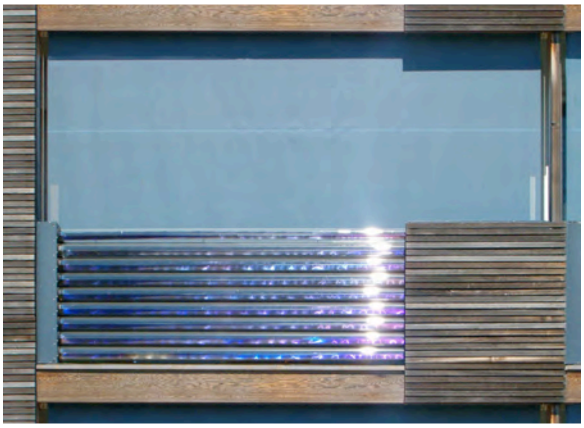
The Task is organized in three Subtasks, derived from the above described objectives and goals. The integration problems related to the different technologies (product development, method of integration) are treated in subtask A. The balance issues between the different types of solar gains, related to energy and cost impacts, are treated in subtask B. Finally the architectural integration issue is treated as a whole in subtask C, based on case studies.

The objectives will be achieved by the Participants in the following Subtasks and activities:

Subtask A: Criteria for Architectural Integration

This Subtask focuses on architectural integration of active solar energy collectors systems (solar thermal, PV and hybrids technologies) that offer an important potential for improvement regarding architectural integration. The objectives are to:

- Establish and communicate architectural criteria for the integration of active solar energy systems in the building envelope.
- Give recommendations to the industry to 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.
- Educate/inform architects on integration characteristics for various technologies and on state of the art of innovative products.



Well integrated vacuum collectors used as balcony rails on the residential building "Sunny Woods".
Architect: Beat Kämpfen Architects, Switzerland.

Photo: EPFL-LESO, Switzerland

Results will consist of:

- Survey on architects needs for an increased/better use of active solar in buildings and to help identify related barriers.
- Document for architects that describes important architectural integration criteria for different categories of solar systems, with good examples.
- Document for product and system developers that describes important architectural integration design criteria for different categories of solar systems, with good examples.
- Initiate collaborations for the development of new products/systems (e.g., through local seminars in connection with Task meetings).
- Dissemination of new knowledge to practicing architects and manufacturers through seminars.
- Task web-site page listing and describing available innovative products.

Subtask B: Methods and Tools

This Subtask is focused on methods and tools for architects to use in the early design stage (EDS). The methods and tools should support EDS decisions and allow further development of the project at preliminary design and construction phases. The use of the building envelope to achieve a good balance of both active and passive solar utilisation is a central concern in this subtask and in the development of methods and tools. The work includes producing material for the Communication Guidelines (Subtask C).

The objectives are to:

- Achieve a comprehensive review of existing methods and tools (state-of-the-art) that architects currently use at EDS when designing buildings that integrate active/passive solar components.
- Identify current barriers that prevent architects from using the existing methods and tools for solar building design.
- Identify important needs and criteria for new or adapted methods and tools to support architectural design and integration of solar components at EDS.
- Provide guidelines for developers of methods and tools for architects designing solar buildings.
- Initiate communication with tool developers (industry) in order to stimulate the development of tools based on the guidelines written as a result of this Subtask.
- In collaboration with Subtask C, collect output data, figures, illustrations and facts produced by various tools in demonstration projects, to be included in the Communication Guidelines.

Results will consist of:

- State-of-the-art presenting existing methods and tools for architectural design and solar building design.
- Survey on architects' barriers, needs and criteria for new methods and tools to support architectural design and integration of active/passive solar components at EDS.
- Recommendations for developers of tools to be used by architects at an early design stage.
- Report; Solar design: Examples on the use of tools for architects.
- Element libraries (method and examples) that could be used in design tools showing the visual impact of various solar options.
- Output material collected from existing tools used in demonstration projects to support the Communication Guidelines (with Subtask C).
- Local seminars for invited architects in connection to Task meetings. Regional/national seminars (with Subtask A, C).

The case study Marché International Support Office, Kemptthal, Switzerland applied a PV integrated in the roof and used PCM technology in the façade.
Architect: Beat Kämpfen Architects, Switzerland.

Photo: Maria Wall, Sweden.

Subtask C: Concepts, Case Studies and Guidelines

This Subtask is looking at concepts for architectural integration as well as case studies, with a whole building perspective. The Subtask also condenses the results into communication guidelines, with support from Subtasks A and B.

The objectives of this Subtask are:

- Develop concepts and principles for high quality architectural integration of solar systems, based on analyses of good examples through national and international architectural colloquiums and workshops.
- Show good examples of buildings and concepts that utilize active and passive solar energy, achieving high quality architecture, sustainable solutions, attractive indoor climate, and high energy performance. The strategies should aim at

reducing the energy demand in buildings and increasing the fraction of renewable energy use such as solar energy.
- Develop knowledge and strategies to promote and implement high quality architecture using solar energy.

Results will consist of:

- Comprehensive collection and selection of case studies of high quality architecture and energy efficient building designs including solar solutions for new build and renovation for various building types (housing, offices, schools, etc.).
- Working method illustrated through selected examples of energy efficient or sustainable urban planning (minor part).
- Presentation of working methods, designs, solar energy potentials through exemplary buildings in communication guidelines, in an IEA SHC web page, articles, architecture magazines, and at seminars for architects, engineers, component and system developers, clients, planners etc. The communication guidelines will include convincing arguments and facts with support from Subtask A and B.

Task Duration

This Task started on May 1, 2009 and will end April 30, 2012.

Participating Countries

Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Norway, Portugal, Singapore, Spain, Sweden and Switzerland.

South Korea also is participating, while waiting to become a formal member of the IEA SHC Programme. See the list of the participants at the end. Updates on participation and results from the Task will be available on the website: http://iea-shc.org/task41.

WORK DURING 2011

Two Task Expert meetings were held in 2011; the 1st in Oslo, Norway in March and the 2nd in Melbourne, Australia in September. Both meetings were linked to public seminars (one in Norway and two in Australia) presenting the work and results of the Task.

Two reports based on the results from the surveys on barriers, needs and criteria were written (Subtask A and B). The report from Subtask B, *International Survey about Digital Tools Used By Architects for Solar Design* can be downloaded from the IEA SHC website. The Subtask A report will be ready in early 2012.

Also, elements illustrating solar components have been developed to use in AutoCad and ArchiCad for illustrating various options of active solar integration into buildings. They are meant as examples, and hopefully in the future manufacturers will develop such elements for real products (including key data) that architects can then choose from in a library, to illustrate how their building will look with active components as building envelope cladding. Examples can be downloaded from a website.

Guidelines for architects and for solar product and system developers respectively, were developed as drafts (Subtask A). These guidelines are focused on the architectural integration criteria of solar products and include good integration.

Proposed case studies have been collected within Subtask C. More than 200 proposals were collected. The process of selecting Task 41 case studies from the proposed ones was finalized. Selection criteria include architectural quality and energy performance. The detailed data collection for the selected case studies is ongoing and the case studies will be available via the Task website.

One additional country became a participant in 2011: Singapore.

WORK PLANNED FOR 2012

Since the Task ends in 2012, many deliverables will be finalized.

Key activities planned for 2012 include:

- Finalize a report based on the survey on architects' barriers, needs and criteria related to architectural integration of solar systems (Subtask A).
- Finalize guidelines for architects that describe important architectural integration criteria for different categories of solar systems, with good examples (Subtask A).
- Finalize guidelines for product and system developers that describe important architectural integration design criteria for different categories of solar systems, with good examples (Subtask A).
- Finalize a list of available innovative products for integrated solar systems and put on a website (Subtask A).
- Finalize recommendations for tool developers related to architectural needs (Subtask B).
- Finalize document on solar design: Examples on the use of tools for architects.
- Collect data on selected case studies and finalize the presentations on the website (Subtask C).
- Finalize the Communication Guidelines (Subtask C).

TASK REPORTS/RESULTS PUBLISHED IN 2011

- Horvat M, Dubois MC, Snow M, Wall M (eds.). *International survey about digital tools used by architects for solar design.* IEA SHC Task 41, Subtask B; 2011. Download at: http://www.iea-shc.org/publications/task.aspx?Task=41.
- Zanetti I, Nagel K. CAAD 3D parametric objects; examples of solar components. On website: www.bipv.ch/index.php?option=com_content&view=article&id=338&Itemil=306&lang=en

OTHER PUBLICATIONS AND PRESENTATIONS IN 2011 (examples)

- Amtmann M., Lechner A., Mach T., Selke T., Article in the professional magazine "Wettbewerbe", September 2011 "Analysis and assessment of energetic, economic and architectural quality of urban solar energy buildings".
- Amtmann M., Oral presentation of the national project "Urban solar energy" and intermediate results of the IEA Task 41 project at the 9th Photovoltaic Conference in Vienna, 20th-21st October 2011.
- Bornatico R., Pfeiffer M., Witzig, A. & Guzzella L. (2011). Optimal sizing of a solar thermal building installation using particle swarm optimization. In Energy, doi:10.1016/j.energy.2011.05.026.
- Dubois, M.-C., Horvat, M. & Kanters, J. (2011). Tools and methods used by architects for solar design: results of an international survey in 14 countries, In Proceedings of CISBAT 2011 Conference, Lausanne, Switzerland, Sept. 14-16. Book of abstracts p. 178 and paper published on CD-rom.
- Edelman, M., Roecker C-, Munari Probst MC., Witzig A. & Foradini F, (2011). Lesosai wizard: a new building energy tool for architects, Plea 2011, Louvain La Neuve, Belgium, July 2011.
- ENEA (2011). Forms of Energy. In proceedings of the 26th European Photovoltaic Solar Energy Conference, in Hamburg, Germany.
- Frontini, F. (2011). Innovation School – ENERBUILD 2011: Verso edifici produttivi e a basso consumo energetico. Oral presentation: Integrazione di tecnologie so-

lari nell'involucro edilizio: BIPV e BIST (Building Integrated Photovoltaics and Solar Thermal), At Klima Energy, Fiera di Bolzano. 23 September 2011.

- Geissler S., Amtmann M., Barth T., Article in the BAU Z Conference transcript: "Potentials of solar energy use in the urban context", IBO, February 2011
- Geissler S., Amtmann M., Barth T., Oral presentation of the national project "Urban solar energy" with a short description of the IEA Task 41 project at the BAU Z congress in Vienna, 17th – 18th February 2011
- Giovanardi A., Lollini R. & Baggio P. (2011). "Analysis of solar thermal collector integration in facade system". Published in proceedings of the 6th Energy Forum Seminar for the building actors, in connection with the Task 41 meeting. 2011, Bressanone, Italy, 6-7 December 2011.
- Korolkow, M., Horvat, M., Dubois, M-C, Kanters J. & Bouffard, E. (2011). Tools and Methods for Solar Building Design: Results of IEA Task 41 International Survey, ISES Solar World Congress 2011, Kassel, August 28th – September 2nd, Paper Nr. 191.
- Maturi L., Lollini R., Baldracchi P., Sparber W. (2011). "Building skin as electricity source: the prototype of a wooden BIPV façade component". Published in the proceedings of the 26th European Photovoltaic Solar Energy Conference and Exhibition, organized by European Commission JRC and WIP Renewable Energies, Hamburg, 5-9 September 2011.
- Munari Probst, MC., & Roecker, C. (2011) "Architectural integration and design of solar thermal systems", 173 pages, EPFL Press, Routledge/Architecture, Lausanne.
- Munari Probst MC. & Roecker, C. (2011). Urban acceptability of building integrated solar systems: LESO-QSV approach. In proceedings of ISES 2011, Kassel, Germany, 28th August - 2nd September 2011.
- Munari Probst MC. & Roecker, C. (2011). Architectural integrability of solar thermal systems: present and future. At Energy Forum, Bressanone, Italy, 4th -5th December 2011.
- Amado M.P. & Poggi, F. (2011). Oeiras Masterplan: A Methodology to Approach Urban Design to Sustainable Development. In Proceedings CISBAT, Lausanne, 2011.
- Kanters, J. (2011). Arkitektoniska hinder för solarkitektur (Architectural barriers for solar architecture). In Energi & Miljö; March 2011, Sweden.
- Kanters, J. (2011). Adequacy of current design tools and methods for solar architecture – results of IEA-SHC Task 41's international survey, In Proceedings of PLEA 2011 - 27th Conference on Passive and Low Energy Buildings, Louvain-la-Neuve, Belgium, 13-15 July, 2011, Vol.2, 65-70.
- Korolkow, M., Horvat, M., Dubois, M.-C., Kanters, J. & Bouffard. É., (2011), Tools and methods for solar building design: results of IEA Task 41 international survey, in ISES Solar World Congress 2011 Proceedings, (DVD, ISBN 978-3-9814659-0-7), Kassel, Germany, 28th Aug.- 2nd Sept, 2011.
- Mach T., Heimrath R., Selke T., Stift F., Grünewald S., Lechner A., Article in the conference transcript of the OTTI symposium: "Active solar thermal systems in the refurbishment of historical buildings", May 2011.

SEMINARS AND WORKSHOPS IN 2011 (examples)

- "Solar Energy & Architecture - Knowledge and Inspiration". 1st of April 2011. Oslo, Norway. Seminar hosted by Dark Arkitekter, Schuco, Context, NTNU. In connection to Task 41 meeting.

- “International Best Practice and the International Energy Agency”. Melbourne Forum Seminar: Solar Energy and Architecture. 28th of September, 2011. Hosted by Melbourne Forum. In connection to Task 41 meeting.
- “Latest International Solar Technologies for Buildings Seminar“. IEA SHC & Australian PV Association (APVA). 29th of September 2011. Hosted by Australian Government and Sustainability Victoria. In connection to Task 41 meeting.
- “Da un concetto ad un risultato concreto: edifici a risparmio energetico e produttivi, che integrano fonti energetiche rinnovabili”, EURAC, in the context of Klimaenergy fair 2011, 23/9/2011, Bolzano, Italy.
- CRSEEL 2011; Conference on sustainable construction including solar technologies. At the University Campus, Caparica, Portugal. Organized by FCT/UNL et al. (http://www.conferencia2011crseel.com/).
- “Architectural integration of PV and solar thermal panels – best practice examples”. Project workshop “Futurebase”, Vienna, 2nd of May 2011. Organized by AIT (Austrian Institute of Technology), architect's office POS architects, WWFF.
- “Modern - Construction Workshop”. Presentation and discussion of the IEA Task 41 project, Vienna, 5th of July 2011. Organized by AEA (Austrian Energy Agency), ÖVI (Austrian Association of Real Estate Agents) and GBV (Austrian non-profit building association).
- Arkitektur & Solenergi – IEA SHC Task 41. Public seminar presenting the Task 41 work. Organized by White Arkitekter et al. Stockholm, 17th of November, 2011.

