INTERNATIONAL ENERGY AGENCY – SOLAR HEATING AND COOLING PROGRAMME

TASK 41 – Solar Energy and Architecture

Product developments and dissemination activities

Coordinated by Subtask A

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Introduction

This document shows product developments and dissemination activities carried out within the framework of, or in close relation to, the project IEA SHC Task 41; Solar Energy and Architecture. This Task gathered researchers and practicing architects from 14 countries in the three year project whose aim was to identify the obstacles architects are facing when incorporating solar design in their projects, to provide resources for overcoming these barriers and to help improving architects' communication with other stakeholders in the design of solar buildings. Participating countries were Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Norway, Portugal, Republic of Korea, Singapore, Spain, Sweden and Switzerland.

The report gives not a complete list of activities, but shows the different types of activities to spread the findings in Task 41 and to initiate product developments in participating countries.

Development of new products/systems

This section describes new products or systems that national institutes and universities have developed or are developing in collaboration with companies.

Many institutes develop their research in collaboration with companies to find innovative technical solutions and new products in order to achieve high performance and reduce the energy use. The relationship between the university research and the industry developments is often a profitable activity to realize new discoveries in industry or/and in research.

Table 1 below gives an overview of national products developed by organizations taking part in Task 41, and is followed by a description of each development.

Country and Institutes	*Development of new products/systems*						
	Photovoltaic			*Solar Thermal*		*BIPV*	
	Roof	Fac.	Flex.	Roof	Fac.	Roof	Fac.
Australia	**1**		**1**	**2**			
Australia National University Centre for Sustainable Energy Systems			1				
Australia National University - ANU - Solar Thermal Group Australian Greenhouse Office - AGO				2			
UNSW - University of New South Wales School of Photovoltaic and Renewable Energy Engineering	1						
Germany							**1**
Fraunhofer ISE							1
Italy		**1**	**1**				**2**
EURAC - European Academy of Bozen Architecture University IUAV The University LUB of Bolzano		1					
EURAC - European Academy of Bozen							1
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development			1				1
Total	**1**	**1**	**2**	**2**			**3**

Table 1 Summary of national products divided for solar technologies (Photovoltaic, Solar Thermal, BIPV) and their application (Roof, Façade or Flexible).

BIPV - PRODUCT

1	**Product/System**	**Building skin as electricity source** *Development of a wood prefabricated building component with PV*
	Institutes	EURAC - European Academy of Bozen Architecture University IUAV The University LUB of Bolzano
	Industrial partners	Legnocase Bioedilizia e coperture - Falegnameria Bomè - E-Buildings - MAA Engineering srl - Agenzia Metropolitana - Masè Termoimpianti - G.&G. Impianti Elettrici - Dreamsrl
	Contact	Laura Maturi - EURAC
	Reference	L. Maturi, R. Lollini, P. Baldracchi, W. Sparber *"Building skin as electricity source: the prototype of a wooden BIPV façade component"* 26th European Photovoltaic Solar Energy Conference - Hamburg 2011

The system includes the development of the prototype of a prefabricated wooden façade component with PV integration. It is realized together with a network of local enterprises organized in a local funded research project. The project involves industrial partners who belong to the wooden building field and the PV sector in collaboration with the Architecture University IUAV of Venezia and The University LUB of Bolzano. The prototype has been conceived and configured on the basis of a theoretical analysis focused on its energy performance, considering both PV performance and building-related aspects, and also taking into account other aspects such as environmental issues, architectural quality, safety and durability.

A modular specimen has been built (scale 1:1) and tested in the EURAC calorimeter to measure its steady-state thermal transmission properties (Figure 1).

Figure 1 The image on the left shows a modular specimen of the prototype that has been conceived, developed and tested in the EURAC laboratory, in the calorimeter which is shown on the right.

The prototype will be installed in a real building, an Elementary school entirely realized with wooden prefabricated components, which is still under construction (Figure 2). This will allow monitoring the prototype working in real conditions.

Figure 2 The rendering shows the Elementary school that will be realized as a prototype building of 200 m2 within the project co-financed by FESR 2007-2013 Obiettivo 2 "Chi Quadrato: costruire strutture in bioedilizia certificate per attivitá formative". The illustration shows the south façade of the building with the installed prototype (3,2 m x 2,85 m). [Source: Studio Arch. Frate]

ST - PRODUCT

2	**Product/System**	**Innovative solar façade** *unglazed thermal collector*
	Institutes	EURAC - European Academy of Bozen
	Industrial partners	CGA ARTAL ITALIANA Frener&Reifer
	Contact	Alessia Giovanardi - EURAC
	Reference	A. Giovanardi, R. Lollini e P. Baggio *"Analysis of solar thermal collector integration in façade system"* 6th Energy Forum 2011, 6-7 December 2011 - Bressanone (IT)

EURAC contacted a few companies (CGA, ARTAL ITALIANA and Frener & Reifer) in order to start the development of an innovative solar façade with unglazed thermal collectors to be implemented in façades with a double function: it is conceived as a metal cover system for the façade being able to produce hot water for the building. The idea is to realize the absorber on the basis of the roll-bond technology and blend it on the two or four edges in order to get a cassette or plank cover system for the façade.

So far there have been problems, mainly with the suppliers of the absorber (CGA and ARTAL ITALIANA) since there is a lack of funding to invest in the realization of the prototype. The idea to develop the element is not discarded yet, and further technical problems regarding hydraulic circuit connections still have to be developed and solved.

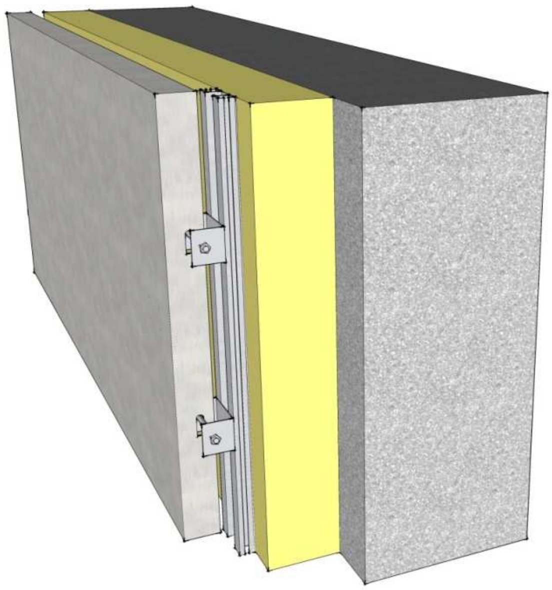

Figure3 The rendering shows the preliminary sketch of the prototype of the innovative solar façade designed by EURAC in partnership with CGA, ARTAL ITALIANA, Frener&Reifer.

PV - PRODUCT

3	**Product/System**	**"Stapelia"** *A landscape integrated photovoltaic component*
	Institutes	ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
	Industrial partners	Schüco - Operating program launched by Regione Campania (2000-2006)
	Contact	Alessandra Scognamiglio - ENEA
	Reference	A. Scognamiglio, C. Cancro. F. Formisano, G. Graditi, C. Privato *"A landscape integrated photovoltaic component called "Stapelia"* 21st European Photovoltaic Solar Energy Conference, 4-8 September 2006, Dresden, Germany

Multifunctional photovoltaic components fit to the integration in valuable sites are a good opportunity for the diffusion of PV technology, especially in countries like Italy where an huge heritage of archaeological areas, historical towns and valuable environments exists. The main feature must be the aesthetic value of the components, being the best way to ensure their acceptability. So, designing such a component requires consideration over the development of some criteria that have to be verified both from the technical and the aesthetical point of view, before dealing with the specific design.

Referring to the technical criteria, considering that the sites can also be not connected to the local electric grid, the components have to be able to work in "stand alone" or "grid connected" condition. Another important technical feature is the components and plants modularity, in order to allow the customer to use the optimal number of elements depending on specific energetic needs, and to succeed in a satisfying electrical structure.

