IEA SHC Task 35 “PV/Thermal Solar Systems”

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ABSTRACT: A PhotoVoltaic/Thermal module, or PV/T module, is a combination of photovoltaic cells with a solar thermal collector, forming one device that converts solar radiation into electricity and heat simultaneously. PV/T modules can generate more energy per unit surface area than a combination of separate photovoltaic panels and solar thermal collectors.
On 1 January 2005, a three-year research work – Task 35 "PV/Thermal Solar Systems" – was initiated as part of the IEA Solar Heating and Cooling Programme. The objectives of this Task are to catalyse the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector.
Activities in the Task are now well under way and include international collaboration on scientific, architectural and commercial aspects with current participation of research and test institutes, manufacturers, consulting engineers and universities from Canada, Denmark, Greece, Hong Kong, Israel, Italy, The Netherlands, South Korea, Spain and Sweden.

KEYWORDS: IEA, SHC, Task 35, PV/Thermal Solar Systems.

1 Introduction

A PV/Thermal Solar System is a combination of photovoltaic components/systems and solar thermal components/systems which produce both electricity and heat from one integrated component or system.

The heart in a PV/Thermal Solar System is a PhotoVoltaic/Thermal module, or PV/T module which is a combination of photovoltaic cells with a solar thermal collector, forming one device that converts solar radiation into electricity and heat simultaneously. As a result, PV/T modules can generate more energy per unit surface area than side by side photovoltaic panels and solar thermal collectors, at a potentially lower production and installation cost. Moreover, PV/T modules share the aesthetic advantage of PV. Because of their high efficiency per unit surface area, PV/T is particularly well suited for applications with both heat and power demand and with limited roof space available. Therefore, the potential of PV/T is especially large in the residential market, both collective and individual. [1]

There are many ways to combine the different PV and Solar Thermal technologies to a PV/T collector: crystalline or amorphous silicon or thin-film PV, liquid or air collectors, flat-plate or concentrating technologies with or without transparent cover, some fully building integrated. So far, most development has been done on silicon technologies with liquid and air, flat-plate type collectors. Furthermore, work has been done on concentrating and combined liquid/air PV/T collectors and on building integrated systems for preheating of e.g. ventilation air. [2]

2 PV/T collector examples

A number of PV/T collectors in different categories are commercially available. The collectors can be divided into the following categories:

- PV/T liquid collector

- PV/T air collector
- PV/T concentrator
- Ventilated PV with heat recovery

Several manufacturers have participated in the development, production and marketing of various PV/T collectors in all the above mentioned categories. However, the number of commercially available collectors is still limited and long-term experiences with operation of the collectors are scarce.

The PV/T liquid collectors can be subdivided into glazed and unglazed collectors. Several manufacturers have focused on commercialisation of glazed PV/T liquid collectors and a commercial product, *PVTWIN*, has recently become available in different sizes and materials from the Dutch manufacturer, PVTWINS, see Figure 1. The manufacturer also produces an unglazed PV/T collector. For some years, another unglazed PV/T collector, *MSS® Multi solar panel*, has been available from the Israeli manufacturer, Millenium Electric T.O.U. Ltd.

Figure 1: PV/T liquid collector – PVTWIN from PVTWINS.

Three commercial PV/T air collector manufacturers exist on the market today. The company, Grammer Solar GmbH (GE), has two different products, *TWINSOLAR* and *PV-Hybridkollektor*. Aidt Miljø A/S Solar Heating (DK) markets the product, *SolarVenti*, and Conserval Engineering, Inc. (CA) has the products, *Solarwall* and *SolarRoof*, see Figure 2. Apart from the summer cottage market, the number of PV/T air collectors installed is very small.

Figure 2: PV/T air collector – SolarRoof from Conserval Engineering Inc. mounted on Chewonki Center for Environmental Education, Wiscasset, Maine, USA.

For PV/T concentrators, there are three commercial manufacturers. Menova Energy Inc. (CA) markets the non-tracking collector, *Power-Spar*, available in different sizes and configurations, and the companies, Arontis Solar Solutions (SE) and HelioDynamics Ltd. (UK), market the tracking concentrators, *Solar8*, see Figure 3, and *Harmony™ HD211* respectively.

Figure 3: PV/T concentrator – Solar8 from Arontis Solar Solutions.

Various projects with PV/T systems in the category ventilated PV with heat recovery have been carried out. The systems typically have emerged from specific solutions for specific buildings, where the primary focus

has been building integration of PV and where the need for ventilation of the PV-systems in order to maximise the electrical yield has been combined with utilisation of this heat for preheating of ventilation air, space heating or similar [3]. Attempts have been made to standardise the design of such systems and one Italian manufacturer, Secco Sistemi, has a commercially available system, *TIS*, see Figure 4.