MEETINGS IN 2011

5th Experts Meeting
March 29-31
April 1: Seminar in English/Norwegian
Oslo, Norway

6th Experts Meeting
September 26-28
Sept. 28 and Sept 29: two seminars
Melbourne, Australia

Extra meeting (a subgroup)
February 16
Copenhagen, Denmark
Objective: to identify development needs related to solar energy integration in urban planning; what could be included in Task 41 and what could be issues for a new Task.

MEETINGS PLANNED FOR 2012

7th (final) Experts Meeting
March 27-29
March 30: Conference in English
Lisbon, Portugal

TASK 41 NATIONAL CONTACTS

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

Subtask A Leader
Maria Cristina Munari Probst
Christian Roecker (co-leader)
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne, Switzerland
mariacristina.munariprobst@epfl.ch
christian.roecker@epfl.ch

Subtask B Leader
Miljana Horvat
Department of Architectural Science
Ryerson University
350 Victoria St.,
Toronto, Ontario, M5B 2K3, Canada
mhorvat@ryerson.ca

Marie-Claude Dubois (co-leader)
School of Architecture
Laval University
1, Côte de la Fabrique, Québec,
Québec, G1R 3V6, Canada
Marie-Claude.Dubois@arc.ulaval.ca

Subtask C Leader
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Gammel Køge Landevej 22
DK-2500 Valby, Denmark
obj@esbensen.dk

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

Austria
Maria Amtmann
Division Buildings & Heating
Austrian Energy Agency
Mariahilfer Straße 136
A-1150 Vienna
maria.amtmann@energyagency.at

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

Thomas Mach
Institute of Thermal Engineering
TU Graz / Graz University of Technology
Inffeldgasse 25/B
A-8010 Graz
thomas.mach@tugraz.at

Andreas Lechner and
Sophie Grünewald
Institute of Design and Typology
TU Graz / Graz University of Technology
Lessingstrasse 25/IV
A-8010 Graz
andreas.lechner@tugraz.at
s.gruenewald@tugraz.at

Belgium
André de Herde and Catherine Massart
Architecture et Climat - UCL
Place du Levant, 1
B-1348 Louvain-La-Neuve
andre.deherde@uclouvain.be
catherine.massart@uclouvain.be

Canada
Marie-Claude Dubois, Pierre Côté, Shirley Gagnon and Émilie Bouffard
School of Architecture, Laval University
1, Côte de la Fabrique, Québec
Québec, G1R 3V6
marie-claude.dubois@arc.ulaval.ca
pierre.cote@arc.ulaval.ca
shirley.gagnon.1@ulaval.ca
emilie.bouffard.1@ulaval.ca

Miljana Horvat, Michael Clesle,
Viktor Kuslikis and Alissa Laporte
Department of Architectural Science
Ryerson University
350 Victoria St.,
Toronto, Ontario, M5B 2K3
mhorvat@ryerson.ca
mclesle@ryerson.ca
vkusliki@ryerson.ca
alissa.laporte@ryerson.ca

Andreas Athienitis and Caroline Hachem
Dept. of Building, Civil and Environmental Engineering
Concordia University (Solar Buildings Research Network)
1455 Maisonneuve W., Montreal
Quebec, H3G1M8
aathieni@encs.concordia.ca
caroline_hachem@yahoo.com

Denmark
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Gammel Køge Landevej 22
DK-2500 Valby
obj@esbensen.dk

Torben Esbensen
Esbensen Consulting Engineers
Møllegade 54-56
DK-6400 Sønderborg
torben@esbensen.dk

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

Germany
Tilmann E. Kuhn and Francesco Frontini
Dept. Thermal Systems and Buildings
Fraunhofer Institut für Solare Energiesysteme ISE
Heidenhofstr. 2
D-79110 Freiburg
tilmann.kuhn@ise.fraunhofer.de
francesco.frontini@ise.fraunhofer.de

Gustav Hillmann and
Margarethe Korolkow
IBUS Architekten und Ingenieure GbR
Alt-Tempelhof 18
D-12099 Berlin
hillmann@ibus-berlin.de
margarethe.korolkow@ibus-berlin.de

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

Gisela Wicht
HTW Berlin University of Applied Sciences Renewable Energies
Ostendstrasse 1
D-12459 Berlin
gisela.wicht@htw-berlin.de

Italy
Roberto Lollini, Alessia Giovanardi and Laura Maturi
EURAC research
Viale Druso/Drususallee 1
I-39100 Bolzano/Bozen
roberto.lollini@eurac.edu
alessia.giovanardi@eurac.edu
laura.maturi@eurac.edu

Alessandra Scognamiglio
Renewable Sources and Innovative Solar Technologies Area
ENEA Portici Research Center
piazzale E. Fermi 1
I-80055 Portici (Na)
alessandra.scognamiglio@portici.enea.it

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

Merete Hoff, Marius Bjørge and Vivianne Steinsåker
DARK Arkitekter AS
Drammensveien 130
N-0277 Oslo
mho@dark.no
marius.bjorge@dark.no
vis@dark.no

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

Axel Andreas Bjørnulf
Schüco International
PB 56, Bogerud
N-0621 Oslo
ABjoernulf@schueco.com

Portugal
Miguel Pires Amado and Maria Rosário Ribeiro
FCT/UNL
Campus da Caparica
PT-2829-516 Caparica
ma@fct.unl.pt
rsa.ribeiro@fct.unl.pt

João Capucho de Freitas
GEOTPU/DEC/FCT
Campus da Caparica
PT-2829-516 Caparica
rdabreu@fct.unl.pt

Vasco Moreira Rato
ISCTE-IUL Instituto Universitário de Lisboa
Av[a] Forças Armadas, Lisboa
vasco.rato@iscte.pt

Carlos Barbosa, Ana Mestre, Eduardo Gonçalves, Marco Silva, Paulo Bago d'Uva, João Rebolo and João Santa Rita
IADE-Instituto de Artes Visuais, Design e Marketing
Av. D. Carlos 1, 4
PT-1200-649 Lisboa
carlos.barbosa@iade.pt
ana.mestre@susdesign.org
muaddib.mail@gmail.com (E. Gonçalves)
marco.silva@iade.pt
paulo.b.uva@gmail.com
jtrebolo@msn.com
joaosr65@gmail.com

Singapore
Stephen K Wittkopf
Solar Energy Research Institute of Singapore (SERIS)
National University of Singapore (NUS)
7 Engineering Drive 1
Building E3A #06-01
Singapore 117574
stephen.wittkopf@nus.edu.sg

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

Spain
María José Jiménez and Ricardo Enriquez Miranda
Energy Efficiency in Building Unit
CIEMAT
Av. Complutense, 22.
E-28040 Madrid
mjose.jimenez@psa.es
ricardo.enriquez@ciemat.es

Sweden
Marja Lundgren, Erik Eriksson, Ulrika Stenkula and Karina Antin
White Arkitekter
P.O. Box 4700
Östgötagatan 100
SE-116 92 Stockholm
marja.lundgren@white.se
erik.eriksson@white.se
ulrika.stenkula@white.se
karina.antin@white.se

Maria Wall and Jouri Kanters
Energy and Building Design
Lund University
P.O. Box 118
SE-221 00 Lund
maria.wall@ebd.lth.se
jouri.kanters@ebd.lth.se

Switzerland

Doris Ehrbar and Marcel Hohl
Lucerne University of Applied Sciences and Arts
Dept. of Engineering and Architecture
Competence Center for Typology and Planning
Technikumstrasse 21
CH-6048 Horw
doris.ehrbar@hslu.ch
marcel.hohl@hslu.ch

Morena Ferrazzo and Francesco Frontini
SUPSI-DACD-ISAAC
Swiss BiPV centre of competence
Via Trevano
CP 105
CH - 6952 Canobbio
morena.ferrazzo@supsi.ch
francesco.frontini@supsi.ch

Maria Cristina Munari Probst
Christian Roecker
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne
mariacristina.munariprobst@epfl.ch
christian.roecker@epfl.ch

Kim Nagel
3S Swiss Solar Systems AG
Schachenweg 24
CH-3250 Lyss
kim.nagel@3s-pv.ch

Andreas Witzig
Vela Solaris AG
Stadthausstrase 125
CH-8400 Winterthur
andreas.witzig@velasolaris.com

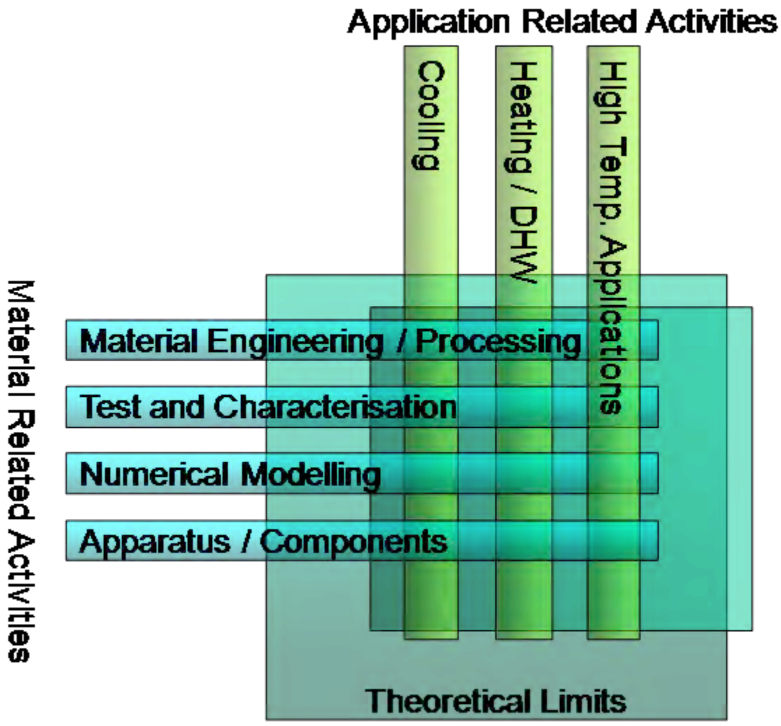
Task 42

Compact Thermal Energy Storage: Material Development for System Integration

Wim van Helden & Andreas Hauer
Operating Agent for the AgentschapNL, Ministry of Economic Affairs, The Netherlands, and the Centre for Applied Energy Research ZAE, Germany, respectively

TASK DESCRIPTION

The objective of this Task is to develop advanced materials for compact storage systems, suitable not only for solar thermal systems, but also for other renewable heating and cooling applications such as solar cooling, micro-cogeneration, biomass, or heat pumps. The Task covers phase change materials, thermo-chemical and sorption materials, and composite materials and nanostructures, and includes activities such as material development, analysis, and engineering, numerical modeling of materials and systems, development of storage components and systems, and development of standards and test methods. The main added value of this Task is to combine the knowledge of experts from materials science as well as solar/renewable heating and energy conservation.



This Task deals with advanced materials for latent and chemical thermal energy storage, on three different scales:

- material scale, focused on the behavior of materials from the molecular to the 'few particles' scale, including for example, material synthesis, micro-scale mass transport, and sorption reactions;
- bulk scale, focused on bulk behavior of materials and the performance of the storage in itself, including for example, heat, mass, and vapor transport, wall-wall and wall-material interactions, and reactor design; and
- system scale, focused on the performance of a storage with in a heating or cooling system, including for exaomle, economical feasibility studies, case studies, and system tests.

The work in the Task is structured in materials oriented, application oriented and cross-cutting working groups.

Subtask A – Materials

Working Group A1: Material Engineering and Processing

The activities in this Working Group focus on engineering new materials or composites, i.e. changing the properties of existing materials and developing new materials with better performance, lower cost, and improved stability. Eventually, this should lead to the ability to design new materials tailor-made to specification. The materials under consideration are those relevant to thermal energy storage using sensible mode, phase change, as well as chemical reactions and sorption technologies.

With respect to materials processing, the work focuses on the processing of raw materials that is required to make these materials function in a realistic environment. In nearly all cases, storage material cannot be used to store heat in its raw form, but needs to be processed into a slurry, encapsulated, or otherwise processed.

This Working Group includes the following activities:

- synthesis of new materials;
- determining material characteristics such as phase diagrams;
- determining the relation between material performance and material structure and composition, in order to direct the search for improved materials;
- creating material safety data sheets;
- determining the role and importance of material containers.
- finding optimal methods for micro- and macro encapsulation of storage materials (particularly phase change, sorption, and thermochemical materials);
- processing phase-change slurries; and
- finding new combinations of materials.

Working Group A2: Tests and Characterisation

The performance characteristics of novel thermal energy storage materials, like phase-change materials or thermochemical materials, often cannot be determined as straightforward as with sensible heat storage materials. In order to have proper comparison possibilities appropriate testing and characterisation procedures should be developed and assessed.

The activities of this Working Group are aimed at developing these new procedures and include:

- comparative testing of materials and their required methods;
- long-term stability determination; and
- (pre-)standardisation of testing methods.

Working Group A3: Numerical Modelling

The activities in this working group are aimed at developing and testing numerical models that help to understand and optimise the material behaviour and the dynamic behaviour of compact thermal energy storage systems and components. Ultimately, these numerical models could help to find ways to optimise the materials in combination with the system components. The activities in this working group help to lay the foundation for such models.

The Working Group includes the following activities:

- Micro-scale modelling
- Meso-scale modelling
- Macro-scale modelling
- Multi-scale approach
- Thermo-mechanical modelling
- Reactor models

Working Group A4: Apparatus/ Components

The storage apparatus is composed of the storage material and the equipment necessary to charge and discharge the storage material in a controlled and optimal way. This includes heat and mass transfer equipment like heat exchangers and pumps or fans and (chemical) reactors. Methods for the design and optimisation of components and apparatus should be developed, together with appropriate testing methods and procedures to assess the long-term behaviour of an apparatus:

- storage container and reactor design;
- storage apparatus design, based on the selected storage materials;
- improve heat transfer from material to reactor wall or heat exchanger wall;
- apparatus performance assessment;
- assessment of durability of components; and
- develop and apply test and validation methods for storages.

Subtask B – Applications

There are several applications for compact thermal energy storage technologies, each with a different set of boundary conditions for the technology. Although the applications themselves place very different requirements on storage technology, the steps that must be taken are very similar for all applications. Hence, the activities within the Working Groups in this Subtask are very similar as well.

The activities in these Working Groups serve the underlying guidance principle of the materials development within the limitations of the application. The materials development will be directed by the desired system performance. A constant assessment of performance criteria for a given application will be used to determine the chances for a given material/system combination. These criteria can come from economic, environmental, production technology or market considerations.

Activities in the Application Working Groups include:

- inventory and analysis of existing store types, their theoretical and practical energy and power density, their possible application and their costs (if available) following the results of IEA SHC Task 32 and IEA-ECES Tasks;
- definition of application boundary conditions, such as load, demand, environment, dimensions, etc.;
- definition of required thermophysical properties for each application;
- selection of relevant candidate materials and system technologies;
- storage system design, based on the selected storage materials (link to A2) and applications;
- assessment of durability of components
- system performance assessment and validation;
- numerical modelling on the application level;
- case studies;
- economical modelling;
- feasibility studies;
- market potential evaluations.