A good result in terms of aesthetic value is achieved by means of a multidisciplinary approach, focusing on the integration between the different functions the PV component has. In fact, since the high communicative role the introduction of innovative technologies producing clean energy has in the context of valuable sites (acceptability), the component has to be pleasant itself, but it has also to be an improving element. A good communication choice can be considered linking the energy generation with an appropriate function easily recognized by people: for example the night illumination.

From a design point of view this means also developing a perfectly integrated component, where all elements are synthesized in a convincing image; in fact technical elements have not to be hidden, but rather integrated in the structure itself.

The lighting photovoltaic component has been designed by a team experienced in architecture and mechanical/electrotechnical engineering, and five prototypes have been realized (Figure 4).

The realization refers to an operating program launched by Regione Campania (2000-2006) aimed to on-site power generation by means of both traditional and renewable sources. Within the framework joined by Universities, Private Companies, Research Centres, ENEA planned the installation of 5 Stapelia units supplying partially an electrolyser for hydrogen production.

Figure 4 A row of Stapelia street lamps in the ENEA Portici Research Centre garden and a view of Stapelia photovoltaic plant at sunset

Name and shape of Stapelia have been inspired by the structure of the homonymous tropical flower, which stellar geometry is based on a pentagon. The basic idea is that one or more components (flowers) can be “planted” where a soft lightning is required. The “corolla” of the flower (600cm high) is composed of five triangular “petals” (glass-glass modules 28W_p each one, with 21 monochrystalline dark blue cells) anchored to a pentagonal steel structure. In the middle of the flower, corresponding to the “pistil”, a double pyramidal box (carter) has been thought to contain a battery housing in the upper half part, whereas on the opposite side some low consumption power leds are arranged on the steel (3 each face of the pistil). A light diffuser surface made of five Plexiglas layers set between the steel structure brackets, ensures a pleasant illumination of the area surrounding Stapelia.

The PV plant is composed by five standard Stapelia units (140W_p power each one) placed along a path that corresponds to the ENEA boundary line, visible from the sea. The border is underlined by the presence of the lightning PV flowers, communicating the subject of the studies carried out by the Research Centre. The total nominal power is about 700W_p; it is a standalone PV plant with an electrochemical battery, however the possibility of connection to the low tension grid has been taken into account.

Figure 5 Stapelia at midday, showing its “lightness” (on the left) and Stapelia at sunset, showing its leds “brightness”

In the case of landscape integrated PV systems, the components can be considered as traditional “urban equipment”, and their look has to be attractive and pleasant.

Generally the components fitting the context features have to be designed case by case, however some requisites they have to satisfy can be summarized:

- The “lightness” thought not only as “structural” lightness, but also “visual” lightness, considering that the PV components presence must not contrast with the installation site;
- The multi-functionality, so that PV components can ensure different functions at the same time (such as energy generators, lighting and attractive elements useful to exploit a path or architectural natural episodes);
- The reversibility, allowing to dismantle the PV component in the case the place state before the intervention should have to be restored, without damage to the site or expansive/difficult works.

Multi-functionality is an intrinsic quality of Stapelia, in fact it has been thought like a PV lighting and attractive element of the landscape, while the reversibility has been guaranteed by light and small foundations. The requirement “lightness” has been obtained by means of the utilization of glass-glass PV modules, with about 44% filling ratio (glass area = 4752cm^2, PV cells area = 2100cm^2), ensuring a good transparency of the element and a low visual impact on the environment. Glass-glass modules have been preferred to polycarbonate ones, despite their weight, because of a better reliability and durability.

Stapelia has been patented by ENEA: is a trade mark (n. 006372866), and it was patented as a European design patent (n. 700/2009, A. Scognamiglio, C. Cancro, F. Formisano).

BIPV - PRODUCT

4	**Product/System**	**"Boogie-Woogie"** *A photovoltaic glass-glass module "dancing" with the building*
	Institutes	ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
	Industrial partners	Schüco
	Contact	Alessandra Scognamiglio - ENEA
	Reference	A. Scognamiglio, G. Graditi, F. Pascarella, C. Privato *"Boogie-woogie, a photovoltaic glass-glass module "dancing" with the building"* 21st European Photovoltaic Solar Energy Conference, 4-8 September 2006, Dresden, Germany

Meeting the aesthetical requirements allowing acceptability of PV modules is indispensable for a large scale diffusion of BIPV systems, modifying the aesthetic appeal of the building.

Glazed envelopes, and particularly façades, are a good option for the diffusion of BIPV, and PV glass-glass special modules can be seen like a good improvement referring to the acceptability: any parameters can be varied, like geometry and shape, cells disposition, colours, dimensions, and transparency degree of the component, but the experience shows that some problems still remain.

A building envelope can be considered an exchange place where the interactions between the inhabitants and the building and between the building and the external ambient manifest themselves. Particularly, the façade is certainly the most communicative element of architecture.

The appearance of the PV panels basically coincides with the set pattern of the cells (generally disposed on a grid or on parallel lines), so the aspect a façade can offer is quite expected. Two hypothetical PV glazed façades, made of glass-glass modules (127cm * 127cm) characterized by a "grid cells pattern" and by a "strips cells pattern", respectively, are shown in Figure 6.

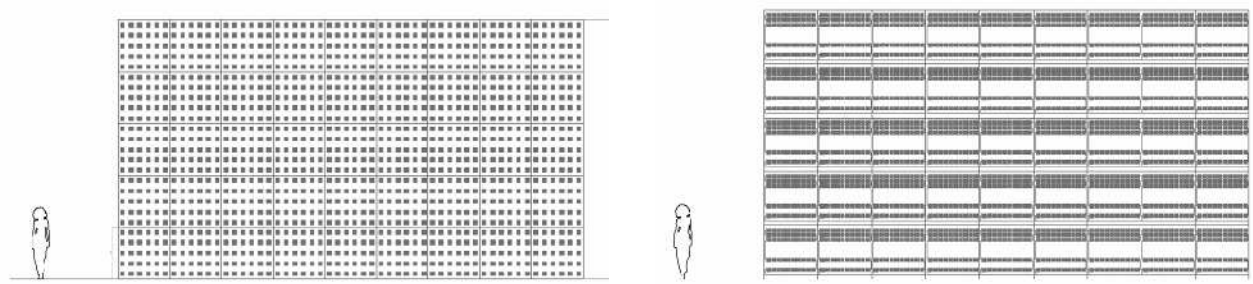

Figure 6 Two hypothetical PV glass-glass modules façade (grid and strips pattern cells disposition)

The first aim of the work is developing a PV module which can be "functional" to its utilization in sustainability oriented architectures, which means a flexible cells pattern suitable for contemporary façades.

An important objective is to harmonize the external and the internal glazed photovoltaic façades look. In fact, if the external façade of a building has a relationship with the outside, its back face "converses" with the inhabitants living inside: PV modules are generally not thought to be seen from the back side, consequently the façade surface on the inside cannot be considered acceptable. It is clear that the not satisfying look of PV glazed envelopes on the inside constitutes a relevant limitation for architects who would use photovoltaic systems.

Transforming the back side of the modules into a surface that can be controlled from the design point of view, could add a very high value to the component. The Boogie-Woogie PV module has to be marked by:

- Random cells pattern allowing façade composition flexibility ;
- Attention to the back side of the module, so that the component could be "bifacial".

Two further design parameters can be investigated to improve the design possibilities: the first one is the possibility to develop for each module front different module backs (improving the design potentialities); the second one is the utilization of the cells wirings as decorative elements of the module composition.

A composition by Piet Mondrian, Broadway Boogie-Woogie, has been taken as reference, giving the PV module its name. It is well known that the Neoplastic painter composed this work inspired by the New York views, by the dancing show of its sparkling buildings, by the flashing and intermittent boards in Times Square. Broadway Boogie-Woogie seems to be really significant referring to the subject of the study; the random effect is obtained by means of a few elements, like colours, differences and contrasts, and by a careful control of regularity and disorder. Mondrian's approach can be transferred to the matter of the module design in a study of a regular and rather standardized electrical grid compatible with a free disposition of the cells.