In Table 1 a complete overview of the manufacturers of commercially available PV/T collectors can be seen.

Figure 4: Ventilated PV with heat recovery – TIS from Secco Sistemi mounted on Centro Ricerche Fiat di Orbassano, Torino, Italy.

Manufacturers:	**Country**	**Website:**
PVTwins	The Netherlands	http://www.pvtwins.nl/
Millenium Electric T.O.U. Ltd.	Israel	http://www.milleniumsolar.com/
Grammer Solar	Germany	http://www.grammer-solar.de/photovoltaik/pv_hybrid.shtml
Aidt Miljø A/S Solar Heating	Denmark	http://www.aidt.dk
Conserval Engineering, Inc.	Canada	http://www.solarwall.com/roof/roof.html
Menova Energy Inc.	Canada	http://www.power-spar.com/
Arontis Solar Solutions	Sweden	http://www.arontis.se
HelioDynamics Ltd.	United Kingdom	http://www.hdsolar.com/
Secco Sistemi	Italy	http://www.seccosistemi.it/solar

Table 1: Manufacturers of commercially available PV/T collectors.

3 Outlook

PV/T is a very promising technology, it has a large potential and PV/T systems can be applied in a large part of the present solar thermal market, including domestic hot water systems.

In the short term, multi-family buildings may be an important market, due to the limited roof area available per household, which promotes area efficient renewable energy applications.

In the medium and long term, the most promising application for PV/T systems seems to be domestic water heating and space heating. For space heating, it is especially true for advanced houses aiming to cover a large part of the energy needs with solar energy. Combination of a heat pump and PV/T could be a promising concept.

In the long term, professional application (industry, agriculture) and applications such as solar cooling will become interesting for PV/T. [3]

The most important challenges in order to ensure a successful implementation of PV/T to the market are to agree on performance and reliability standards for PV/T. Furthermore, work has to be done to increase the optical and thermal efficiency and the long-term reliability of PV/T. It is also necessary to develop solutions so PV/T can become an integral part of the building design ensuring an easy integration into the building construction and the heating and electrical systems. [3]

4 IEA SHC Task 35

On January 1st, 2005, a three-year research work – Task 35 "PV/Thermal Solar Systems" – was initiated as part of the International

Energy Agency (IEA) Solar Heating and Cooling (SHC) Programme. The objectives of this Task are to catalyse the development and market introduction of high quality and commercial competitive PV/Thermal Solar Systems and to increase general understanding and contribute to internationally accepted standards on performance, testing, monitoring and commercial characteristics of PV/Thermal Solar Systems in the building sector.

The Danish Energy Authority, acting through Henrik Sørensen, Esbensen Consulting Engineers A/S, Denmark, is designated as Operating Agent for the Task. Björn Karlsson, Lund University, Sweden, is, sponsored by the Swedish Energy Agency, Subtask leader for Subtask C.

The task is organised in 5 subtasks, each focusing on the key issues identified being important to meet the overall objective of the task.

In **Subtask A: Market and Commercialisation of PV/T** the objectives are to investigate and identify the critical design parameters and commercial performance criteria, which determine the targets and conditions for successful new components and systems. The objectives will be achieved by the conduction of a market survey of potential markets for PV/Thermal Solar Systems in the participating countries and identification of the primary commercial parameters.

The objectives of **Subtask B: Energy Analysis and Modelling** are to provide the necessary understanding of the energy transfer processes in PV/Thermal Solar Systems in order to define, to model and to predict the energy performance of the systems separately and in a whole building context.

In **Subtask C: Product and System Development, Tests and Evaluation** the aims are to develop, test and evaluate PV/Thermal Solar System components and concepts and the experiences from products and components already on the market. The work includes R&D-activities in close collaboration with manufacturers of PV/Thermal Solar Systems in order to improve overall performance and solve generic problems with existing concepts and components.

The aims of **Subtask D: Demonstration Projects** are to gain the knowledge from full-scale demonstration of PV/Thermal Solar Systems in order to verify and identify the potential for improvement of energy performance, expectations to reliability, durability and economical feasibility. This will be achieved by dialogue with project stakeholders, monitoring of selected projects and facilitation of workshops for design teams and task participants.

Finally, the objectives of **Subtask E: Dissemination** are to provide efficient and targeted information of the task results to all stakeholders of the Task and to make this information available to the target audiences through various media and formats according to the preferences of the target audience.