This subtask is subdivided in three Working Groups, each representing a particular application or group of similar applications:

- Working Group B1: Cooling
- Working Group B2: Heating / DHW
- Working Group B3: High Temperature Applications

Subtask C – Cross-Cutting

Working Group C: Theoretical Limits

The objective of this Working Group is to determine the theoretical limits of compact thermal storage materials and systems from a physical, technical and economical viewpoint. In short, this Working Group defines the maximum possible performance that can be expected from a thermal storage system in a given application. As such, it gives a reference point with which the performance of lab tests, field tests, and real-life systems can be compared. In a first step physical limits shall be determined, e.g. the energy stored per volume and per mass as a function of temperature, with respect to different mechanisms as sensible, latent, sorption or chemical storage. In a second step technical aspects shall be evaluated. In many cases the energy storage density and the efficiency of the system are deteriorated when a large specific thermal power must be drawn from the system. In a third step economical constraints of storage systems shall be evaluated.

Duration

This is a fully Joint Task with the IEA Energy Conservation through Energy Storage Programme (ECES Annex 24). The Task started on January 1, 2009 and will end on December 31, 2012.

Participating Countries

Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Netherlands, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States

WORK DURING 2011

The Task activities in the subsequent working groups were as follows:

Materials engineering and processing: the decision was made to extend the materials database to economic data and environmental issues. The material data of sensible TES materials will also be included. As the performance data of the material are very much dependent on the application, much attention will be paid to the inclusion of the boundary conditions for the determination of the performance data, in order to enable a fair comparison between storage materials. New national activities were started on solid-solid PCMs, molecular alloys based on sugar alcohols, Cellulosis-PCM, Zeolite/MgSO4 and others.

Materials testing and characterisation: Further results from the round-robin test of different PCM samples were assembled and compared with the previous outcomes. In a dedicated DSC measuring workshop, organised in May 2011, a group of 12 experts used DSC machines from a number of suppliers both to train themselves in performing DSC analysis and to compare the measurements on a number of samples. Striking differences were found between the measurements. The causes for these differences were investigated and methods for improvement were set up. These encompass both a unified measurement procedure and a unified calibration procedure. These will be tested in the coming period. Meanwhile, the round-robin tests will be continued with additional sample materials.

Numerical modelling: Progress was made in the development of dedicated numerical models, using the reaction force approach, to simulate the dehydration of magnesium sulphate. The deliverable on the state of the art in numerical modelling software will be completed with descriptions of numerical simulation methods for sorption materials. The first experimental data were collected that will be used for benchmarking the numerical codes. In total, 9 institutes will provide experimental data, with possible 3 additional institutes that did not confirm the provision of data yet.

Apparatus and components: The deliverable on storage design aspects and design flow charts is planned to be ready early 2012. The individual design process descriptions will be worked out further, as will the storage design aspects description.
The table of contents of the deliverable on Performance Measurement Test Protocol was deepened one step and the second draft will be reviewed in the coming period.

Cooling applications: A setup was made for the evaluation criteria of storage materials for cooling applications. The table of contents for the report on boundary conditions for cooling applications was drafted and two sets of boundary conditions for two cooling applications were discussed.

Heating and domestic hot water applications: As the different project that work on prototypes for this application have serious delay, the list of deliverables for this working group was reviewed. It was concluded that the case studies for several applications, the techno-economical potential for each application, and the field tests could not be achieved in the Task period and therefore were skipped.

High Temperature Applications: Two State-of-the-art-reports will be compiled: One on high temperature applications based on the final report of Annex 19 (ECES) and the other on numerical modelling in high temperature applications. The report on lab-scale activities on process heat applications at 200°C and field test on CSP (Concentrated Solar Power) applications will follow. The reports are ready in draft now and will be published early 2012.

Theoretical limits: A study into the physical limits of thermal storage was drafted and discussed. Storage design variants were discussed and improved. This categories will be included in the report on theoretical limits. The suggestion to utilize analytical models to assess critical parameters in idealized TES (PCM, sorption and chemical reactions) was accepted.

WORK PLANNED FOR 2012

Key activities planned for 2012 include:

- First version of materials data base.
- Round-robin and comparison of characterization of compact storage materials completed and drafts defined for calibration and measurement procedures.
- Report on the state-of-the-art modeling techniques of PCM/TCM materials.
- Report on storage design aspects and design flow charts.
- Description and performance analysis of selected cooling applications
- Listing of boundary conditions and requirements for the room heating and domestic hot water application area
- Report on state of the art of high temperature storage applications
- Proposal for the completion of the first 4 years of this Task and a proposal for a 3 year extenstion (2013-2015) of the Task.

REPORTS PUBLISHED IN 2011

No reports were published.

REPORTS PLANNED FOR 2012

Report on the state-of-the-art modeling techniques of PCM/TCM materials

Report on storage design aspects and design flow charts

Report on state of the art of high temperature storage applications

MEETINGS IN 2011

5th Experts Meeting
February 20-21
Belfast, Northern Ireland
(in conjunction with IC-SES Conference)

6th Experts Meeting
September 20-22
Minneapolis, Minnesota, USA

MEETINGS PLANNED FOR 2012

7th Experts Meeting
March 27-29
Tokyo, Japan

8th Experts Meeting
September
t.b.d.

TASK 42/ANNEX 24 CONTACTS

TASK MANAGEMENT CONTACTS

Operating Agents
Andreas Hauer
ZAE Bayern
Germany
hauer@muc.zae-bayern.de

Wim van Helden
Wim van Helden Renewable Heat
Schagen, The Netherlands
wim@wimvanhelden.com

Working Group A1 Leader
Elena Palomo
University of Bordeaux
France
elena.palomo@bordeaux.ensam.fr

Working Group A2 Leader
Stefan Gschwander
Fraunhofer Institute for Solar Energy Systems FhG-ISE, Freiburg
Germany
Stefan.Gschwander@ise.fraunhofer.de

Working Group A3 Leader
Camilo Rindt
Eindhoven University of Technology
The Netherlands
C.C.M.Rindt@wtb.tue.nl

Working Group A4 Leader
Wim van Helden

Working Group B1 Leader
Motoi Yamaha
Chubu University, Tokyo, Japan
yamaha@isc.chubu.ac.jp

Working Group B2 Leader
Jane Davidson
University of Minnesota, Minneapolis
USA
jhd@me.umn.edu

Working Group B3 Leader
Lluisa Cabeza
University of Lleida
Spain
lcabeza@diei.udl.cat

Working Group C Leader
Eberhard Lävemann
ZAE Bayern, Garching
Germany
laevemann@muc.zae-bayern.de

COUNTRY CONTACTS

Australia
Frank Bruno
University of South Australia
Frank.Bruno@unisa.edu.au

Austria
Dagmar Jähnig
AEE Intec
d.jaehnig@aee.at

Olivier Pol
Arsenal
Olivier.Pol@arsenal.ac.at

Wolfgang Streicher
TU Graz
w.streicher@tugraz.at

Bernhard Zettl
ASiC Austria Solar Innovation Center
zettl.bernhard@asic.at

Belgium
Johan Van Bael
VITO
johan.vanbael@vito.be

Canada
Handan Tezel
University of Ottawa
handan.tezel@uottawa.ca

Denmark
Simon Furbo
Technical University of Denmark
sf@byg.dtu.dk

France
Elena Palomo
Universite Bordeaux
palomo_elena@yahoo.fr

Frédéric Kuznik
Thermal Science Centre of Lyon
frederic.kuznik@insa-lyon.fr

Lingai Luo
University of the Savoie
Lingai.Luo@univ-savoie.fr

Philippe Papillon
INES
philippe.papillon@cea.fr

Philippe Stevens
EDF
philippe.stevens@edf.fr

Germany
Andreas Hauer
ZAE Bayern
hauer@muc.zae-bayern.de

Franziska Scheffler
University of Magdeburg
Franziska.Scheffler@ovgu.de

Henner Kerskes
ITW Stuttgart
kerskes@itw.uni-stuttgart.de

Jimmy Ofili
Lehrstuhl für Chemische Reaktionstechnik
Jimmy.Ofili@crt.cbi.uni-erlangen.de

Frank Salg
Vaillant GmbH
frank.salg@vaillant.de

Oliver Opel
Leuphana Universität Lüneburg
opel@leuphana.de

Peter Schossig
Fraunhofer ISE
peter.schossig@ise.fraunhofer.de

Roland Heinzen
University of Kassel
heinzen@uni-kassel.de

Italy
Valerio Lo Brano
University of Palermo
lobrano@dream.unipa.it

Netherlands
Camilo Rindt
Technical University Eindhoven
c.c.m.rindt@tue.nl

Herbert Zondag
Energy research Center of the Netherlands ECN
zondag@ecn.nl

Slovenia
Venceslav Kaucic
National Institute of Chemistry
slavko.kaucic@KI.si

Spain
Ana Lazaro
Universidad de Zaragoza
ana.lazaro@unizar.es

Cristina Prieto
Abengoa Solar NT
cristina.prieto@solar.abengoa.com

Lluisa Cabeza
University of Lleida
lcabeza@diei.udl.es

Miren Blanco
Tekniker
mblanco@tekniker.es

Patricio Aguirre
Tecnalia
patricio.aguirre@tecnalia.com

Rocio Bayon Cabeza
CIEMAT
rocio.bayon@ciemat.es

Sweden
Viktoria Martin
KTH
vmartin@kth.se

Switzerland
Elimar Frank
SPF
elimar.frank@solarenergy.ch

Robert Weber
EMPA
robert.weber@empa.ch

Turkey
Halime Paksoy
Cukurova University
hopaksoy@cu.edu.tr

United Kingdom
Philip Griffiths
University of Ulster, Belfast
p.griffiths@ulster.ac.uk

Changying Zhao
University of Warwick
C.Y.Zhao@warwick.ac.uk

Phil C. Eames
CREST; University of Loughborough
p.c.eames@lboro.ac.uk

United States
Jane Davidson
University of Minnesota
jhd@me.umn.edu

Jan Kosny
Fraunhofer Centre for Sustainable Energy
jkosny@fraunhofer.org

Task 43

Advanced Solar Thermal Testing and Characterization for Certification of Collectors and Systems

Les Nelson
Western Renewables Group
Co-Operating Agent for the U.S. Department of Energy

Jan Erik Nielsen
PlanEnergi
Co-Operating Agent for the Danish Energy Agency

Kevin DeGroat
Antares Group, USA
Program Manager

TASK DESCRIPTION

Task 43 is an international collaboration focusing on research and development, where needed, of new test and certification procedures for conventional and advanced solar thermal products, at both the collector and system levels. The scope of the task includes performance testing and characterization, qualification testing, environmental impact assessment, accelerated aging tests, numerical and analytical modelling, component substitution procedures, and entire system design assessment. Task activities draw on the knowledge of industry, testing laboratories, standard-setting authorities and certification bodies in the areas of solar collector and system performance and durability to ensure wide-ranging involvement of affected stakeholders. By researching testing issues and investigating innovative approaches, the outputs of this task will help optimize the time and resources industry, laboratories and certification bodies expend on testing and certification. Consumer protection and the development and dissemination of credible information on solar heating and cooling benefits are guiding principles of this Task.

Stakeholders in Task 43 activities will work out the methods to be used to apply the Task research results to specific products, standards and certifications, including global certification schemes now under discussion. Task results will also be communicated to those legal authorities who define how certification shall be conducted, for use as they see fit.

Task 43 is organized into two Subtasks:

- **Subtask A**: Collectors *(Leader: Enric Mateu Serrats, Spain)*

The objective of Subtask A is to examine existing testing and certification procedures for all types of solar thermal collectors, with the objective of identifying opportunities for improvement and harmonization.

- **Subtask B**: Systems *(Leader: Harald Drück, Germany)*

The objective of Subtask B is to perform analyses of testing and certification procedures for entire solar thermal systems.

Main Task Deliverables

The results of the Task will be several technical reports and, potentially, changes to test standards and certification protocols based on the results of the Task work. Major outcomes will include:

- Roadmaps for Both Task A and Task B activities going forward.
- State-of-the-art white paper on collector testing, measurement and certification issues.
- Report on the results of round-robin collector test projects now underway in Europe and North America.
- If deemed appropriate, draft recommendations for revising collector performance test standards, qualification criteria, and/or safety test standards .
- Report regarding computer modeling versus empirical testing of systems and balance of system components.
- Report regarding the impact of component substitution and down/upsizing of systems on system performance.
- Reports/white papers regarding the establishment of a collector “class” system for Impact Resistance Testing, Exposure Testing, and Mechanical Load Testing.
- Joint meetings with testing and certification stakeholders to promote international harmonization.
- Determination of the advisability of pursuing a global certification scheme.
- A communication plan for distributing information on the outcomes of Task activities to stakeholders.

Task Duration

The Task started on July 1, 2009 and will end June 30, 2012.

Participating Countries

Australia, Austria, Canada, Denmark, France, Germany, Portugal, Sweden, Switzerland, Spain, United States,

WORK CONDUCTED IN 2011

Subtask A: Collectors

Draft White Paper templates for each of the major collector products have been completed. Additional work will proceed to finalize these documents. A Gannt Chart-based Workplan for all Subtask A activities has been prepared by CENER.

Low to Medium Temperature Collector developments include:

- The EU QUAIST Project (Quality Assurance in Solar Heating and Cooling Technology) is nearing completion, with results for rounds one and two of the testing laboratory round robin collector testing and data reporting expected in early 2012. The results of this activity will help inform the final work and recommendations for Task 43.

Air Heating Collector developments include:

- Canadian Standards Association has promulgated a draft standard; the public comment period ended in early 2011. The standard is expected to be final by end 2011.
- Within the EU project NEGST, a draft-standard for testing solar air collectors based on existing standards has been developed. This draft provides test methods and calculation procedures for determining the steady-state thermal performance of glazed air heating solar collectors.
- A Draft white paper template for Air Heating Collectors has been prepared; parties responsible for specific sections have been identified, and work on completion of each section is in progress:

Concentrating Collector developments include:

- SRCC Standard 600 has been promulgated and is being used as a starting point for revisions to EN by TC312/WG1. SRCC is in the process of adopting new protocols and definitions concerning topic areas:
  - Aperture and absorber area
  - Concentrating PV-Thermal collectors
  - Incident angle modifier
  - Thermal Shock/Internal Cold Fill
  - Exposure testing

- In the U.S., multiple laboratories are currently testing products in accordance with Standard 600. SRCC and NREL continue to provide detailed guidance on specific operational testing issues as they are encountered. 4 concentrating collector models by 4 manufacturers are now certified.

- Work continues within SRCC to further refine Standard 600, with international cooperation from stakeholders.