The basic pattern can be considered similar to an electrical bus bars disposition with the energy moving throughout the grid, while the coloured condensations can be red as photovoltaic cells clinging to the grid (Figure 7). Just defined the composition of the module front – considering the right cells density depending on the requirements due to the daylight control – it is necessary to work out the design of the electrical contacts (series and parallel connections).

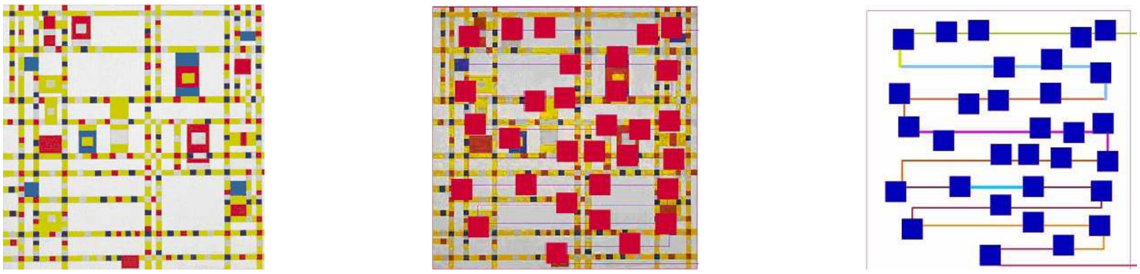

Figure 7 Piet Mondrian - Broadway Boogie-Woogie (1942-1943) (on the left) - Interpretation/Overlapping (in the middle) – Electrical contacts design (on the right)

Referring to the appearance of the module back side (on the building inside), the idea is to define coloured areas (same cells shape and dimensions) corresponding to the back side of the PV cells. This way to each front side of the module (building exterior) infinite chromatic variations (building interior) could be associated. The interiors quality is influenced too, in terms of daylight as well as visual comfort of the inhabitants, being also the light quality conditioned by the cells pattern and density. The utilization of Boogie-Boogie modules gives the designer the possibility of developing a "random" composition of the external façade, coherent with the internal one and fit to the requirements of the inhabitants (Figure 8).

Figure 8 Utilization Boogie-Woogie modules; external façade (on the left) and internal façade (on the right)

The appearance of a Boogie-Woogie façade looks more similar to a "pixelled" façade then a photovoltaic traditional one. Boogie-Woogie module can be produced by means of standard rolling technology, with the only addition of a new layer (transparent/opaque) ink jet printed. The new layer is an ink jet printed film, and it designs the back side of the module. The material fit to this utilization has to resist to the module rolling temperatures, so it is characterized by properties similar to that ones of EVA (such as Dupont butacyte). Boogie-Woogie is an Italian patent (invention patent n. RM2005A000060 del 11.02.05) and inventors are: A. Scognamiglio, G. Graditi, F Pascarella, C. Privato.

In the following matrix are compared a standard PV module (PV), a glass-glass PV module for building integration (PV GG) and Boogie-Woogie (PV BW).

Performance indexes	***weight***	***PV***	***PV GG***	***PV BW***
Energy performance	0,3	++++	+++	+++
Building performance	0,1	+	++	++++
Day-light control	0,2		+++	++++
Aesthetic value	0,4		++	++++

BIPV - PRODUCT

	Product/System	**BIPV -** *Transparent façade*
	Institutes	Fraunhofer ISE (Institute for Solar Energy System)
	Industrial partners	Interpane Signet Solar GenOptik
3	**Contact**	Francesco Frontini - SUPSI
	Reference	F. Frontini, Tilmann E. Kuhn *"A new angle selective, see-through BIPV façade for solar control"* EuroSun2010, Sep-Oct 2010 - Graz (AU)

The new angle-selective façade system (Figure 9) is a static, transparent solar-control façade, which can be produced using the usual production technologies for windows and glazing units. It consists of at least two laminated glass panes with two series of opaque stripes, one is sandwiched between the two panes of the laminate and the other is on the inward-facing surface of the laminate.

Due to the different refractive indices of air and glass, that are respectively 1 and around 1.52, together with the specific position of the ceramic frit stripes on the glass, the new façade offers high solar control and can protect the occupants against glare. The visual contact to the outside is also guaranteed and varies with the viewing direction. The opaque stripes can be produced in different materials or colours, depending on the architectural concept and on the shading requirements: dark colours are favoured to maximize the shading and anti-glare performance. The invention (patent application n° DE 10 2007 013 331 A1, submitted by T. E. Kuhn - Fraunhofer-ISE) can be implemented with photovoltaic stripes on either the outer and/or the inner layer. The efficiency of the system strictly depends on the design and on the technology adopted in the construction.

Figure 9 Left: schematic view of the new transparent, angle-selective façade. The stripes (represented in blue) can be produced with photovoltaic technology. On the right: a detailed view of the first prototype with black ceramic frit stripes.

The new angle-selective façade can be used either as a stand-alone system for a glazed façade or as an extra shading device layer. The following pictures shows designs to integrate the system either into existing building, where the new glass elements could be installed outside the existing windows, or into new buildings.

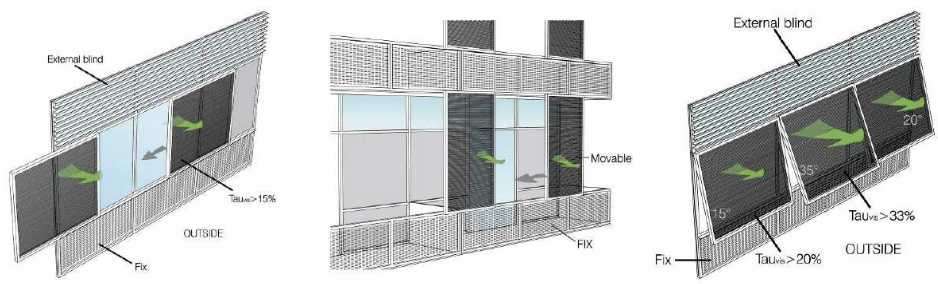

Figure 10 The illustrations present three ideas for façade integration of the angle-selective glazing as external shading or as tilted windows.

PV - PRODUCT

4	**Product/System**	**SLIVER Cell -** *Solar modules flexible and transparent*
	Institutes	Australia National University Centre for Sustainable Energy Systems (CSES)
	Industrial partners	Origin Energy
	Contact	Mark Snow - UNSW
	Reference	E. Franklin and A. Blakers *"SLIVER® cells for concentrator systems"* 19^{th} European PV Solar Energy Conference, June 2004 - Paris

SLIVER solar cells are a new type of solar cells with the potential to revolutionize the global solar power industry, developed at the Centre for Sustainable Energy Systems with funding assistance from Origin Energy. Solar modules made from SLIVERs can be lightweight, flexible and transparent and offer imaginative opportunities for building integration and other applications. SLIVERS have the potential to revolutionise the photovoltaics industry and simultaneously address the critical environmental issue of global warming.

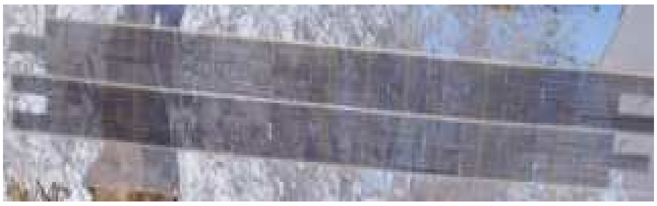

Figure 11 A bifacial flexible module absorbing light from both sides.

Figure 12 A 0,1 m^2 flexible module capable of generating over 14 W.

A one-square-meter solar panel using SLIVER Cell technology needs the equivalent of two silicon wafers to convert sunlight to 140 watts of power. The unique attributes of SLIVER Cell technology could open many new SLIVER Cell applications, in addition to conventional rooftop and off-grid uses, including:

- Transparent SLIVER Cell panes to replace building windows and cladding;
- Flexible, roll-up solar panels and high-voltage solar panels;
- Solar powered aircraft, satellite and surveillance systems.