4.1 Results so far

Activities in the Task are now well under way and include international collaboration on scientific, architectural and commercial aspects with current participation of research and test institutes, manufacturers, consulting engineers and universities from Canada, Denmark, Greece, Hong Kong, Israel, Italy, The Netherlands, South Korea, Spain and Sweden. The main results for the different Subtasks are listed in the following:

Subtask A – Market and Commercialisation:

A compilation of several existing market surveys regarding PV, Solar Thermal and PV/T has been drafted to the Task experts. At the same time the planning of a market survey within the framework of IEA SHC Task 35 has been initiated.

An overview of commercially available PV/T collectors has been drafted to the experts and when the document is completed it will be made available at the public website.

The document will be updated every half year.

The drawing up of a document dealing with identification of key persons/groups in the PV/T market is on-going.

A review of the deliverable, *D3-5: PV-Thermal systems marketing and R&D roadmap* from the EU-project PVTF, which is part of the cluster project PV Catapult, has been initiated. The Task experts have here been asked to provide input to whether the conclusions in the deliverable are valid for their respective countries.

Subtask B – Energy analysis and modelling: The preparation of the deliverable DB1: *Report on heat transfer models and electrical performance of PV/Thermal Solar Systems* has been started. Here an investigation of already available simulation models, TRNSYS components and theoretical models is being described and the document will be relevant to all experts interested in starting modelling PV/Thermal Solar Systems.

Subtask C – Product and system development, test and evaluation:

Categorisation of PV/T collectors has been initiated and the overview of PV/T collectors and projects initiated by IEA PVPS Task 7, activity 2.5 and continued by the IEA SHC PVPS Joint Working Group on PV/Thermal Solar Systems has been updated.

Investigation of the needs for development of PV/T-systems, -components and -control strategies has been performed by asking industry, manufacturers and designers. Only few answers have been received and therefore mainly the experience from the participating Task experts will be used in the further work in this area.

Important input has been provided to the PV Catapult deliverable D8-6: *PVT performance measurement guidelines* and the document deals with performance testing issues for liquid cooled non-concentrating PV/T collectors. From this work it will be possible to characterise a PV/T collector in such a way that the annual energy production, both thermal and electrical, can be predicted for any given site.

A number of PV/T collectors will be tested at various laboratories during 2006 in order to achieve a much better understanding of the performance of already existing systems.

Subtask D – Demonstration projects:

Interviews with stakeholders for already realised PV/T projects have been planned and are now being initiated on a national basis. The interviews will be used to give general recommendations on future demonstration projects and will also give information of whether monitoring results are available or/and whether it is possible to monitor in the context of Task 35.

There are also activities focusing on the identification and initiation of new demonstration projects allowing for monitoring and comparison with simulated performance of the systems in accordance with the findings in the Task. An advertisement will be made at the official Task website to help locating suitable host(s) for demonstration of a particular PV/T technology or –system.

Subtask E – Dissemination: An article presenting an overview of PV/Thermal Solar Systems and the research work IEA SHC Task 35 has been drawn up in the middle of April 2006 for the Austrian journal "erneuerbare energie". The journal reports about research and development in the field of renewable energies.

The official Task website http://www.iea-shc.org/task35 is continuously being updated and in April 2006 the website has been renewed and undergone graphical changes in order to be more attractive and professionally looking.

4.2 How to join

National experts can be assigned to participate in the Task from both SHC and PVPS (Photovoltaic Power Systems) Executive Committee members (www.iea-

shc.org or www.iea-pvps.org). The Task welcomes all experts who would like to join and contribute to the Task – especially industries working in this field are invited to contribute to the planning of the activities and asking the important questions to be dealt with seen from their perspective. Everybody with the interest in PV/Thermal Solar Systems are invited to contact Project Manager Jan Hansen, Esbensen Consulting Engineers A/S, j.hansen@esbensen.dk, +45 3326 7308 or Operating Agent Henrik Sørensen, Esbensen Consulting Engineers A/S, h.soerensen@esbensen.dk, +45 3326 7304, to discuss participation and exchange of information.

More information on the project can be seen at www.iea-shc.org/task35

5 Acknowledgements

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6 References

[1] Marco Bakker, Wim van Helden, Herbert Zondag and Marcel Elswijk, Energy Research Centre of the Netherlands ECN, *"PVT RESEARCH AT ECN"*, Paper presented at European Conference and Cooperation Exchange on Sustainable Energy Systems for Buildings and Regions, 2005.

[2] W.G.J. van Helden, Research Centre of the Netherlands ECN, *"E3-1 Introduction PVT first draft primer for PVT presentation material templates"*, draft paper made in IEA SHC Task 35, 2006.

[3] H.A. Zondag, W.G.J. van Helden, M. Bakker, *"D3-5: PV-Thermal systems marketing and R&D roadmap"*, Deliverable of the EU project PV Catapult – Contract n° 502775 (SES6), Energy Research Centre of the Netherlands ECN, 2006.