- Within the WP2 of the EU project QAiST, task T2.1.1 is focused on the extension of the EN 12975 to fully include medium temperature collectors (tracking, concentrating collectors, and evacuated tube collectors). The main activities proposed, but not yet agreed are:
  - Parameter definitions and requirements
  - Deep review of existing performance models and testing procedures
  - Performance test method: Parameters and test conditions, validation included (if needed)
  - Performance collector component characterisation (receiver, reflector, tracking and over temperature protection systems)

Subtask B: Systems

At the September 3, 2011 informal Task 43 meeting in Kassel, Harald Drück presented an updated summary of progress to date on Systems work, as well as outstanding actions and responsible parties. As of end 2011, numerous parallel activities were underway to complete work.

WORK PLANNED FOR 2012

- **Characterization of Performance of Solar/Heat Pump Systems -** Includes collaboration with Intelligent Energy Europe (IEE) and Keymark, as well as activities under CEN/TC 312 Working Group 3.

- **Inclusion of Work and Results from Combisol Project** – Under the management of CEA (France) and INES (France), Combisol will encourage an accelerated market deployment of combined solar water and space heating (SCS) – hence a higher share of heat produced by solar energy - and will promote an improved quality of the systems installed.

- **Definition of Boundary Conditions of System Performance Modeling** – Work needed to improve computer simulation of system performance.

- **Incorporation of QAiST Round Robin Results** – Work to develop recommendations for standards harmonization based collector testing consistency.

- **Development of Research Recommendations for Systems Testing** – Work will contribute to the Task Roadmap.

- **Development of Paper Characterizing Research Results on Actual Performance vs. Predictions:**
    - Component/material substitution
    - Collector size extrapolation
    - Recommendations for incorporating results in system tests/standards

- **Report on Durability and Reliability** – Identification of inconsistencies, gaps and problems between actual qualification and safety testing and known issue areas not currently included in certification.

- **Work on Power Failure Issues** – Define and promulgate proposed test procedures to address previously identified system behavior modes regarding failure of power supply to systems.

- **Reports on Testing and Characterization of System Performance Related to Occupant Comfort and Public Benefits** – Work to characterize the value of accurate testing and performance characterization as regards end user satisfaction and societal benefits.

- **Outreach and Information Dissemination** – Several Parallel Activities designed to:
    - Populate and maintain a Task web page to promulgate results
    - Establish a proactive means of alerting Task stakeholders and interested parties about ongoing developments
    - Establish a regular forum for interested parties provide input or ask questions about Task-related topics.

MEETINGS IN 2011

4th Task Experts Meeting
May 17
May 18: Industry Workshop
Raleigh, North Carolina, United States
21 experts from 6 countries attended

The ½ day Industry Workshop was held in conjunction with the American Solar Energy Society Exhibition and Conference, also in Raleigh, where several Task experts updated attendees on rating and certification activities connected with Task 43. 49 participants attended the Industry Workshop.

5th (Informal) Task Experts Meeting
September 3
Kassel, Germany
16 experts attended

Held in conjunction with the ISES Solar World Congress.

REPORTS PUBLISHED IN 2011

No publically available reports were published in 2011.

WORK PLANNED FOR 2012

- **Concentrators**
  SRCC Standard 600 continues to evolve. Coordination with ongoing development of European concentrating collector testing methodologies should be pursued to avoid parallel development of duplicative standards.

- **Round Robin Collector Testing**
  European round robin testing of collectors and systems began under the QAiST program,13 laboratories currently participating. First and second rounds complete – data analysis progressing. Intra-laboratory test results will be examined to assess variance from mean results, and verify accuracy of measuring protocols. Results tentatively scheduled for early 2012.

  Parallel but independent North American round robin tests are underway under Florida Solar Energy Center management - 6 laboratories participating. First round not yet complete, second round completion expected late 2012.

- **US Heat Meter Standard**
  During 2011, the US Environmental Protection Agency led an effort to define the scope of work required to develop a US standard for heat meters.

  This collaborative effort led to a proposal asking the International Association of Plumbing & Mechanical Officials (IAPMO) and ASTM International to develop a consensus heat meter standard, drawing on aspects of International Organization of Legal Metrology (OIML R 75) International Recommendation and European Standard EN1434.

- **Global Certification**
  Under the auspices of The Spanish Association for Standardization and Certification (AENOR), a project will be undertaken to evaluate the possibility of a global certification scheme. This effort has been termed: Towards Global Certification of Solar Collectors. Work on this began in late 2011, and will continue in 2012.

- **Communications**
  Work to populate the Task website with up to date work products will continue.

MEETINGS PLANNED FOR 2012

6th Task Experts Meeting
July 10
San Francisco, California, USA

In conjunction with SHC 2012.

REPORTS PLANNED FOR 2012

Task 43 is scheduled to end on June 30, 2012, and a report on progress to date and recommendations for continuing Task activities, if any, is anticipated for mid-2012.

TASK 43 NATIONAL CONTACTS

Co-Operating Agent
Les Nelson
International Association of Plumbing & Mechanical Officials (IAPMO)
5001 East Philadelphia Street
Ontario, CA 91761
USA
les.nelson@iapmo.org
Phone: (909) 218-8112

Co-Operating Agent
Jan Erik Nielsen
PlanEnergi
Jyllandsgade 1
9520 Skørping
DENMARK
jen@solarkey.dk
Phone: +45 96820400

Program Manager
Kevin DeGroat
Antares Group
4351 Garden City Drive, Ste. 301
Landover, MD 20785
USA
kdegroat@antares.org
Phone: (301) 731-1900 Ext. 14

Subtask A Leader (Collectors)
Enric Mateu Serrats
CENER (National Renewable Energy Center)
Ciudad de la Innovación, nº 7
31621 Sarriguren (Navarra)
SPAIN
emateu@cener.com
Phone: +34 948 25 28 00

Subtask B Leader (Systems)
Harald Drück
University of Stuttgart (ITW)
Pfaffenwaldring 6
70550 Stuttgart
GERMANY
drueck@itw.uni-stuttgart.de
Phone: +49-(0)711-685-635 53

Task 43 Participants

Alfred Brunger	alfred.brunger@exova.com	Exova (formerly Bodycote)
Ana Neves	ana.neves@ineti.pt	INETI
Andreas Bohren	andreas.bohren@solarenergy.ch	University of Applied Sciences Rapperswil HSR
Andreas Haberle	andreas.haberle@pse.de	PSE AG
Barry Johnston	barry@solartwin.com	Solar Twin
Bengt Perers	bpr@du.se	Delarna University
Daniel Eggert	eggert@isfh.de	Institut für Solarenergieforschung Hameln (ISFH)
Doug McLenahan	dmcclena@nrcan.gc.ca	Natural Resources Canada
Enric Mateu Serrats	emateu@cener.com	CENER
Fabienne Sallaberry	fsallaberry@cener.com	CENER
Francisco Fernandes	ffernandes@energie.pt	Energie
Graham Morrison	g.morrison@unsw.edu.au	University of New South Wales
Harald Drueck	drueck@itw.uni-stuttgart.de	ITW University of Stuttgart
Franz Helminger	franz.helminger@ait.ac.at	Austrian Institute of Technology
Heinrich Huber	heinrich.huber@ait.ac.at	Austrian Institute of Technology
Jim Huggins	huggins@fsec.ucf.edu	Florida Solar Energy Center/SRCC
Joakim Bystrom	info@lumicum.se	Lumicum
Joakim Byström	joakim@absolicon.com	Absolicon
Jordi Cadafalch	jordi.cadafalch@rdmes.com	RDMES
Josef Buchinger	josef.buchinger@arsenal.ac.at	Arsenal Research
Karsten Lampe	lampe@isfh.de	ISFH
Ken Guthrie	Ken.Guthrie@sustainability.vic.gov.au	Sustainability Victoria, Standards Australia Committee
Korbinian Kramer	Korbinian.Kramer@ise.fraunhofer.de	Fraunhofer Institute, ISE
Jurken Kosok	juregen.kosok@de.bosch.com	Bosch
Lourdes Ramirez Santigosa	lramirez@cener.com	CENER
Manual Lopes Prates	lopes.prates@ineti.pt	INETI
Manuel Collares-Pereira	collares.pereira@ineti.pt	INETI
Maria Joao Carvalho	mjoao.carvalho@ineti.pt	INETI
Mark Thornbloom	ThoM@vitoteam.com	Kelelo Engineering
Markus Kratz	m.kratz@FZ-Juelich.de	Forschungszentrum Jülich - PTJ
Markus Peter	markus.peter@dp-quadrat.de	University of Oslo
Nele Rumler	rumler@isfh.de	Institut für Solarenergieforschung Hameln (ISFH)
Paolo Trisoglio	paolo.trisoglio@modulouno.it	Modulo Uno
Peter Kovacs	peter.kovacs@sp.se	SP Technical Research Institute of Sweden

Pierluigi Premoli	Pierluigi.Premoli@icim.it	Institute of Industrial Certification for Mechanics ICIM
Pilar Navarro Rivero	privero@itccanarias.org	Canary Islands Institute of Technology
Richard Pelan	richard.pelan@kingspan - renewables.com	Kingspan Renewables
Robert Hassett	robert.hassett@ee.doe.gov	U.S. Department of Energy
Rodolphe Morlot	rodolphe.morlot@ademe.fr	Agence de l'Environnement et de la Maîtrise de l'Energie
Roland Sterrer	Roland.Sterrer@arsenal.ac.at	Austrian Institute of Technology
Sandy Klein	klein@engr.wisc.edu	Wisconsin State University
Sarah Miller	sarah.miller@csiro.au	Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia)
Stefan Albrecht	s.abrecht@slar-experience.de	Solar Experience
Stephan Fischer	fischer@itw.uni-stuttgart.de	ITW University of Stuttgart

Task 44

Solar and Heat Pump Systems

Jean-Christophe Hadorn
BASE Consultants SA
Operating Agent for the Swiss Federal Office of Energy

TASK DESCRIPTION

SOLAR + HEAT PUMP

The objective of this Task is to assess performances and relevance of combined systems using solar thermal and heat pumps, to provide a common definition of performances of such systems, and to contribute to successful market penetration of these new promising combinations of renewable technologies.

The scope of the Task considers solar thermal systems in combination with heat pumps, applied for the supply of domestic hot water and heating in family houses. It is thus dedicated to small systems in the range of 5 to 20 kW.

Any type of solar collector can be considered: using a liquid heat transfer fluid, air, hybrid collectors, or even hybrid thermal and photovoltaic or “PVT” collectors. All of them can be glazed or unglazed.

Any type of source of heat for the heat pump can be considered: air, water or ground source. The main focus will be on heat pumps driven by electricity, as the market is so oriented. However during the course of the Task it might be become relevant to consider thermally driven heat pumps since 100% solar could then be achieved.

To limit the scope, comfort cooling of buildings is not directly addressed in the Task common work, although it is not forbidden for a heat pump to be used for cooling purposes besides its main heating objective, for example in reverse mode.

The Task covers market available solutions as well as advanced solutions, which may be still in a laboratory stage or still will be developed during the course of the Task.

The Task is a joint effort of the Solar Heating and Cooling Programme and the Heat Pump Programme (HPP). It is Task 44 for SHC and Annex 38 for HPP.

The Task is organized in the following Subtasks:

Subtask A: Solutions and Generic Systems
(Lead Country: Germany, Fraunhofer ISE, Sebastian Herkel)

The objective of Subtask A is to collect, create and disseminate information about the current and future solutions for combining solar thermal and heat pump to meet heat requirements of a one family house. Subtask A deals mainly with manufactured systems and systems installed and monitored.

Subtask B: Performance Assessment
(Lead Country: Austria, AIT, Ivan Malenkovic)

The objective of this subtask is to reach a common definition of the figures of merits of solar + heat pump systems and how to assess them.This work can lead to prenormative definition on how to test and report the performance of a combined solar and heat pump system.

Subtask C: Modelling and Simulation
(Lead Country: Switzerland, SPF, Michel Haller)

The objective of subtask C is to provide modelling tools of all generic solar and heat pump systems and to report sensitivity analysis on most of the systems such as being able to pinpoint important features and marginal ones in a given system configuration. Sizing of systems will also be possible using the output of this Subtask, either with the computing tools developed or with general or system specific tables.

Subtask D: Dissemination and Market Support

(Lead Country: Italy, EURAC, Wolfram Sparber).

The objective of this subtask is to provide information to the external world of Task 44 during the course of the Task so that value added created by the participants can be transferred as fast as possible to a growing market. A second objective is to deliver the final book of Task 44 aimed as a reference document in the field of solar heat and heat pumps.

Main Deliverables

- Technical reports on existing and monitored systems
- Map of generic systems with pros and cons
- New set of performance indicators
- Procedure to test combined solar and heat pump systems
- Technical reports on systems tested in laboratory with this procedure
- New reference framework for simulating solar and heat pumps systems
- New components models or compiled existing ones
- Website with all major reports and papers
- Educational material on the website
- Support to national workshops about the topic "solar and heat pump"
- Papers at international conferences
- Newsletters during Task's duration
- Final handbook with all methods developed and results found

Duration

The Task started on 1 January 2010 and will end on 31 December 2013.

ACTIVITIES DURING 2011

- The Subtasks have been working smoothly.
- The 3rd and 4th Experts meetings were held in Barcelona in April, a joint meeting with IEA SHC Task 45, and in Marseille in October just before ESTEC 2011, and as a joint meeting with IEA SHC 48.
- Task participants presented their work at the Solar World Congress 2011 in Kassel, Germany.

RESULTS IN 2011

Subtask A: Solutions and Generic Systems

A1 Review of existing and new systems
More than 100 systems were identified during 2011. In an available powerpoint presentation, 80 different S+HP (Solar + Heat pump) system are depicted. A two pages leaflet describing in detail each solution is available for more than 20 systems. A draft Report of deliverable A1 has been issued.

The classification into generic systems is somewhat difficult and the seven basic configurations sketched in 2010 end up to be many more.

Subtask A therefore decided to classify all systems in four new categories: the parallel concept, the serial, regenerative and the complex concept. The so-called "square view" scheme developed in 2010 became the reference tool of the work in Subtask A.

In Subtask A, it is proposed for comparing all the demonstration projects to use the Seasonal Performance Factor (SPF) definitions developed in Subtask B primarily for testing systems on test rigs in laboratory. This will help to rapidly benchmark both the concept and the monitored results. The nomenclature of the relationships between sources and sinks in a S+HP system could also be derived from the "square view" which will prove to be a versatile tool.

Overall, Subtask A succeeded in 2011 to describe in a similar way different S+HP concepts from different manufacturers and designed for different local conditions.

A2 Reporting field test results
During 2011 thirty projects were reported on by participants. Some have already been monitored and the results presented during Task meetings. These projects will also produce interesting material for simulation and models validation in Subtask C. By the end of 2011, seventeen projects were running and had monitored data are available, six more projects are scheduled to deliver data in 2012.