SLIVER Cells have several properties that make them ideally suited for use in flexible modules. Firstly, because they are fabricated from mono-crystalline silicon, they have high and stable efficiencies. In addition, the elongate form factor of the cells means that when connected in series, system voltage can be rapidly built, at a rate of 5 to 10 V/cm^2. Hence, battery voltage can be generated in a small area, allowing cells to be incorporated into small portable electronic devices. The dimensions of the cells mean they are naturally flexible, particularly about their long axis, and do not require any post processing for them to be incorporated into flexible modules.

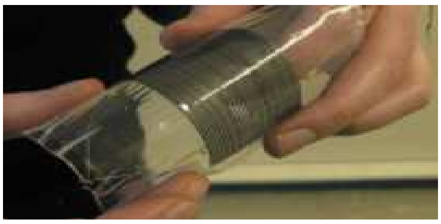

Figure 13 A small module showing the flexibility of all components.

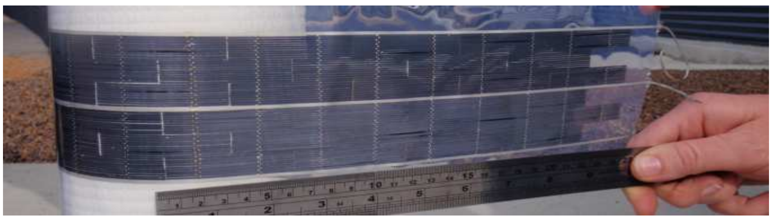

Figure 14 Module can be flexed to radii of curvature smaller than 5 cm.

CSES is developing flexible photovoltaic modules based on SLIVER Cells. The performance of these modules is over 130 W/m^2 with a power to weight ratio of greater than 150 W/kg, a radius of curvature of 5 cm or smaller, and operating temperatures between -40˚C and +65˚C. Modules can be either unifacial or bifacial depending on the desired application.

ST - PRODUCT

5	**Product/System**	**Solar air heater with phase change material thermal storage**
	Institutes	Australia National University - ANU- Solar Thermal Group Australian Greenhouse Office - AGO
	Industrial partners	T3 Energy
	Contact	Mark Snow - UNSW (University of New South Wales) mike.dennis@anu.edu.au - ANU
	Reference	http://solar-thermal.anu.edu.au/low-temperature/air-heaters/

The system is designed to produce solar heated air, solar hot water and photovoltaic electricity all from one array. Furthermore, it uses phase change material (PCM) to store heat for later use. The solar collectors integrate with the roof forming a weatherproof skin. The panels are modular in design and a typical house may use 40-50 of them in an array. The phase change material used is paraffin wax. The wax is encapsulated in custom designed containers and stored in a heat bank which looks like a hall cupboard. The system uses a controller to determine which of six modes of operation should be used to maintain a comfortable indoor temperature.

Figure 15 A view of the roof with the Solar air heater.

Figure 16 A view of the integrated Solar air heater.

It is to develop and commercialize a solar air heating system that is suitable for space heating as well as for commercial applications such as drying. A solar air heating system consists of a number of individual solar air heating modules that can be arranged end-to-end or side by side to provide any desired heat or temperature output under the design conditions.

Solar energy that is intercepted by the unit is converted into hot air which can be either used directly, or stored in phase change material (PCM) thermal storage for later use. PCMs store energy by changing phase from solid to liquid (i.e. melting) and releasing heat by changing phase from liquid to solid (i.e. freezing). A range of PCMs are being evaluated, all with a melt/freeze temperature of about 40°C.

As an extension to this project the technologies are being evaluated for their effectiveness:

- Low reflectivity glass;
- Selective surface on absorber plate;
- Alternative materials for the body of the unit.

The project extension allowed for two major additions to the original solar air heater unit:

- Solar water heating. Solar water heating capability of the unit can be incorporated into the unit by bonding flattened copper pipes to the underside of the absorber plate. Some of the heat from the absorbed solar radiation is conducted to water flowing through these pipes. However, it is not claimed that this technology is as effective as that of a purpose designed solar water heater;
- SLIVER Cell incorporation. Recent research by the ANU's photovoltaic team has led to the development of SLIVER Cells, described before in this report. These cells are soon to be manufactured and commercialized by Origin Energy, and the Project Extension will allow for SLIVER Cell PV technology to be incorporated into the solar thermal unit. Thus it will be possible to obtain solar hot air, solar hot water and electricity from a single unit.

ST - PRODUCT

6	**Product/System**	**Solar cooling using ejectors**
	Institutes	Australia National University - ANU - Solar Thermal Group
	Contact	Mark Snow - UNSW (University of New South Wales) mike.dennis@anu.edu.au - ANU
	Reference	http://solar-thermal.anu.edu.au/low-temperature/solar-cooling-using-ejectors/

The ejector is a thermally driven compressor that operates in a heat pump refrigeration cycle. In a heat pump system, the ejector takes the place of the electrically driven compressor, but uses heat rather than electricity to produce the compression effect.

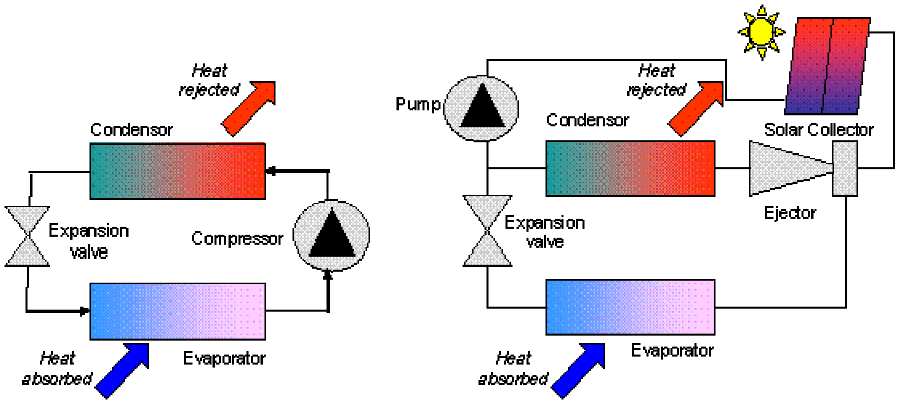

Figure 17 Solar driven ejector heat pump compared to a conventional electric heat pump.

The ejector has no moving parts and is simple and reliable which makes it attractive for commercial production. However, the thermal efficiency of the ejector is low which implies that the ejector requires a large solar collector and large condenser to operate in a heat pump application. Thus the savings in electricity consumption must be compared with the additional cost of the solar collector. One is trading capital cost for operating cost, as with most solar systems.

A liquid pump is required to generate a pressure difference for the ejector heat pump to operate, but since liquid is being compressed, the amount of electricity required is relatively small. All other components in the heat pump circuit are conventional.

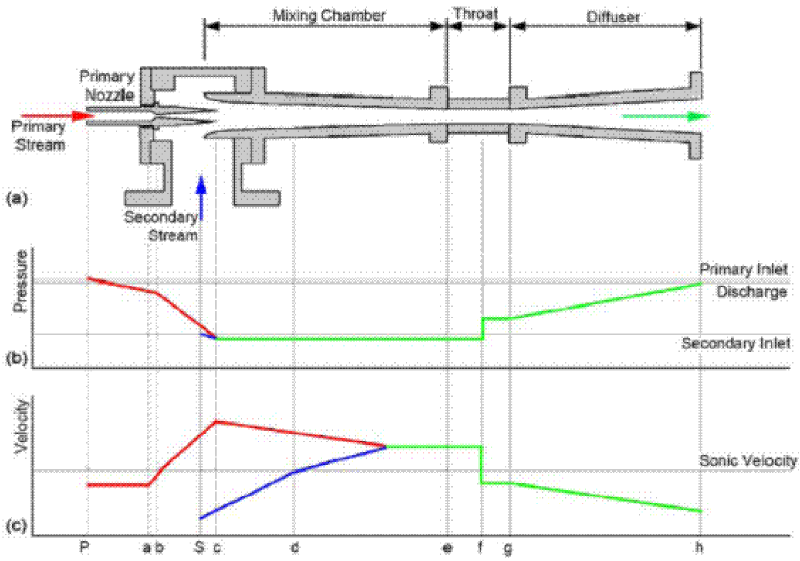

Figure 18 Typical ejector cross-section, pressure and velocity profiles along an ejector operating in critical mode. Primary, secondary and discharge streams are indicated in red, blue and green respectively. Adapted from Chunnamond & Aphornratana (2004) pump**.**

The ejector cycle consists of high and low temperature sub cycles. In the high temperature sub cycle, heat that is transferred to the ejector cycle from the heat source causes vaporisation of the ejector cycle working fluid in the generator at a temperature slightly above the saturation temperature of the refrigerant. Vapour then flows to the ejector where it is accelerated through a converging-diverging nozzle.