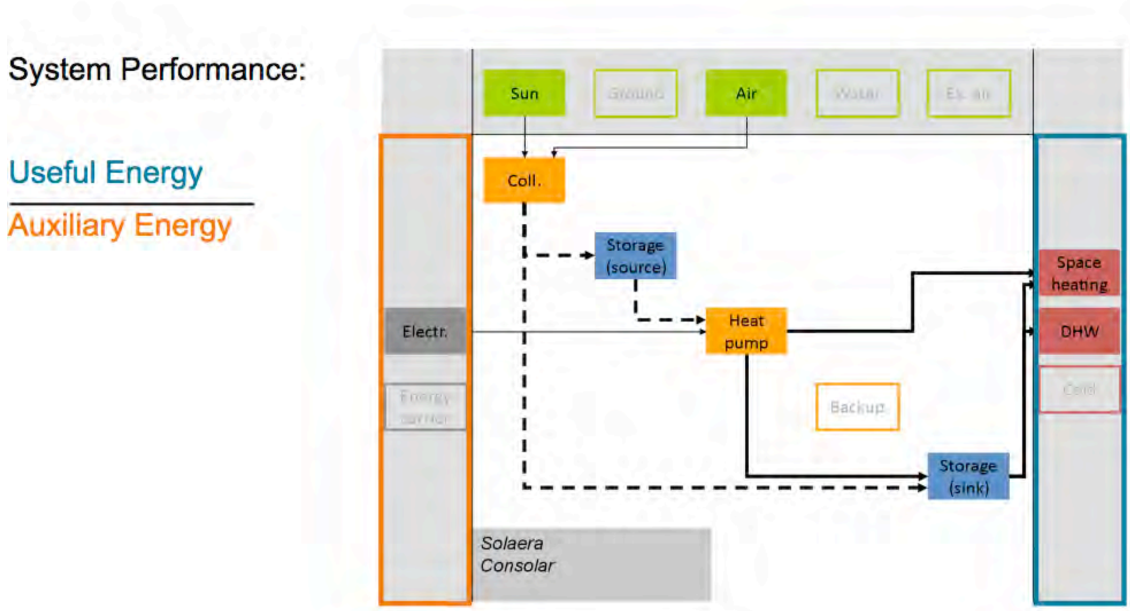


Figure 1. New "square layout" to describe a solar and heat pump combination.

A template for reporting field results was produced that will be used to present all the results from monitored installations in the field.

A3 Dissemination and information
Many projects involved in our work were presented at the Solar World Congress 2011 in Kassel, Germany. At Estec 2011 in Marseille there were also several projects and topics coming from our work. The Operating Agent encouraged participants to refer to the Task common work when presenting their projects at conferences.

"Solar and heat pump systems" is appearing slowly to be a generic term just as we anticipated when we began the Task.

The templates prepared for activity A1 and A2 in Subtask A will be an important vehicle for dissemination next year since all systems.

Subtask A also issued in 2011 a PowerPoint presentation of all systems presented in the Task called "Overview of commercial S+HP systems". This document is used as for teaching material in Subtask D. It contains 245 slides with 2 or 3 slides per system.

A4 Subtask
Work on the report for this activity has not yet started.

Subtask B: Performance Assessment

B1 Definition of performance indicators
The Subtask leader worked out a proposal for performance indicators during 2011. Version 2 of the document contains a proposal for the system boundaries and performance figures. Deliverable B1 is now available as a draft. It proved to be much

more time consuming than anticipated to come to a consensus among participants on performance indicators. Several topics were discussed such as system and component efficiency, primary energy, CO_2 emissions or savings, among others.

One important question when dealing with hybrid systems such as S+HP systems is how to calculate the benefit of the combination "solar and heat pump". Is a benefit to be calculated against other alternative solutions like solar and wood or solar and gas, or against "solar only" or "HP only" solutions? Working on examples from Subtask A will bring more light on this matter.

B2 Testing on stands - procedure and results

A number of participating institutes are testing S+HP total systems or at least system components on stands. A common procedure of testing is still being discussed. Currently, we are lacking results from first tests on systems in laboratories and 2012 will bring awaited results.

B3 Standard test definition - pre normative

A short overview of relevant Solar Thermal and Heat Pump standards were reported on in the new B1 deliverable. Applicability to S+HP systems and recommendations for revision however is still to be worked out. But prior to deriving a generic vision, the various methods developed by all the participants will be described in technical reports. The question "can this Task propose one test method to cover all system configurations and applications?" still holds. The EU project "Qaist" also lead by our Subtask B leader advances in parallel with our work and has a similar the goal to reach standardized definitions and procedures for testing S+HP systems. We therefore join forces in international collaboration.

B4 Dissemination and information

This activity is quiet for the moment, but papers from the Subtask leader were presented at the Solar World Congress 2011 in Kassel and Estec 2011 in Marseille.

B5 Subtask

Work on the report for this activity has not yet started.

Subtask C: Modelling and Simulation

C1 reference framework

The framework has been issued thanks to the strong commitment of the Subtask leader. Deliverable C1.2 (Reference Framework: Draft 2) is completed and only minor changes are to be expected until the final report in March 2012. This document can be used for system simulations.

Changes in boundary conditions for simulations have been reported in version 1.2 of the document. Our common boundary conditions will be implemented on different simulation platforms since not all participants want to use TRNSYS, and the implementations will be shared with other participants. This is a common effort not possible without our international collaboration.

C2 Models of sub component and validation

Four working groups on solar collector, ground heat exchanger, heat pump, and heat storage, each led by an expert in the field were set up during 2011. It is not always easy to find participants as no special funding is available for this activity.

A New Heat Pump Model (Type 877) for TRNSYS was presented by Austria in 2011. Its validation is being carried out by Switzerland.

For the deliverable C2 "Models of sub components and validation" a description of models and model features is quite advanced for collector models and for heat pump models, and only started for ground heat exchanger models and PCM storage models due to lack of committed experts. The report is due October 2012.

C3 System simulations and validation

Several systems are under investigations by different teams, but no completed results in 2011. Some preliminary results though show good correlations with monitored data for some important S+HP configurations.

Deliverable C3 "System simulation and validation" was started with the reporting on validation of uncovered collector model (Germany, Switzerland) and a ground heat exchanger (Germany).

C4 System intercomparison data
This activity has not yet started.

C5 Dissemination and information
This activity has not yet started although some participants have presented their work during conferences.

C6 Subtask
Work on the report for this activity has not yet started.

Subtask D: Dissemination and market support

D1 Webpage and educational material
The Task website is continuously adapted and enriched. Some educational material from Subtask A is available in the web restricted area for participants.

A list of publications dealing with our topic from participants in conferences and journals is available on the public section of the website.

D2 Newsletter and guideline for planners
The first newsletter was issued in October 2011 and is available on our web site.

D3 Workshops and Conferences
Several papers were presented at international conferences.

The Operating Agent OA presented the Task at a press conference during ESTEC 2011.

D4 System intercomparison report
The technical report will start when material is available from the other subtasks.

Work on a Policy Position paper on "S+HP" systems began in 2011 and will be available in 2012.

D5 T44A38 handbook
The table of contents for the final handbook has been revised to reflect the work by topic and authors are being assigned to each chapter. This way of acting in advance on the final document is to avoid to passing the deadline of the activity, December 2013.

D6 Subtask report
Work on the report for this activity has not yet started.

WORK PLANNED FOR 2012

Key activities planned for 2011 include:

- Activities as planned in each subtask
- Meetings in Povoa do Varzim, Portugal and Lyngby, Denmark
- Articles for conferences and publications
- Annual Task newsletter
- Distribution of a Policy Position Paper

LINKS WITH INDUSTRY

Several solar manufactures collaborate with university labs in our Task. We also work in contact with the European Heat Pump Association (EHPA).

REPORTS PUBLISHED IN 2011

Subtask A
A1: Review of existing and new systems – draft Nov 2011
A2: Field test results template for reporting – draft Nov. 2011

Subtask B
B1: Definition of performance indicators – draft Nov. 2011

Subtask C
C1: T44A38 reference framework for simulation – May 2011

C2: Models of Sub components and validation - Draft

Subtask D
D1.1: Teaching material 1: Collection of S+HP examples in slides – Nov. 2011
D2: Task newsletter 1 – Oct. 2011
D7: S+HP Policy paper – final draft 2011

REPORTS PLANNED FOR 2012

Subtask A
A2: Reporting field test results - draft

Subtask B
B1: Definition of performance indicators
B2: Testing on stands – procedures and results, draft
B3. Standard test definition - draft

Subtask C
C1: T44A38 reference framework for simulation, publication in 2012
C2: Models of Sub components and validation
C3: System simulations and validation – Draft
C4: System intercomparison - Draft

Subtask D
D1.2:Teaching material on monitored systems - draft
D2: T44A38 newsletter 2 – 2012
D7: Policy paper

MEETINGS IN 2011

3rd Experts Meeting
April 7-8
Barcelona, spain

4th Experts Meeting
October 18-19
Marseille, France
(In conjunction with ESTEC 2011)

MEETINGS PLANNED FOR 2012

5th Experts Meeting
May 3-4
Povoa do Varzim, Portugal

6th Experts Meeting
October
Lyngby,Denmark

TASK 44 NATIONAL CONTACTS

Operating Agent
Jean-Christophe Hadorn
BASE Consultants SA
8 rue du Nant
CH-1207 Geneva, Switzerland
Tel: + 41 22 840 20 80
jchadorn@baseconsultants.com

Subtask A Leader
Sebastian Herkel
Dept. Thermal Systems and Buildings
Fraunhofer Institute for Solar Energy Systems
Heidenhofstrasse 2,
79110 Freiburg, Germany
Tel: +49 761 4588 5117
sebastian.herkel@ise.fraunhofer.de
www.ise.fraunhofer.de

Subtask B Leader
Ivan Malenkovic
Energy Department
Sustainable Thermal Energy Systems
AIT Austrian Institute of Technology
Österreichisches Forschungs und Prüfzentrum Arsenal Ges.m.b.H.
Giefinggasse 2
1210 Vienna, Austria
Tel: +43(0) 50550-6350
ivan.malenkovic@ait.ac.at
www.ait.ac.at

Subtask C Leader
Michel Haller
Institut für Solartechnik SPF
Hochschule für Technik Rapperswil HSR
Oberseestr. 10
CH-8640 Rapperswil, Switzerland
Tel: +41 55 222 48 36
michel.haller@solarenergy.ch
www.solarenergy.ch

Subtask D Leader
Wolfram Sparber
Institute for Renewable Energy
EURAC research
Viale Druso 1
I-39100 Bolzano, Italy
Tel: +39 0471 055 601
wolfram.sparber@eurac.edu
www.eurac.edu

Austria
Alexander Thür
AEE - Institut für Nachhaltige Technologien
a.thuer@aee.at

Martin Vukits
AEE intec
m.vukits@aee.at

Ivan Malenkovic
AIT Vienna
ivan.malenkovic@ait.ac.at

Hilbert Focke
ASIC - Austria Solar Innovation Center
focke.hilbert@asic.at

Martin Hallegger
General Solar Systems GmbH
martin.halleger@generalsolar.com

Christian Struger
General Solar Systems GmbH
christian.struger@generalsolar.com

Andreas Heinz
Institut für Wärmetechnik TU Graz
andreas.heinz@tugraz.at

Werner Lerch
Institut für Wärmetechnik TU Graz
werner.lerch@tugraz.at

Fabian Ochs
UNI Innsbruck
fabian.ochs@uibk.ac.at

Belgium
Filip Van der Schoor
Lessius Mechelen campus De Nayer
Filip.VandenSchoor@mech.kuleuven.be

David Wintershoven
Lessius Mechelen campus De Nayer
david.wintershoven@lessius.eu

Canada
Jeremy Sager
Natural Resources Canada
jsager@nrcan.gc.ca

Roberto Sunyé
Natural Resources Canada
rsunye@nrcan.gc.ca

Denmark
Ole Balslev-Olesen
Cenergia Energy Consultants
obo@cenergia.dk

Ivan Katic
Danish Technological Institute
ik@teknologisk.dk

Elsa Andersen
DTU
ean@byg.dtu.dk

Klaus Ellehauge
Ellehauge & Kildemoes
klaus.ellehauge@elle-kilde.dk

Flemming Hedegaard
Grundfos Holding A/A
Poul Due Jensens Vej 7
DK-8850 Bjerringbro
fhedegaard@grundfos.com

European Association
Thomas Nowak
EHPA
thomas.nowak@ehpa.org

Finland
Mr. Sunliang Cao
Aalto University
sunliang.cao@tkk.fi

Kai Sirén
Aalto University School of Science and Technology Department of Energy Tech.
kai.siren@tkk.fi

France
Cedric Paulus
CEA INES
cedric.paulus@cea.fr

Radulescu Mihai
EDF R&D
mihai.radulescu@edf.fr

Germany
Ulrich Leibfried
Consolar
ulrich.leibfried@consolar.de
Sebastian Herkel
Fraunhofer Institut
sebastian.herkel@ise.fraunhofer.de

Korbinian Kramer
Fraunhofer Institut
korbinian.kramer@ise.fraunhofer.de

Jörn Ruschenburg
Fraunhofer Institut
joern.ruschenburg@ise.fraunhofer.de

Christian Stadler
General Solar Systems Deutschland GmbH
christian.stadler@generalsolar.com

Antoine Dalibard
HFT Hochschule für Technik Stuttgart
Antoine.Dalibard@hft-stuttgart.de

Ruben Pesch
HfT-Stuttgart
ruben.pesch@hft-stuttgart.de

Christoph Trinkl
Hochschule Ingolstadt Institut für Angewandte Forschung
christoph.trinkl@fh-ingolstadt.de

Peter Pärisch
Institut für Solarenergieforschung GmbH
paerisch@isfh.de

Erik Bertram
Institut für Solarenergieforschung Hameln/Emmerthal GmbH
bertram@isfh.de

Christian Schmidt
ISE
christian.schmidt@ise.fraunhofer.de

Harald Drueck
ITW University of Stuttgart
drueck@itw.uni-stuttgart.de

Frank Thole
Schueco

fthole@schueco.com

Sebastian Bonk
Universität Stuttgart Institut für Thermodynamik und Wärmetechnik (ITW)
bonk@itw.uni-stuttgart.de

Anja Loose
Universität Stuttgart Institut für Thermodynamik und Wärmetechnik (ITW)
loose@itw.uni-stuttgart.de

Wolfgang Kramer
Wagner & Co. Solartechnik GmbH
wolfgang.kramer@wagner-solar.com

Italy

Pietro Finocchiaro
Dipartimento dell'Energia - UNIPA
finocchiaro@dream.unipa.it

Bettina Nocke
Dipartimento dell'Energia - UNIPA
bettinao@dream.unipa.it

Roberto Fedrizzi
EURAC
roberto.fedrizzi@eurac.edu

Gerhard Frei
EURAC
gerhard.frei@eurac.edu

Wolfram Sparber
EURAC
wolfram.sparber@eurac.edu

Matteo D'Antoni
EURAC Research
matteo.dantoni@eurac.edu

Osama Ayadi
Politechnico di Milano
osama.ayadi@polimi.it

Alberto Mauro
Politechnico di Milano
alberto.mauro@polimi.it

Lorenzo Pistocchini
Politechnico di Milano
lorenzo.pistocchini@polimi.it

Portugal

Jorge Facao
LNEG Lisbon
jorge.facao@ineti.pt

Spain

Òscar Càmara Moreno
Aiguasol
oscar.camara@aiguasol.coop
Daniel González i Castellví
Aiguasol
dani.gonzalez@aiguasol.coop

Jorge Payá Herrero
Institute for Energy Engineering
Universidad Politécnica de Valencia
jorpaher@iie.upv.es

Dani Carbonell Sanchez
RDMES
dani@rdmes.com

Sweden

Elisabeth Kjellsson
Building Physics
Lund University
elisabeth.kjellsson@byggtek.lth.se

Bengt Perers
DTU DK & SERC Sweden
beper@byg.dtu.dk

Hatef Madani
KTH
hatef.madani@energy.kth.se

Ulrik Pettersson
SP Sveriges Tekniska Forskningsinstitut
SP Technical Research
ulrik.pettersson@sp.se

Chris Bales
SREC, Borlange
cba@du.se

Switzerland

Bernard Thissen
Energie Solaire SA
bernard@energie-solaire.com

Marc Baetschmann
ETH Zürich
marc.baetschmann@3s-pv.ch

Christian Hutter
H+S Solar
ch.hutter@hssolar.ch

Sara Eicher
HEIG-VD
sara.eicher@heig-vd.ch

Catherine Hildbrand
heig-vd
catherine.hildbrand@heig-vd.ch

Jacques Bony
HEIG-VD
jacques.bony@heig-vd.ch

Mircea Bunea
HEIG-VD
Mircea.Bunea@heig-vd.ch

Peter Kurmann
Hochschule für Technik und Architektur
Peter.Kurmann@hefr.ch

Thomas Afjei
Institut Energie am Bau - FHNW
thomas.afjei@fhnw.ch

Ralf Dott
Institut Energie am Bau - FHNW
ralf.dott@fhnw.ch

Daniel Philippen
SPF
daniel.philippen@solarenergy.ch

Elimar Frank
SPF Institut für Solartechnik
elimar.frank@spf.ch

Michel Haller
SPF Institut für Solartechnik
michel.haller@spf.ch

Pierre Hollmuller
Université de Genève - ISE
pierre.hollmuller@unige.ch

Floriane Mermoud
Université de Genève - ISE
floriane.mermoud@unige.ch

Jörg Marti
Vela Solaris
joerg.marti@velasolaris.com

Andreas Witzig
Vela Solaris
andreas.witzig@velasolaris.com

United States

Tim Merrigan
NREL
Tim.Merrigan@nrel.gov

Tim Moss
SANDIA
tamoss@sandia.gov

Les Nelson
Western Renewables
lnelson@westernrenewables.com

Task 45

Large Solar Heating/Cooling Systems, Seasonal Storage, Heat Pumps

Jan Erik Nielsen
PlanEnergi
Operating Agent for the Danish Energy Agency

TASK DESCRIPTION

The main objective of this Task is to assist in a strong and sustainable market development of large solar district heating and cooling systems. The systems can include seasonal storages and/or heat pumps/ chillers.

The main focus is on the system level: How to match the actual system configuration to the actual needs and local conditions including the surrounding regional energy system (free electricity market). Or in other words: For the given conditions of load and energy prices, which system type and size to choose to have a competitive heat price and a large solar fraction.

It is important that the systems are installed and controlled/operated properly in order to perform well. To secure that, guidelines and standards have to be updated and developed and recognised performance guarantee procedures established.

To push the market development, a strong effort will be done in promoting the benefits of the technologies and results from the Task to the decisions makers in the sectors of district heating and cooling and process heating and cooling. The issue of financing the "upfront investment in 25 years of heat production" will be dealt with - and models for services of Energy Service Companies (ESCo's) will be proposed and sought tried out.

Scope

The scope of the Task covers large-scale solar thermal systems – pre-heat systems as well as any combination with storages, heat pumps, CHP-units, boilers, etc. for the supply of block and district heating & cooling.

Task 45 is organized into three Subtasks:

Subtask A: Collectors and Collector Loop
(Lead country: Denmark)

The general objectives of Subtask A are to:

- Assure use of suitable components
- Assure proper and safe installation including compatibility with district heating and cooling network
- Assure the performance of the collector field

Subtask B: Storage
(Lead Country: Germany)

The general objectives of Subtask B are to:

- Improve the economy of (seasonal) storage technologies
- Increase knowledge on durability, reliability and performance of (seasonal) storage technologies
- Demonstrate cost effective, reliable and efficient seasonal storage of thermal energy

Subtask C: Systems
(Lead Country: Austria)

The general objectives of subtask C are to:

- Provide decision makers and planners with a good basis for choosing the right system configuration and size
- Give decision makers and planners confidence in system performance

Task Duration

This Task started on January 1, 2011 and will end December 31, 2013.

Participating Countries

Austria, Canada, Denmark, France, Germany, Italy, Spain

WORK DURING 2011

Subtask A: Collectors and collector fields

Activities included:

- Preliminary test results produced

related "Models for correction of collector efficiency parameters depending on collector type, flow rate, tilt and fluid type".

- Work started on "Guidelines for requirements for collector loop installation". Proposal for content made and work on hydraulic aspects, stagnation behaviour, and safety initiated.
- Drafted collector field performance guarantee procedure.

Subtask B: Storages

First round of survey done concerning ongoing/required R&D for seasonal storages.

Subtask C: Systems

Activities included:

- System categories defined. Template for detailed technical information.
- Updated database for large solar system in the air - systems outside Europe missing.
- Questionnaire on tools for feasibility study.
- Draft ESCo compendium.
- Draft procedure for performance checking of collector field and heat exchanger.
- Draft guidelines for planning, installation, commissioning and operation.
- Significant input to design handbook.

Dissemination/presentations included:

- Two presentations at EU Renewable Heating and Cooling Technology Platform workshops (RHC) in February and April.
- Presentation at the Polish national workshop in Warsaw in May.
- Presentation at ISES 2011, Kassel, Germany in May.
- Presentation at IEA SHC/ESTIF meeting in October.
- Presentation at Joint Workshop IEA ECES/SHC, Munich, Germany in November.
- Presentation at the "Solar Summit 2011" in Freiburg, Germany in November.

Workshops included:

- Common industry workshop with Task 44 on solar & heat pumps (the first Task 45 meeting held in conjunction to a Task 44 meeting - and in between the two Task meetings a common workshop was organized).
- Industry workshop held after the second Task 45 meeting.

WORK PLANNED FOR 2012

Subtask A: Collectors and Collector Loop

Activities planned include:

- Finish testing related to "Models for correction of collector efficiency parameters depending on collector type, flow rate, tilt and fluid type".
- Conduct preparatory work on requirements and test methods for collector loop pipes: list of standards, collect experience on operating conditions.
- Prepare final draft on "Guidelines for requirements for collector loop installation".
- Draft document on control and operation strategies.
- Finalize collector field performance guarantee procedure.
- Finalize heat exchanger performance guarantee procedure.
- Work on Handbook based on subjects above.

Subtask B: Storages

Activities planned include:

- Draft document on research requirements for seasonal storages.

Subtask C: Systems

Activities planned include:

- Report on sensitivity analysis- elaboration of optimized and standardized system concepts (solar fraction, storage size, economics etc.).

- Finalize ESCo compendium.
- Finalize procedure for performance checking of collector field and heat exchanger.
- Prepare first draft on “Procedures for performance check/ monitoring/ surveillance”.
- Prepare final draft of guidelines for planning, installation, commissioning and operation.
- Work on Handbook from subjects above.

REPORTS PUBLISHED IN 2011

No publically available reports were published in 2011.

REPORTS PLANNED FOR 2012

The following reports/documents will be available on the SHC website:

- Report on collector tests
- ESCo compendium
- Performance checking of collector field and heat exchanger

MEETINGS IN 2011

1st Experts Meeting
April
Barcelona, Spain

2nd Experts Meeting
October
Alberta, Canada

MEETINGS PLANNED FOR 2012

3rd Experts Meeting
May 21-23
Denmark
Joint meeting planned with IEA DHC Programme

4th Experts Meeting
September
Austria
Joint meeting planned with SHC Tasks 48 and 49.

TASK 45 NATIONAL CONTACTS

Operating Agent
Jan Erik Nielsen
PlanEnergi
Aggerupvej 1
4330 Hvalsö
DENMARK
jen@planenergi.dk
Phone: +45 4646 1229

Subtask A Leader
Simon Furbo
DTU.BYG
Denmark

Subtask B Leader
Dirk Mangold
SOLITES
Germany

Denmark
Per Alex Sørensen
PlanEnergi

Leo Holm
Marstal Fjv.

Per Kristensen
Braedstrup Fjv.

Italy
Maurizio De Lucia
Università di Firenze

Germany
Harald Drück
ITW, Stuttgart University

Rolf Meissner
Ritter XL Solar GmbH
Observer

Thorsten Urbanek
TU Chemnitz
Observer

Task 47

Renovation of Non-Residential Buildings towards Sustainable Standards

Fritjof Salvesen
Asplan Viak AS
Operating Agent for the Norwegian Ministry of Petroleum and Energy

TASK DESCRIPTION

Buildings are responsible for up to 35 % of the total energy consumption in many of the IEA participating countries. The EU Parliament approved in April 2009 a recommendation that member states have to set intermediate goals for existing buildings as a fixed minimum percentage of buildings to be net zero energy by 2015 and 2020.

For the existing non-residential buildings a dramatic reduction in primary energy consumption is crucial to achieve this goal.

A few exemplary renovation projects have demonstrated that total primary energy consumption can be drastically reduced together with improvements of the indoor climate. The experience gained from these projects has not been systematically analyzed to make it a reliable resource for planners. Because most property owners are not even aware that such savings are possible, they set energy targets too conservative. Buildings renovated to mediocre performance can be a lost opportunity for decades. It is therefore important that building owners be aware of such successes and set ambitious targets.

This Task will start by analyzing highly successful renovations and develop innovative concepts for the most important market segments.

Equally important, local authorities, companies, and planners also need the knowledge how to achieve market penetration of such solutions. Success stories and planning knowledge will be communicated to target audiences to accelerate a market break-through of highly effective renovations in non- residential buildings.

The objectives of this Task are to:

- Develop a solid knowledge base on how to renovate non-residential buildings towards the NZEB standards in a sustainable and cost efficient way.
- Identify the most important market and policy issues as well as marketing strategies for such renovations.

The Task deals with several types of non-residential buildings, including protected and historic buildings:

- Office buildings
- Educational buildings
- Nursing homes
- Hotels
- Supermarkets and shopping centers

Depending on available projects among the participating countries, the following types may also be recognized; hospitals, industrial halls, and indoor swimming pools.

A broad range of technologies will be included and solar energy will play a significant role in bringing the use of primary energy down to NZEB standard.

The Task is organized in the following Subtasks:

Subtask A: Advanced Exemplary Projects - Information Collection & Brief Analysis
(Lead Country: Norway, Asplan Viak AS, Fritjof Salvesen)

The objectives are to:

- Systematically analyze and document renovation projects meeting Task selection criteria in order to quantify which measures achieve the greatest energy savings or improvement in comfort and at what costs.
- Identify the driving forces and barriers in the decision-making processes for detailed analysis in Subtask B.
- Identify innovative, promising concepts and technologies for detailed analysis in Subtask C.
- Identify environmental impacts and architectural quality for detailed analysis in Subtask D.

Subtask B: Market and Policy issues and Marketing Strategies
(Lead Country: Norway, Segel AS, Trond Haavik)

The objectives are to:

- Identify segments in the non- residential building stock with high potential for energy efficiency savings and which type of owners are most likely to go for major renovation projects.
- Identify the most important barriers and driving forces in decision-making processes for high ambition renovation in the non-residential sector and how to overcome them.
- Develop knowledge about which boundary conditions are important to make renovations attractive/ affordable/cost effective and more available.
- Increase the understanding of how improved non-energy benefits (including outcome subtask D) as a result of substantial renovation, increase the value of the building and thereby make the investments profitable.

Subtask C: Assessment of Technical Solutions and Operational Management
(Lead Country: Germany, Fraunhofer ISE, Doreen Kaltz)

The objectives are to:

- Describe the HVAC and control systems of the recommended retrofit concept. This includes information about the building shell, the HVAC system, the daylighting and artificial lighting concepts as well as available measurement or energy consumption data. The documentation of the data is an important contribution to Subtask A.
- Identify required measuring points for a basic monitoring of building and HVAC system.
- Develop a methodology for evaluating the different building and plant concepts.
- Identify and develop successful NZEB concepts considering the building envelope as well as the heating, cooling, ventilation and lighting concept.
- Evaluate the building and plant performance on basis of energy monitoring or monthly energy bills (if measurements are made available by participants).
- Analyze the fault detection and identify optimization potential due to smart building and plant control.

Subtask D: Environmental and Health Impact Assessment *(Lead Country: Belgium, University of Louvain La Neuve, Sophie Trachte).*

The objectives are to:

- Develop a global (including local and global environment) approach for building renovation based on environmental, urban infrastructure, comfort and health impacts.
- Identify quantifiable and qualitative criteria and requirements for environmental impacts of renovation projects based on BREEAM assessment methodology.
- Identify indoor climate and indoor space issues with particular relevance to the topic of the user's health and user's comfort (visual, acoustical etc).
- Identify "quality of life" issues with particular relevance to the topic of the urban infrastructure, of the urban transportation network and of the collective or public spaces.
- Identify the adaptability of building and flexibility issues with particular relevance to the acceptance of renovations without causing heavy impact on the environment.

Main Deliverables
In general, the dissemination of the task results will take place at a national level. The publications listed below will be available from the Task's public website in PDF format. The publications may be used as a

basis for making national publications.
The following documents and information meetings are planned during the Task:

1. The Task website went public in mid-2011, including secure sites for the Task participants.
2. Brochures of exemplary renovation projects will be available on the public website by spring 2012. They are designed for designers, planners and building owners
3. Two seminars will be held in conjunction with expert meetings presenting exemplary projects from the participating countries
4. A "Lessons learned summary" will be prepared from the exemplary projects of Subtask A.
5. A report will be published describing decision making processes, non-energy benefits as well as barriers and driving forces from the case studies of Subtask B.
6. A report will be published summarizing renovation policies and strategies.
7. Presentations will be given at national and international conferences the building industry and/or the real estate sector as target group.
8. A report will be published with recommendations and conclusions from Subtask C.
9. "Guidelines for designers and planners" with recommendations will be published.

Duration
The Task started on 1 January 2011 and will end on 30 June 2014.

Participating Countries
Australia, Austria, Belgium, Denmark, Germany, Italy, Norway

WORK DURING 2011

The Task got underway with two Experts Meetings – Oslo in April and Copenhagen in September.