Since much of the vapour enthalpy is converted to kinetic energy, conservation of energy suggests that the vapour temperature and pressure will be very low. The low pressure at the exit of the nozzle acts to draw vapour flow from the evaporator (Figure 18,c).

The generator and evaporator flows then mix in the ejector and the combined flow undergoes a transverse compression shock (Figure 18,f). Thus thermal compression replaces the electrical compressor in a conventional heat pump. Further compression takes place in the diffuser such that a subsonic stream emerging from the ejector then flows into the condenser (Figure 18,h).

At the condenser, heat is rejected from the working fluid to the surroundings, resulting in a condensed refrigerant liquid at the condenser exit. The ejector needs to provide sufficient exit pressure such that the saturation temperature of the refrigerant at this point is greater than the condenser cooling medium, otherwise heat cannot be rejected and the cycle ceases to operate. This is the malfunction mode of the ejector, caused by excessive condensing backpressure. Malfunction can be overcome by supplying greater generator pressure and temperature.

Liquid refrigerant leaving the condenser is then divided into two streams; one enters the evaporator after a pressure reduction through the expansion valve, the other is routed back into the generator after undergoing a pressure increase through the refrigerant pump. The fluid is evaporated in the evaporator, absorbing heat from the air-conditioned environment, and then it is entrained back into the ejector completing the cycle.

Although figure 12 indicates a direct connection of the generator and solar array, there is usually an additional heat exchange circuit (Figure 19) in the high pressure loop to eliminate the possibility of two phase refrigerant flow in the solar collector. For readers familiar with p-h diagrams, Figure 19 clearly shows the high and low pressure ejector sub cycles.

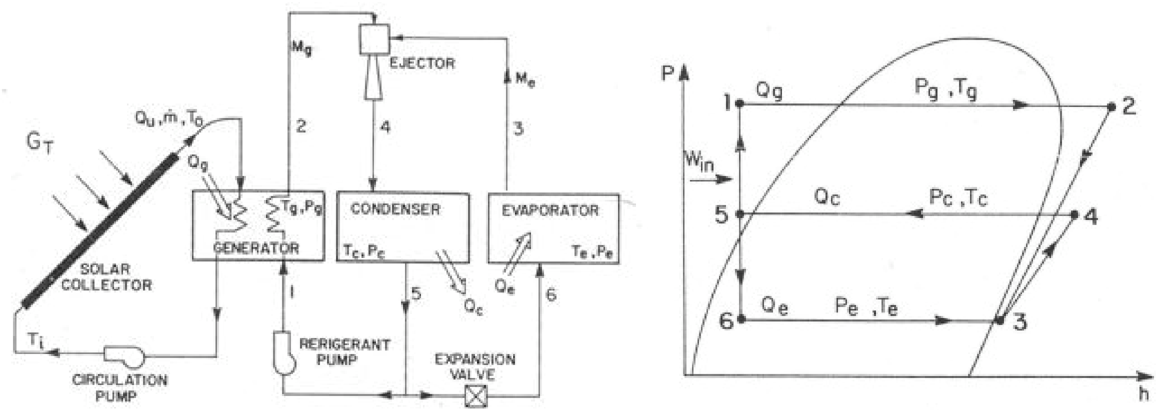

Figure 19 Solar powered ejector based solar cooling system (Sokolov, 1993).

Despite the complexity of internal operation, the ejector may still be considered to be a compressor and its performance may be defined conventionally by its compression ratio (P_c/P_e) and its isentropic efficiency. The ejector heat pump cycle still benefits from subcooling prior to evaporation and from minimizing superheating through compression.

The advantages of simplicity and reliability of the ejector will be apparent. Additionally, the ejector mechanism offers freedom of choice of refrigerant and is not complicated by the need for compressor lubricant compatibility. Also, the ejector is tolerant of liquid slugging since both generator and evaporator ports are essentially open tubes.

ST - PRODUCT

7	**Product/System**	**Experimental PVT Air System for Residential Dwellings**
	Institutes	UNSW (University of New South Wales) School of Photovoltaic and Renewable Energy Engineering
	Contact	Mark Snow - UNSW S. M. Bambrook: s.bambrook@student.unsw.edu.au Prof. Alistair Sproul: a.sproul@unsw.edu.au
	Reference	S. M. Bambrook, A. B. Sproul, *"Experimental PVT Air System for Residential Dwellings"* Solar2010, the 48th AuSES Annual Conference - 1-3 December 2010, Canberra, ACT, Australia

This is an initial result of an experimental of PVT air system including the ducts and a high efficiency fan in order to maximize the useful electrical and heat energy extracted. Experimental results compare the PVT performance at a zero air flow rate and at 0.06 kg/s.m^2. An increase in the electrical output of the PVT system is observed due to a decrease in the operating temperature of the mechanically ventilated photovoltaic modules. The PVT system design uses 6 PV modules integrated into a shallow rectangular insulated duct which is constructed of 50 mm thick extruded polystyrene sandwiched between galvanized steel sheets. Although not included as part of the simulations, 4 channels were added in the design for the duct beneath the PVT unit with the channel dividers serving two purposes: providing support for the frameless PV modules, and acting as fins to assist heat transfer from the module to the passing air stream. At the upper end of the PVT duct is simply a black metal cover and beneath this is a 500 mm diameter circular delivery duct. This was designed to produce similar air flow through each of the channels behind the PV modules. Semi-rigid 500 mm diameter ducting was used for the delivery duct and connected to a wall mounted, rigid duct section, within which the 300 mm diameter fan was installed.

Figure 20 Experimental PVT system

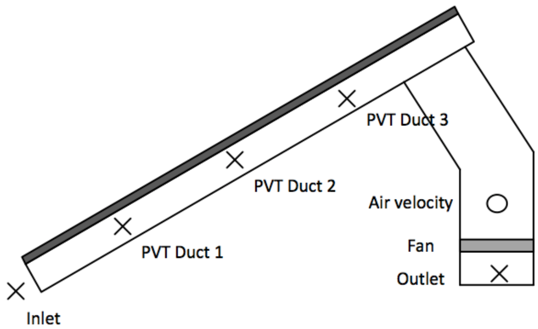

Figure 21 Schematic of thermocouple and air velocity sensor location

The major finding is that the electrical energy gained by cooling the PV modules was found to be greater than the energy consumed by the fan at an air flow rate of 0.06 kg/s.m^2. At this air flow rate, the 660 W_p array generated an electrical output of 3.2 kWh in addition to a heat energy output of 11.6 kWh on a sunny day in winter. Thermal and electrical efficiencies of the PVT system over a range of air flow rates are presented. The experimental PVT system is shown to have good potential for implementation into a residential dwelling for the purpose of electricity generation and space heating.

	0 kg/s.m^2	0.06 kg/s.m^2
Thermal output	0 kWh	11.6 kWh
Electrical output	2.9 kWh	3.2 kWh
Fan energy	0 kWh	0.1 kWh
Net Electrical output	2.9 kWh	3.1 kWh

Workshops, seminars and summer school

In this section, workshops and seminars organized or planned within Task 41 are presented stating the participant, organizer, date and title. Also presentations made by Task 41 participants to disseminate Task 41 on national conferences or seminars arranged by others are presented here.