The Task website was developed within the SHC framework. There is a public section and a password protected work area for task participants.

Subtask A: Exemplary Renovation Projects

The participants agreed on the following selection criteria for task 47 exemplary projects:

- ***Building types:*** Office, Educational, Culture, Hotels, Historic/ protected buildings are included.
- ***Energy:*** Goal: Towards a NZEB building. Optimized building envelope and technical installation using the best available technologies/products on the market. Within the given constraints of the individual building (e.g. for protected / historic buildings). At least 60% reduction in the primary energy demand (heating, cooling, ventilation, lighting, DHW and pumps) (according to the calculation rules given by the EPBD standard or other similar standards). The renovated standard should be better than the national standard building code for new buildings. Embodied energy strategies to be considered.
- ***Economics:*** Marketable solutions.
- ***Market potential:*** Replicable building concepts.

For the public presentation of task 47 exemplary projects, an eight pages template has been developed. It is expected that approximately 10 projects will be uploaded on the public web before summer.

Subtask B: Market and Policy issues
The subtask is still in its early phase which focusing on the simplified building stock analysis using existing data sets from participating countries.

Subtask C: Technical Solutions And

Operational Management
The subtask is still in its early phase, however it was decided to develop a common database for the subtask b, C and D for the demonstration projects and their energy and non-energy aspects.

Subtask D: Environmental And Health
The subtask is still in the early phase. It was decided that this work would focus on educational buildings.

WORK PLANNED FOR 2012
Presentations of a number of exemplary renovation projects will be uploaded on the public web.

A seminar in connection with the autumn expert meeting will be considered.

The task will be represented at the SHC 2012 Conference in San Francisco in July.

LINKS WITH INDUSTRY
Some of the task participants are representing consultancies.

In some countries like Norway, a national Task 47 project is organized with several industry partners.

REPORTS PUBLISHED IN 2011
No reports have been published in 2011.

REPORTS PLANNED FOR 2012
Subtask A: Presentations of Exemplary Renovation Projects

MEETINGS IN 2011

1st Experts Meeting
April 29-30
Oslo, Norway

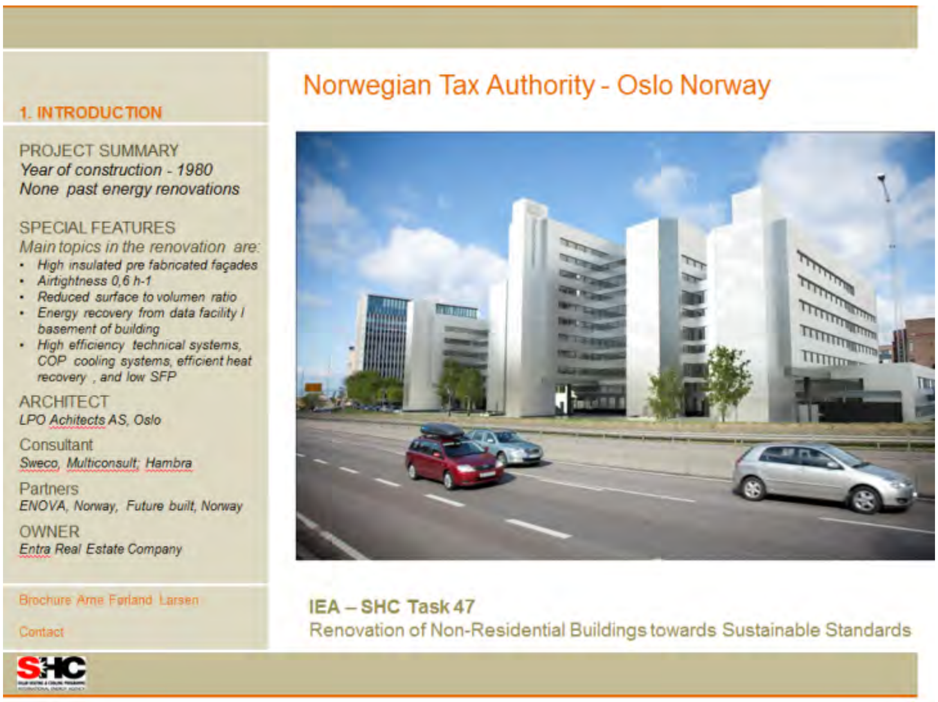
2nd Experts Meeting
September 29-30
Copenhagen, Denmark

MEETINGS PLANNED FOR 2012

3d Experts Meeting
April 12-13
Rome, Italy

4th Experts Meeting
September/October
Brussels, Belgium

Front page of Subtask Template



TASK 47 PARTICIPANTS

Operating Agent and
Subtask A Leader
Fritjof Salvesen
Asplan Viak AS
P.O.Box 24
NO-1300 Sandvika
Norway
fritjof.salvesen@asplanviak.no

Subtask B Leader
Trond Haavik
Segel AS
Box 284
NO-6770 Nordfjordeid
Norway
trond.haavik@segel.no

Subtask C Leader
Doreen Kalz
Fraunhofer - Inst. Solar Energy Systems
Heidenhofstrasse 2
DE-79110 Freiburg
Germany
Doreen.kalz@ise.fraunhofer.de

Subtask D Leader
Sophie Trachte
Architecture et Climat - University of Louvain La Neuve
Place Du Levant 1
BE-1348 LOUVAIN LA NEUVE
Belgium
sophie.trachte@uclouvain.be

NATIONAL EXPERTS & CONTACTS

The following is a list of National Experts & Contacts as identified as Participants of Task meetings or interested during 2011. Please go to the Task page on the SHC web site for updates: http://www.iea-shc.org/task47

Australia
Richard Hyde
Fac. Architecture, Design and Planning
University of Sydney

Francis Barram
Fac. Architecture, Design and Planning
University of Sydney

Austria
Thomas Mach
Graz University of Technology

Claudia Dankl
Østerreichische Gesellschaft fur Umwelt und Technik

Christian Hettfleisch
AIT Austrian Institute of Technology

Belgium
Wouter Hilderson
Passiefhuis-Platform vzw

Denmark
Kirsten Engelund Thomsen
Danish Building Research Institute

Jørgen Rose
Danish Building Research Institute

Germany
Johann Reiss
Fraunhofer - Inst. Bauphysik

Roman Jakobiak
Daylighting

Italy
Ezilda Costanzo
ENEA

Norway
Michael Klinski
SINTEF Building and Infrastructure

Ann Kristin Kvellheim
Enova

Arne Førland-Larsen
Asplan Viak AS

Task 48

Quality Assurance and Support Measures for Solar Cooling

Daniel Mugnier
TECSOL SA
Operating Agent for the French Energy Agency (ADEME)

TASK DESCRIPTION

A tremendous increase in the market for air-conditioning can be observed world-wide, especially in developing countries. The results of the past IEA SHC Tasks and work on solar cooling (the most recent Task 38: Solar Air-Conditioning and Refrigeration) on the one hand showed the great potential of this technology for building air-conditioning, particularly in sunny regions. On the other hand, it showed that further work is necessary to achieve economically competitive systems and provides solid long-term energy performance and reliability.

Objectives

This Task will work to find solutions to make solar thermally driven heating and cooling systems at the same time efficient, reliable and cost competitive. These three major targets should be reached by focusing the work on four levels of activity:

1) Development of tools and procedure to make the characterization of the main components of SAC systems.

2) Creation of a practical and unified procedure, adapted to specific best technical configurations.

3) Development of three quality requirements targets.

4) Production of tools to promote Solar Thermally Driven Cooling and Heating systems.

Scope

The scope of the Task is the technologies for production of cold water or conditioned air by means of solar heat, that is, the subject which is covered by the Task starts with the solar radiation reaching the collector and ends with the chilled water and/or conditioned air transferred to the application. However, the distribution system, the building and the interaction of both with the technical equipment are not the main topic of the Task, but this interaction will be considered where necessary.

Structure

The Task is divided into 4 subtasks (including the detailed activities corresponding for each as noted below).

Subtask A: Quality procedure on component level

A1: Chiller characterization
A2: Life cycle analysis at component level
A3: Heat rejection
A4: Pumps efficiency and adaptability
A5: Conventional solar collection
A6: State of the art on new collector & characterization

Subtask B: Quality procedure on system level

B1: System/Subsystem characterization & field performance assessment
B2: Good practice for DEC design and installation
B3: Life cycle analysis at system level
B4: Simplified design tool used as a reference calculation tool: design facilitator
B5: Self detection on monitoring procedure
B6: Quantitative quality and cost competitiveness criteria for systems

Subtask C: Market support measures

C1: Review of relevant international standards rating and incentive schemes
C2: Methodology for performance assessment, rating and bench marking
C3: Selection and standardisation of best practice solutions
C4: Measurement and verification procedures
C5: Labelling possibilities investigation
C6: Collaboration with Task 45 for contracting models
C7: Certification process definition for small systems

Subtask D: Dissemination and policy advice

D1: Web site
D2: Best Practices brochure
D3: Simplified short brochure
D4: Guidelines for roadmaps on solar cooling
D5: Updated specific training seminars adapted to the quality procedure
D6: Outreach report

Main Deliverables

The main deliverables include:

- Report on best practices on solar collection components for quality, reliability and cost effectiveness.
- Quality procedure document/check lists guidelines for solar cooling.
- Self detection on monitoring procedure report.
- Soft tool package for the fast predesign assessment of successful projects.
- Report and database of existing international standards, rating and incentive systems relevant to solar cooling.
- Report on the rating, measurement and verification of solar cooling performance and quality.
- Report on the selected standard engineering systems ,
- Report on alternative uses of the developed standards and rating framework.
- Technical report about the results of the Life Cycle Assessment of Solar Cooling systems and LCA tool.
- Website dedicated to the Task.
- Training material for installers and planners and training seminars feedback report.
- Semi-annual e-newsletter for the industry.
- Industry workshops in national languages in participating countries addressing target groups (related to Experts meetings).
- Best practices brochure.
- Simplified short brochure (jointly edited by the Subtask Leader (Greenchiller) and IEA SHC Programme.
- Guidelines for Roadmaps on Solar Cooling and possibly general international roadmap on solar cooling (optional).

Duration

The Task started in October 2011 and will be completed in March 2015.

Participating Countries

Australia, Austria, Belgium, Canada, France, Germany, Italy, Singapore, South Africa, Spain, United States

WORK DURING 2011

The main activities were:

- Built in and regular update of the Task Workplan (participants' involvement): The main evolution on the Work Plan and Annex (updated on a version dated at October 2011) were on the Participant list and above all their participation in related activities. The updated documents are available on the Task website (www.iea-shc.org/task48

- Confirmation of Task participants: After the Task preparation meeting which occurred in March 2011 in Paris, some interests came from countries such as Singapore and South Africa. And, we had the great honor to welcome at the kick off meeting in Marseille Professor Kim Tiow Ooi from Nanyang Technical University. The will to enlarge the participation over traditionnal European countries has permitted to welcome as well M. Lucio Mesquita representing Queen's University and therefore Canad. Dr. Mesquita, a native from Brasil, will try in the next months to motivate Brazilian authorities to examine the possible participation of Brazil in Task 48 Other contacts have been established with:
    - Mexico, Professor Roberto Best from UNAM (Mexico city)
    - Israel (Prof. Gershon Grossman from Technion Haifa)
    - Japan, R&D manager of the company, Kawasaki

- Task preparation meeting 1: Paris, March 28-29, 2011 (host: TECSOL, 25 attendees)
  The full content of the presentations made at this meeting are available in the Task 48 website available for the Public at « Events » section.

- First Task meeting (Marseille, October 2011): 28 participants from 9 countries participated in the Task 48 kick-off meeting in Marseille October 2011. The meeting permitted work on the organization of the different activities and confirmed the participation of the countries in this new Task through different institutes and track.

- Common workshop with SHC Task 44: The Task kick off meeting was held in conjunction to a Task 44 meeting (same place, same hotel and same schedule) - and at the end of the 2 Task meetings, a common workshop was organized. This meeting was a very fruitful to exchange among Task 48 and Task 44 experts on a transversal issue: Performance indicators, performance calculation and evaluation procedure for thermally driven chillers and Solar heating/DHW/cooling applications (heat pumps and solar): approaches, differences, next steps.

  Nearly 40 experts attended and 2 main presentations were made by Ivan Malenkovitch of AIT (Austria) and Task 44 Subtask B leader and Stephen White of CSIRO (Australia) and Task 48 Subtask C leader.

- Press conference at ESTEC 2011: A press conference was co-organized by the OA's of Task 48 and Task 44, profiting from the proximity of the 2 Experts meetings during this conference. The objective of this event was to present the IEA SHC Programme and Tasks 44 and 48 to the media and the ESTEC attendees interested in SHC activities.

- Task Announcement during OTTI conference on Solar Air Conditioning (Larnaca, October 2011): This conference was held 2 weeks after the start of the Task and one week before the kick off meeting. This conference is considered to be the most important one on solar cooling. The Task 48 OA, as member of the Scientific Committee, proposed to OTTI to profit from the conference to make a short announcement of the Task.

- Established website: The Task website was developed. It can be found at www.iea-shc.org/task48. This website was very useful in preparation for the kick off meeting.

Results in 2011

The subtask work did not start, but almost all the activities in the Work Plan were confirmed during the kick off meeting, with significant contributions from participants. The quality procedure document/check lists (B5) was combined with C3 and the application for validation of preselected best practice examples (B8) was deleted due to a lack of contributions.

WORK PLANNED FOR 2012

According to the Work Plan, the following reports and deliverables should be available by the end of 2012:

- Subtask C: Report and database of existing inter-national standards, rating and incentive systems relevant to solar cooling
- Subtask C: Report on the rating, measurement and verification of solar cooling performance and quality
- Subtask D: Task newsletters #1 & #2
- Subtask D: Updated website

MEETINGS IN 2011

1st Expert Meeting
October 18-19
Marseille, France
(In conjunction with ESTEC 2011)

MEETINGS PLANNED FOR 2012

2nd Experts Meeting
March 26-27
Milano, Italy

3rd Experts Meeting
September 10-11
Graz, Austria
(In conjunction with Gleisdorf Solar)

TASK 48 NATIONAL CONTACTS

Operating Agent
Daniel MUgnier
TECSOL SA
105 avenue Alfred Kastler – BP90434
FR – 66000PERPIGNAN
France
Tel: + 33 4 68 68 16 40
daniel.mugnier@tecsol.fr

Subtask A : Quality procedure on component
Prof. Mario Motta
Politecnico di Milano
Dep. Energy - Via Lambruschini 4
Milano 20156, Italy

Subtask B : Quality procedure on system level
Dr. Alexander Morgenstern
Fraunhofer ISE
Heidenhofstraße 2
Freiburg 79110, Germany

Subtask C : Market support measures
Dr. Stephen White
CSIRO
PO Box 330
Newcastle, NSW 2300, Australia

Subtask D : Dissemination and policy advice
Dr. Uli Jakob
Green Chiller Association
Verband für Sorptionskälte e.V.
Stendaler Str. 4
10559 Berlin, Germany

NATIONAL EXPERTS & CONTACTS

The following is a list of national experts & contacts as identified as participants of Task meeting or interested during 2011.