Some of these initiatives have been organized in connection to Task 41 meetings during the three year Task. These occasions have given the opportunity to spread the Task's activities to practitioners and researchers and to find industrial interest in research in order to create partnerships and future developments. In particular these initiatives have been useful to inform, architects, consultants, municipalities, real estate owners as well as universities and product developers about existing and innovative criteria and guidelines of solar design (Subtask A), tools (Subtask B), examples of solar buildings (Subtask C). Moreover, innovative products developed by partnerships between universities, research institutes and companies as well as case studies showing innovative use of solar in architecture have been presented.

Another initiative was the "Montreal PhD Summer Workshop on Net-Zero Energy Solar Buildings: Theory, Modelling and Design" organized by Concordia University and the IEA SHC Task 40/ECBCS Annex 52 in cooperation with IEA SHC Task 41. This one week event included lectures and work together in a workshop during the last day.

Another workshop was the "Innovation School - ENERBUILD 2011" organized by EURAC, interesting for its organization and results. It was a student workshop that included a cycle of lessons with experts and one week internship in one of the different company partnerships of this initiative.

The AIT Austrian Institute of Technology organized a student workshop on building-integrated solar technology at the University of Applied Sciences Technikum within the master program Renewable Urban Energy Systems.

The NTNU (Norwegian University of Science and Technology) organized a series of workshops for practitioners and students in partnership with architects' offices.

In total 41 workshops, seminars and events organized in connection with Task 41 are listed in Table 2. Some of the events dealt with all the subjects within Task 41.

Country and Institutes	*Workshops and seminars*						
	Photovoltaic		*Solar Thermal*		*PV/ ST/Hybrid*		*Task 41*
	Arch.	Tech.	Arch.	Tech.	Arch.	Tech.	Diss.
Australia							**2**
The City of Melbourne, Sustainability Victoria, City West Water, Building Commission and AIRAH partner							1
IEA SHC & Australian PV Association (APVA) Australian Government and Sustainability Victoria							1
Austria							**2**
AEA (Austrian Energy Agency), ÖVI (Austrian Association of Real Estate Agents) GBV (Austrian non-profit building association)							1
AIT Austrian Institute of Technology, Architect's office pos architects, Wirtschaftsagentur Wien							1
Canada						**1**	
Department of Building, Civil and Environmental Engineering Concordia University (Solar Buildings Research Network)						1	
Germany							**2**
International Solar Energy Society - ISES							1
Bergische Universität Wuppertal HTW Berlin - University of Applied Sciences							1
Italy	**2**				**2**	**3**	
EURAC - European Academy of Bozen					2	3	
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development	2						
Norway	**7**						
Technologies - Dark Arkitekter AS Norwegian Architects Association (NAL) – Ecobox	2						
NTNU - Norwegian University of Science and Technology	5						
Portugal							**1**
Faculdade de Ciências e Tecnologia							1
Sweden	**1**			**1**			**11**
White Arkitekter, Lund University and others	1						11
White Arkitekter S-Solar manufacturer				1			
Switzerland						**6**	
SUPSI- Scuola universitaria professionale della Svizzera italiana BiSol- Building Integrated Solar Network ISAAC -Istituto sostenibilità applicata all'ambiente costruito EPFL - École Polytechnique Fédérale de Lausanne LESO - Laboratoire d'Energie Solaireet de Physique du Bâtiment						6	
Total	**10**			**1**	**2**	**10**	**18**

Table 2 Summary of the workshops and seminars organized by different institutes or universities participants in the Task 41 divided for topics: Architectural and/or technical for Photovoltaic, Solar Thermal, PV/ST/Hybrid and dissemination initiatives to promote the Task's works.

TECHNICAL AND ARCHITECTURAL WORKSHOP

1	**Title**	**"Il fotovoltaico integrato: verso edifici a bilancio energetico nullo"**
	Institute organizer	SUPSI - Scuola universitaria professionale della Svizzera italiana Dipartimento ambiente costruzione e design **Istituto sostenibilità applicata all'ambiente costruito**
	Date and place	June, 22nd, 2012 - Canobbio (Switzerland)

Figure 1 Flyer of the launch of initiative "Il fotovoltaico integrato: verso edifici a bilancio energetico nullo" in Switzerland - June, 22nd, 2012

ARCHITECTURAL WORKSHOP

2	**Title**	**"Bread & Environment" -** The lecture for architects I
	Institute organizer	Teknologien - Dark Arkitekter AS Norwegian Architects Association (NAL) - Ecobox Klaudia Farkas, NTNU about IEA Task 41-Solar Cells in Architecture
	Date and place	May, 2nd, 2012 - Oslo (Norway)

Figure 2 Flyer of the launch of initiative "Bread & Environment" in Oslo – May, 2nd, 2012 – Building in the picture: Energy Wall in Bejing designed by Simone Giostra

DISSEMINATION WORKSHOP

From 3 to 13	**Title**	**IEA Task 41 Solar energy and Architecture** Dissemination at national conferences and seminars
	Institute organizer	Elforsk (E) Linköpings Kommun (L) Lund University (LU) NCC Construction Sverige AB (N) Svenska Kyrkan (S) White Arkitekter (W) Participation of Marja Lundgren, White presenting IEA SHC Task 41 Energimyndigheten / Swedish Energy Agency (EM) Skånes Energiting 2011 (SE) Participation of Marie-Claude Dubois, LU and Marja Lundgren, White presenting IEA SHC Task 41 Energimyndighetens Energiutblick 2012 (EM) Presentation by Jouri Kanters , LU Energikontoret Skåne 2012 (ES) Presentation by Maria Wall, LU
	Date and place	April 20th, 2012 - Malmö, (ES) March 15th, 2012 - Gothenburg (EM February 10th , 2012 - Gothenburg (Sweden), (W) February 3rd , 2012 - Malmö (Sweden), (LU) November 30th , 2011 - Linköping (Sweden), (L) November 10th , 2011 -Stockholm (Sweden), (E) June 9th , 2011-Malmö (Sweden), (SE) November 10th , 2010 - Stockholm (Sweden), (E) October 12th , 2010 - Stockholm (Sweden), (S) June 4th, August 27th , 2009 -Stockholm, Gothenburg (Sweden), (N) May 27th-Stockholm, 2009 (Sweden), (W)


IEA Task 41 www.iea-shc.org/task41

ARKITEKTUR
& SOLENERGI

Om arkitektur och solenergi

Här kommer Sveriges första nyhetsbrev om Arkitektur och Solenergi, se bifogad pdf. Informationen kommer från ett internationellt forsknings- och utvecklingsprojekt med fokus på arkitektonisk integration riktat till samhällsbyggnads- och fastighetssektorns alla aktörer. Nyhetsbrevet kommer en gång i halvåret. Målet är att skriva brett om solenergi och arkitektur.

Om IEA SHC Task 41

International Energy Agency (IEA) är en fristående organisation som arbetar för att säkra tillförlitlig, kostnadseffektiv och ren energi för 28 medlemsländer. Inom programmet Solar Heating and Cooling bedrivs IEA Task 41: Solar Energy and Architecture som startade 2009. I Task 41 pågår nu en utveckling av riktlinjer och rekommendationer kring arkitektonisk integrering av solenergisystem. Målet är att ta fram riktlinjer för arkitekter samt visa exempel på god arkitektur med aktiv solenergi i ett internationellt perspektiv.

IEA Task 41 leds av Maria Wall vid Lunds Tekniska Högskola och den svenska delen koordineras av Marja Lundgren, White arkitekter. Svenskt deltagande i Task 41 finansieras av Energimyndigheten, ARQ och Arkus.

Trevlig läsning och skön sommar!