Please go to the Task page on the SHC website for updates: http://www.iea-shc.org/task48/index.html

Australia
Stephen White
CSIRO

Austria
Alexander Thür
AEE Intec

Tim Selke
AIT Vienna

Reinhard Hofstaetter
ASIC

Moritz Schubert
SOLID

Daniel Neyer
University of Innsbruck

Belgium
Sébastien Thomas
University of Liege

Canada
Steve Harrisson
Queen's University

Lucio Mesquita
Thermosol Consulting

France
Amandine Le Denn
TECSOL

François Boudehenn
CEA INES

Franck Lucas
PIMENT

Patric Joubert
LEPTIAB

Germany
Alexander Morgenstern
Jochen Doll
Fraunhofer ISE

Christian Zahler
Industrial Solar GmbH

Mathias Safarik
ILK Dresden

Christian Schweigler
Martin Helm
Manuel Riepl
ZAE Bayern

Dirk Pietruschka
ZAFHNET

Clemens Pollerberg
Fraunhofer Umsicht

Uli Jakob
Green Chiller Association

Italy
Roberto Fedrizzi
EURAC

Mario Motta
Marcello Aprile
University Politechnico di Milano

Marco Beccali
Marco Finocchiaro
Bettina Nocke
University of Palermo, Dept Energia

Singapore
Kim Tiow
Nanyang Technical University

South Africa
Erik M Kideren
Ashway Ikapa

Spain
Angel Carrera
Aiguasol

United States
Khalid Nagidi
Energy Management Consulting

SHC Programme Members

As of January 2011

EXECUTIVE COMMITTEE MEMBERS

AUSTRALIA
Mr. Max Maffucci
Standards Australia International
GPO Box 5420
Sydney NSW 2001
Tel: +61/2 8206 6710
Fax: +61/2 8206 6015
max.maffucci@standards.org.au

Alternate
Mr. Ken Guthrie
Sustainability Victoria
Urban Workshop
Level 28
50 Lonsdale Street
Melbourne 3000
Tel: +61/412 178 955
kenguthrie@bigpond.com

AUSTRIA
Mr. Werner Weiss *(Chairman)*
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf
Tel: +43/3112 5886 17
Fax: +43/3112 5886 18
w.weiss@aee.at

Alternate
Mrs. Sabine List
BMVIT
Renngasse 5
A-1010 Vienna
Tel: +43/1 71162 652919
Sabine.list@bmvit.gv.at

BELGIUM
Prof. André De Herde
Architecture et Climat
Université Catholique de Louvain
Place du Levant, 1
B-1348 Louvain-la-Neuve
Tel: +32/10 47 21 42
Fax: +32/10 47 21 50
andre.deherde@uclouvain.be

CANADA
Mr. Doug McClenahan
CanmetENERGY
580 Booth Street
Ottawa, Ontario K1A 0E4
Tel: +1/613 996 6078 or Mob: +1/613/884-2333
Fax: +1/613 996 9416
dmcclena@nrcan.gc.ca

CHINA
Prof. He Tao
China Academy of Building Research
30#, Beisanhuandonglu
Chaoyang District
Beijing 100013
Tel: +86/10 64517746
Fax: +86/10 84288287
iac@vip.sina.com

Alternate
Mr. Zhang Xinyu
(same address as above)
Tel: +86/10 84278906
Fax: +86/10 84288287
zxyhit@163.com

DENMARK
Mr. Jens Windeleff
Danish Energy Agency
Amaliegade 44
DK-1256 Copenhagen K
Tel: +45/33 92 68 18
Fax: +45/33 11 47 43
jew@ens.dk

Alternate
Mr. Jan Erik Nielsen
PlanEnergi
Aggerupvej 1
DK-4330 Hvalsö, DENMARK
Tel: +45/4646 1229
Fax: +45/9839 2498
jen@solarkey.dk

EUROPEAN COMMISSION
Mr. Jose Riesgo
European Commission -DG ENER
Directorate C - New and Renewable Sources of Energy, Energy Efficiency & Innovation
Rue De Mot 24-3/ 152
B-1049 Brussels
Tel: +32/2 29 57939
Fax: +32/2 29 66261
Jose.Riesgo@ec.europa.eu

FINLAND
Mr. Martti Korkiakoski
Tekes, Finnish Funding Agency for Technology and Innovation
P.O.Box 69
FI-00101 Helsinki
Tel: +358 1060 55875
martti.korkiakoski@tekes.fi

FRANCE
Ms. Céline Coulaud
Département Energies Renouvelables (DER)
ADEME - Centre de Sophia Antipolis
500 route des Lucioles
06560 VALBONNE
Tel: +33/4 93 95 72 53
Fax: +33/4 93 65 31 96
celine.coulaud@ademe.fr

GERMANY
Dr. Robert Drese
Projektträger Jülich
Energietechnologien (ERG1)
Forschungszentrum Jülich GmbH
52425 Jülich
Tel: +49/2461 61 9293
Fax: +49/2461 61 3131
r.drese@fz-juelich.de

Alternate
Dr. Peter Donat
Projektträger Jülich
Geschäftsbereich Erneuerbare Energien
Forschungszentrum Jülich GmbH
Zimmerstraße 26-27
10969 Berlin
Tel: +49/30 20199 427
Fax: +49/30 20199 470
p.donat@fz-juelich.de

ITALY
Mr. Michele Zinzi
ENEA UTEE-ERT s.p. 104
Via Anguillarese, 301
00123 Rome
Tel: +39/06 3048 6256
Fax: +39/06 3048 3930
michele.zinzi@enea.it

MEXICO
Dr. Wilfrido Rivera Gomez-Franco
National University of Mexico
Apdo. Postal #34
62580 Temixco, Morelos
Tel: +52/555 622 9740
Fax: +52/777 325 0018
wrgf@cie.unam.mx

Alternate
Dr. Camilo Arancibia Bulnes
same address as above
Tel: +52/555 622 9831
Fax: +52/777 325 0018
caab@cie.unam.mx

NETHERLANDS
Mr. Lex Bosselaar
NL Agency
Postbus 8242
3503 RE UTRECHT

Tel: +31/88 602 24 95
Fax: + 31/88 602 90 25
lex.bosselaar@agentschapnl.nl

NORWAY
Dr. Tore Wigenstad
ENOVA
Prof. Brochs gt. 2
7030 Trondheim
Mob: +47/906 44 054
Tore.Wigenstad@ENOVA.NO

Alternate
Dr. Anne Gunnarshaug Lien
SINTEF Building and Infrastructure
NO-7465 Trondheim
Visit address: Alfred Getz v 3
Tel: +47/97 75 79 30
Fax: +47/73 59 82 85
anne.g.lien@sintef.no

PORTUGAL
Mr. João A. Farinha Mendes *(Vice Chair)*
LNEG – Edificio G
Departmento de Energias
Estrada do Paco do Lumiar, 22
1649-038 Lisboa
Tel: +351/21 092 4768
Fax: +351/21 712 7195
Farinha.mendes@lneg.pt

SINGAPORE
Mr. Kian Seng ANG
Building and Construction Authority
Director, Research
200 Braddell Road, ZEB Level 3
579700
Tel: +65 6248 9988
Fax: +65 6258 0558
ang_kian_seng@bca.gov.sg

SOUTH AFRICA
Dr. Thembakazi Mali
Senior Manager: Clean Energy Solutions
SANERI
P.O. Box 786141
Sandton, 2146
Tel: +27 10 201 4782
Fax: +27 10 201 4937
thembakazim@saneri.org.za

Alternate
Prof. Ernst Uken
Head: CPUT Energy Institute
P.O. Box 652
8000 Cape Town
Tel: +27 21 460 3127
Fax: +27 21 460 3728
ukene@cput.ac.za

SPAIN
Dr. María José Jiménez Taboada
Renewable Energy Division
CIEMAT
Carretera de Senés s/n
E-04200 Tabernas (Almeria)
Tel: +34/950/387922
Fax: +34/950/365015
mjose.jimenez@psa.es

Alternate
Mr. Ricardo Enríquez Miranda
Renewable Energy Division
CIEMAT
Avenida Complutense, 40
E-28040 Madrid
Tel: +34/91 3466052
Fax: +34/91 3466037
ricardo.enriquez@ciemat.es

SWEDEN
Dr. Jörgen Sjödin
Energy Technology Department
Swedish Energy Agency
Box 310
SE-631 04 Eskilstuna
Tel: +46/16 544 21 38
jorgen.sjodin@swedishenergyagency.se

Alternate
Ms. Marie Claesson
Same address as above
Tel: +46/16 544 20 73
Marie.Claesson@swedishenergyagency.se

SWITZERLAND
Mr. Andreas Eckmanns
Federal Office of Energy
CH 3003 Bern
Tel: 41/31 322 54 61
andreas.eckmanns@bfe.admin.ch

Alternate
Mr. Urs Wolfer
Same address as above
Tel: +41/31 322 56 39
Fax: +41/31 323 25 00
urs.wolfer@bfe.admin.ch

UNITED STATES
Dr. Bahman Habibzadeh
U.S. Department of Energy
1000 Independence Ave, SW
Washington, DC 20585-0121
Tel: +1/202 287 1567
Bahman.Habibzadeh@ee.doe.gov

OPERATING AGENTS

TASK 36 - Solar Resource Knowledge Management
Dr. David S. Renné
2385 Panorama Ave.
Boulder, CO 80304 UNITED STATES
Tel: +1/303 517 8290
Fax: +1/303 444-1757
drenne@mac.com

TASK 38 - Solar Air Conditioning and Refrigeration
Dr. Hans-Martin Henning
Fraunhofer-Institut for Solar Energy Systems
Heidenhofstr. 2
D-79110 Freiburg, GERMANY
Tel: +49/761 45885134
Fax: +49/761 45889000
hans-martin.henning@ise.fraunhofer.de

TASK 39 - Polymeric Materials for Solar Thermal Applications
Mr. Michael Köhl
Fraunhofer Institute for Solar Energy Systems
Heidenhofstr. 2
D-79 110 Freiburg, GERMANY
Tel: +49/761 45885124
Fax: +49/761 45889124
michael.koehl@ise.fraunhofer.de

TASK 40 – Towards Net Zero Energy Solar Buildings
Mr. Josef Ayoub
CanmetENERGY
Natural Resources Canada
1615 Lionel-Boulet Blvd.
Varennes QC J3X 1S6, CANADA
Tel: +1/450 652 1981
Fax: +1/450 652 517
Josef.Ayoub@rncan-nrcan.gc.ca
jayoub@encs.concordia.ca

TASK 41 - Solar Energy and Architecture
Ms. Maria Wall
Dept. of Architecture and Built Environment
Lund University
P.O. Box 118
SE-221 00 Lund, SWEDEN
Tel: +46/46 222 9662
Fax: +46/46 222 4719
maria.wall@ebd.lth.se

TASK 42 - Compact Thermal Energy Storage
Mr. Wim van Helden
Renewable Heat
Oosterstraat 15
1741 GH Schagen, NETHERLANDS
Tel: +31/224 752098
Mob: +31/ 62014 3224
wim@wimvanhelden.com

TASK 43 - Rating and Certification Procedures
Mr. Les Nelson
IAPMO
5001 E. Philadelphia St.
Ontario, CA 91761 USA
Tel: +1/909/218 8112
Les.nelson@iapmo.org

Mr. Jan Erik Nielsen
PlanEnergi – Zealand Department
Aggerupvej 1
DK-4330 Hvalsö, DENMARK
Tel: +45/4646 1229
Fax: +45/9839 2498
jen@solarkey.dk

TASK 44 - Solar and Heat Pump Systems
Mr. Jean-Christophe Hadorn
BASE CONSULTANTS SA
8 rue du Nant
CH-1211 Geneva, SWITZERLAND
Tel: + 41/22 840 20 80
Fax: +41/22/840 20 81
jchadorn@baseconsultants.com

TASK 45 - Large Solar Heating & Cooling Systems
Mr. Jan Erik Nielsen
PlanEnergi – Zealand Department
Aggerupvej 1
DK-4330 Hvalsö, DENMARK
Tel: +45/4646 1229
Fax: +45/9839 2498
jen@solarkey.dk

TASK 46 - Solar Resource Assessment and Forecasting
Dr. David S. Renné
2385 Panorama Ave.
Boulder, CO 80304 UNITED STATES
Tel: +1/303 517 8290
Fax: +1/303 444-1757
drenne@mac.com

TASK 47 - Renovation in Non-Residential Buildings
Mr. Fritjof Salvesen
Asplan Viak AS
Kjørboveien 12
P.O.Box 24
1300 Sandvika, NORWAY
Tel: +47 40 40 7853
Fax: +47/67 52 52 99
fritjof.salvesen@asplanviak.no

TASK 48 – Quality Assurance and Support Measures for Solar Cooling
Mr. Daniel Mugnier
TECSOL SA.
105 av Alfred Kastler - BP 90434
66 004 Perpigan Cedex, FRANCE
Tel: +33 4 68 68 16 42
Fax : +33 (0) 4 68 68 16 41
E-mail : daniel.mugnier@tecsol.fr

TASK 49 - Solar Process Heat for Production and Advanced Applications
Mr. Christoph Brunner
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf, AUSTRIA
Tel: +43/3112 5886 17
Fax: +43/3112 5886 18
c.brunner@aee.at

ADMINISTRATION

SHC SECRETARIAT
Ms. Pamela Murphy
KMGroup
9131 S. Lake Shore Dr.
Cedar, Michigan 49621, USA
Tel: +1/231 620 0634
Fax: +1/231 228 6017
pmurphy@KMGrp.net
secretariat@iea-shc.org

SHC INFORMATION CENTER
Mr. Uwe Trenkner
Trenkner Consulting
Rue Anatole France 134
1030 Brussels, BELGIUM
Tel: +32/2 242 15 55
Mob: +32/499 265 865
uwe@trenknerconsulting.com
communications@iea-shc.org

WEBMASTER
Mr. Randy Martin
R. L. Martin & Associates, Inc.
6851 Spanish Bay Drive
Windsor, Colorado 80550, USA
Tel: +1 /970 219 2605
Fax: +1/303 379 4498
randy@rlmartin.com

IEA SECRETARIAT LIAISON
Mr. Yoshiki Endo
International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15, FRANCE
Tel: +33/1 40 57 65 62
Fax: +33/1 40 57 67 59
yoshiki.endo@iea.org

SHC CONFERENCE
Dr. Andreas Häberle
PSE AG
Emmy-Noether-Str. 2
79110 Freiburg
Germany
Tel: +49 761 479 14 14
Fax: +49 761 479 14 44
andreas.haeberle@pse.de

IEA SOLAR HEATING & COOLING PROGRAMME

www.iea-shc.org