Energimyndigheten ARQ Arkus LUNDS UNIVERSITET white SHC

Figure 3 Info flyer for IEA SHC Task 41 "Arkitektur & Solenergi" in Sweden 2009- 2012

ARCHITECTURAL WORKSHOP

14	**Title**	**"Fotovoltaico e Preesistente. Spunti di discussione sull'impiego del fotovoltaico nelle città e nel paesaggio"**
	Institute organizer	ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development Participation of EURAC with presentation "Preservare ed innovare: Esperienze di ricerca internazionali" describing also Task 41 activities.
	Date and place	March, 22nd, 2012 - Naples (Italy) - Energy MED

Figure 4 Flyer of the launch of initiative "Fotovoltaico e Preesistente. Spunti di discussione sull'impiego del fotovoltaico nelle città e nel paesaggio"

ARCHITECTURAL and DISSEMINATION WORKSHOP

15	**Title**	**"Fotovoltaico integrato: la sfida per gli edifici del futuro"**
	Institute organizer	EURAC - European Academy of Bozen Participation of Francesco Frontini - SUPSI with a presentation on Task 41 activities "Occasioni internazionali di ricerca: il progetto IEA Task 41 Solar Energy and Architecture"
	Date and place	January, 26th, 2012 - Bolzano (Italy) - Klimahouse

Figure 5 Flyer of the seminar in the context of Klimahouse "Fotovoltaico integrato: la sfida per gli edifici del futuro" in Bolzano on the 26th of January 2012

TECHNICAL WORKSHOP

16	**Title**	**"Innovation School - ENERBUILD 2011: Verso edifici produttivi e a basso consumo energetico"**
	Institute organizer	EURAC - European Academy of Bozen Participation of Francesco Frontini - SUPSI with presentation "Integrazione di tecnologie solari nell'involucro edilizio: BIPV e BIST (Building Integrated Photovoltaics and Solar Thermal)
	Date and place	From September 22nd to December 02nd, 2011- Bolzano (Italy)

Figure 6 Flyer of the launch of initiative "Innovation School – ENERBUILD 2011: Verso edifici produttivi e a basso consume energetico" from September 22nd to December 02nd, 2011

DISSEMINATION AND ARCHITECTURAL WORKSHOP

17	**Title**	**"Arkitektur & Solenergi"** IEA SHC Task 41. Public seminar presenting the Task 41 work
	Institute organizer	White Arkitekter et al.
	Date and place	November 17th, 2011- Stockholm (Sweden)

Figure 7 Flyer of the launch of initiative "Arkitektur & Solenergi" in Stockholm on November 17th, 2011

TECHNICAL WORKSHOP

18	**Title**	**“Latest International Solar Technologies for Buildings Seminar”**
	Institute organizer	IEA SHC & Australian PV Association (APVA) Australian Government and Sustainability Victoria
	Date and place	September 29th , 2011 - Melbourne (Australia)

Figure 8 Flyer of the launch of initiative “Latest International Solar Technologies for Buildings Seminar” in Melbourne on September 29th, 2011

TECHNICAL WORKSHOP

19	**Title**	**“International Best Practice and the International Energy Agency”**
	Institute organizer	The City of Melbourne, Sustainability Victoria, City West Water, Building Commission and AIRAH partner
	Date and place	September, 28th , 2011 - Melbourne (Australia)

Figure 9 Flyer of the launch of initiative “International Best Practice and the International Energy Agency” on September 28th, 2011

TECHNICAL WORKSHOP

20	**Title**	**“Da un concetto ad un risultato concreto: edifici a risparmio energetico e produttivi, che integrano fonti energetiche rinnovabili”**
	Institute organizer	EURAC - European Academy of Bozen
	Date and place	September 23th, 2011 - Bolzano (Italy) - Klimaenergy

EURAC education

Seminario

Da un concetto ad un risultato concreto: il “Net Zero Energy” per gli edifici futuri

Figure 10 Flyer of the launch of initiative “Da un concetto ad un risultato concreto: edifici a risparmio energetico e produttivi, che integrano fonti energetiche rinnovabili” in Bolzano in the context of Klimaenergy fair 2011

ARCHITECTURAL WORKSHOP

21	**Title**	**ISES Solar World Congress; Presentation in the subject area *Solar Buildings*: “Tools and Methods for Solar Building Design: Results of IEA Task 41 International Survey”**
	Institute organizer	International Solar Energy Society -ISES Presentation by German Task 41 participants.
	Date and place	August 28th - September 2nd 2011, Kassel (Germany)

Figure 11 Venue of the ISES SWC 2011 – Kongress Palais Kassel (© Kassel Marketing GmbH)

TECHNICAL WORKSHOP

22	**Title**	**"Modern - Construction Workshop"** Presentation and discussion of the IEA Task 41 project,
	Institute organizer	AEA (Austrian Energy Agency), ÖVI (Austrian Association of Real Estate Agents) and GBV (Austrian non-profit building association)
	Date and place	July 5th, 2011 - Vienna (Austria)

Figure 12 Association that organized the"Modern - Construction Workshop" in Vienna on the 5th July, 2011

TECHNICAL WORKSHOP

23	**Title**	**"CRSEEL 2011; Conference on sustainable construction including solar technologies"**
	Institute organizer	FCT/UNL et al.
	Date and place	May, 18th , 2011 -University Campus, Caparica, Caparica (Portugal)

Figure 13 Flyer of the launch of initiative "CRSEEL 2011; Conference on sustainable construction including solar technologies" on May 18th, 2011

TECHNICAL AND ARCHITECTURAL WORKSHOP

24	**Title**	**“Architectural integration of PV and solar thermal panels – best practice examples”**, presentation at the project workshop for the plus energy building concept study “Futurebase” in Vienna
	Institute organizer	AIT (Austrian Institute of Technology), Architect's office pos architects, Wirtschaftsagentur Wien.
	Date and place	May 2nd, 2011 - Vienna (Austria)

Figure 14 Institute and architect office that organized the initiative “architectural integration of PV and solar thermal panels – best practice examples”, project workshop “Futurebase” in Vienna on the 2nd May, 2011

ARCHITECTURAL and DISSEMINATION SEMINAR

25	**Title**	**“Solar Energy and Architecture - Knowledge and inspiration”**
	Institute organizer	Dark Arkitekter AS
	Date and place	April 1st, 2011 - Oslo (Norway)

Figure 15 Flyer of the launch of initiative “Photovoltaics, forms, landscapes” of the 26th EUPVSEC on the 6th of September 2011

TECHNICALWORKSHOP

26	**Title**	**“Montreal PhD Summer Workshop on Net-Zero Energy Solar Buildings: Theory, Modelling and Design”**
	Institute organizer	Concordia University and IEA SHC Task 40/ECBCS Annex 52 (in cooperation with IEA SHC Task 41)
	Date and place	June, 20 - 25th , 2011 - Montreal (Canada)

Figure 16 Flyer of the launch of initiative “Montreal PhD Summer Workshop Net-Zero Energy Solar Buildings: Theory, modeling, and Design”, on the 20-25th, June 2011

ARCHITECTURAL WORKSHOP

27	**Title**	**“Photovoltaics, forms, landscapes”**
	Institute organizer	ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
	Date and place	September, 6th, 2011 - Hamburg - 26th EUPVSEC (Germany) Next edition: September, 25th, 2012 - Frankfurt – 27th EUPVSEC (Germany) - information available at: www.pv-landscapes.com

Figure 17 Flyer of the launch of initiative “Photovoltaics, forms, landscapes” of 26th EUPVSEC on the 6th of September 2011

ARCHITECTURAL WORKSHOP

From 28 to 32	**Title**	**“Formal characteristic of photovoltaics”** **5 Workshops on architectural integration of photovoltaics**
	Institute organizer	NTNU (Norwegian University of Science and Technology) 1th Workshop at DARK Architects; 2nd Workshop at ARC Architects; 3rd Workshop at Lund and Hagem Architects; 4th Workshop at Bergersens Architects; 5th Workshop at LPO Architects.
	Date and place	From March to October 2010 - Trondheim and Oslo (Norway)

Figure 18 Flyer of the launch of initiative “Formal characteristic of photovoltaics”, from March to October 2010

TECHNICAL WORKSHOP

33	**Title**	**A new generation façades providing cooling and heating** Workshop with Real Estate holders on their expectations on solar thermal as a façade component
	Institute organizer	White Arkitekter (W) S-Solar manufacturer
	Date and place	December16th - Stockholm, 2010 (Sweden), (W)

Figure 19 Workshop on product development with Real Estate holders, arranged by White and product manufacturer S-Solar, for which the participation and knowledge in IEA Task 41 has been of great importance

ARCHITECTURAL WORKSHOP

34	**Title**	**“Seminario - Energia solare e architettura - casi studio nazionali di edifici ed aree urbane”**
	Institute organizer	EURAC - European Academy of Bozen ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
	Date and place	September, 23rd, 2010 - Bolzano (Italy) - Klimaenergy

Figure 20 Flyer of the seminar in the context of Klimaenergy fair in Bolzano on the 23rd of September 2010

TECHNICAL WORKSHOP

35	**Title**	**“Quality and reliability of building integrated photovoltaic modules and thermal collectors”**
	Institute organizer	SUPSI -BiSol- IEA SHC Task 41 - ISAAC - EPFL - LESO
	Date and place	August, 23th – 24th , 2010 Lugano (Switzerland)

Figure 21 Flyer of the launch of initiative “Quality and reliability of building integrated photovoltaic modules and thermal collectors” on the 23th – 24th of August 2010

TECHNICAL SEMINAR

36	**Title**	**“Forms of Energy”**
	Institute organizer	ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, in collaboration with Domus, EURAC ,InArch and IED
	Date and place	June, 10th, 2010 Rome (Italy)

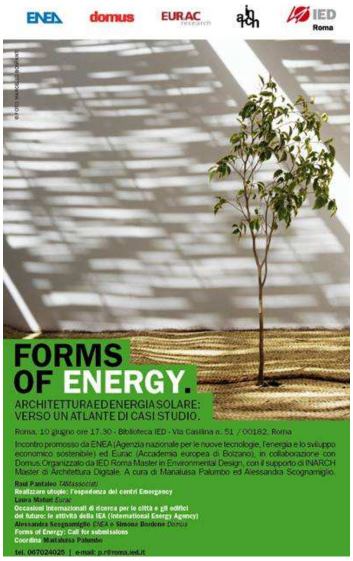

Figure 22 Flyer of the launch of initiative “Forms of Energy”, Rome on the 10th of June 2010

ARCHITECTURAL WORKSHOP

37	**Title**	**“Progettazione integrata e architettura solare - Verso edifici a bilancio energetico nullo”**
	Institutes organizer	EURAC- European Academy of Bozen
	Place and date	March, 19th, 2010 - Bolzano (Italy)

Figure 23 Flyer of the workshop in Bolzano on the 19th of March 2010

TECHNICAL WORKSHOP

38	**Title**	**“Opportunities of collaboration between the BUILDING and SOLAR sectors”**
	Institute organizer	SUPSI -BiSol- IEA SHC Task 41 - ISAAC - EPFL - LESO
	Date and place	February, 01st – 02nd , 2010 - Trübbach (Switzerland)

Figure 24 Flyer of the launch of initiative “Opportunities of collaboration between the BUILDING and SOLAR sectors” on the 1st - 2nd of February 2010

DISSEMINATION WORKSHOP

39	**Title**	**“Public Presentations Day Task 40 & 41”**
	Institute organizer	Bergische Universität Wuppertal, HTW Berlin – University of Applied Sciences, organized as part of the Task 40 and Task 41 Task Meetings.
	Date and place	October 7th 2009 St. Paul’s Church on the campus of University of Wuppertal (Germany)

Figure 25 Task 40 and Task 41 participants

TECHNICAL WORKSHOP

40	**Title**	**"Interactive tools and assistance for the architectural integration of solar installation"**
	Institute organizer	SUPSI - BiSol
	Date and place	November, 16 - 17th, 2009 Lugano (Switzerland)

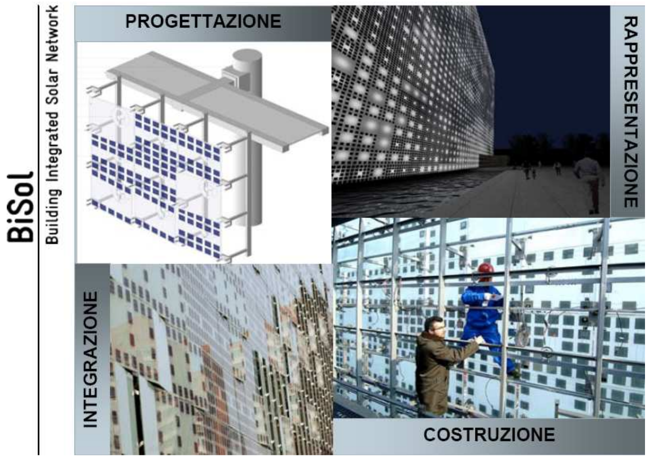

Figure 26 Flyer of the launch of initiative "Interactive tools and assistance for the architectural integration of solar installation" on the 16th – 17th of November 2009

TECHNICAL WORKSHOP

41	**Title**	**"Facilitate the acceptance of solar installation in the built environment"**
	Institute organizer	SUPSI -BiSol- IEA SHC Task 41 - ISAAC - EPFL - LESO
	Date and place	March, 23th – 24th , 2009 - Luzern (Switzerland)

Figure 27 Flyer of the launch of initiative "Facilitate the acceptance of solar installation in the built environment" on the 23th - 24th of March 2009

Apart from workshops and seminars, university courses have been carried out on solar energy, the use of solar technologies and products in buildings and to spread Task 41 results. Examples of university courses are presented below:

UNIVERSITY COURSE

1	**Course**	**Specialization course program on "Interactive Energy façade" in Master program Renewable Urban Energy Systems of the University of Applied Sciences Technikum Vienna**
	Institute organizer	**University of Applied Sciences Technikum with an expert from AIT** Austrian Institute of Technology (Sustainable Building Technologies)
	Period	Winter term 2011/12
	Topic	Design course for the development of an interactive solar façade system for refurbishments including aspects for - Architectural design criteria for BiPV, - Use of planning tools in the early planning stage, - Analyses on best-case examples of successful building integrated PV-projects.

Figure 28 Logo of the UAS Technikum Vienna and of the AIT Austrian Institute of Technology that have been organized the course on Renewable Urban Energy Systems

UNIVERSITY COURSE

2	**Course**	**Solar energy**
	Institute organizer	Institute of Heat Engineering at the Technical University of Graz
	Period	Winter term 2010/11
	Topic	The best practice examples worked out in the IEA Task 41 were included within the lecture content.

Figure 29 Logo of the Institute of Heat Engineering at the Technical University that organized the course on “Solar energy”.

UNIVERSITY COURSE

3	**Course**	**Master studio about historical buildings and the integration of solar energy technologies**
	Institute organizer	Technical University of Graz Institute of Building Structure and Housing Construction Theory
	Period	Winter term 2010/11
	Topic	The IEA Task 41 best practice examples of solar integration have been presented and discussed.

Figure 30 Logo of the Institute of Heat Engineering at the Technical University that has organized the “Master studio about historical buildings and integration of solar energy technologies”.

UNIVERSITY COURSE

4	**Course**	**“Solares Bauen”**
	Institute organizer	HTW – University of Applied Sciences, Berlin Part of the bachelor’s study program “Environmental Engineering/ Renewable Energy Systems”
	Period	Since 2009 including Task 41, every semester for bachelor students, HTW Berlin.
	Topic	Solar Building

Figure 31 Logo of the University of Applied Sciences that organized the study program “Environmental Engineering/Renewable Energy Systems”

UNIVERSITY COURSE

	Course	**“Interdisziplinäre Rahmenbedingungen und solare Architektur”**
5	**Institute organizer**	HTW – University of Applied Sciences, Berlin Part of the master’s study program “Environmental Engineering/ Renewable Energy Systems”
	Period	Since 2009 including Task 41, every semester for master students, HTW Berlin.
	Topic	Interdisciplinary General Requirements and Solar Architecture

Figure 32 Logo of the University of Applied Sciences that organized the study program “Environmental Engineering/Renewable Energy Systems”