
Main RD&D issues for PVT – A manufacturer’s perspective

Report DC2 of IEA SHC Task 35 on PV/Thermal Solar Systems

February 2008

FINAL DRAFT

Report compiled by:

H.A. Zondag,
Energy research Centre of
the Netherlands (ECN)



Report DC2 of subtask C

**Main RD&D issues for PVT
A manufacturer's perspective**

By

Herbert Zondag
Energy research Centre of the Netherlands (ECN)





IEA Solar Heating and Cooling Programme

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

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

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

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

A total of 39 Tasks have been initiated, 30 of which have been completed. Each Task is managed by an Operating Agent from one of the participating countries. Overall control of the program rests with an Executive Committee comprised of one representative from each contracting party to the Implementing Agreement. In addition to the Task work, a number of special activities—Memorandum of Understanding with solar thermal trade organizations, statistics collection and analysis, conferences and workshops—have been undertaken.

Final draft – March 2008

The Tasks of the IEA Solar Heating and Cooling Programme, both underway and completed are as follows:

Current Tasks:

Task 32	<i>Advanced Storage Concepts for Solar and Low Energy Buildings</i>
Task 33	<i>Solar Heat for Industrial Processes</i>
Task 34	<i>Testing and Validation of Building Energy Simulation Tools</i>
Task 35	<i>PV/Thermal Solar Systems</i>
Task 36	<i>Solar Resource Knowledge Management</i>
Task 37	<i>Advanced Housing Renovation with Solar & Conservation</i>
Task 38	<i>Solar Assisted Cooling Systems</i>
Task 39	<i>Polymeric Materials for Solar Thermal Applications</i>

Completed Tasks:

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

Completed Working Groups:

CSHPSS, ISOLDE, Materials in Solar Thermal Collectors, and the Evaluation of Task 13 Houses

To find Solar Heating and Cooling Programme publications and learn more about the Programme visit www.iea-shc.org or contact the SHC Executive Secretary, Pamela Murphy, e-mail: pmurphy@MorseAssociatesInc.com.

September 2007

Introduction

In the EU project PV-Catapult, that was carried out during the period 2003-2005, a roadmap for the marketing and R&D of PVT was carried out. Within IEA SHC task 35, it was decided to find if the recommendations and conclusions presented therein would have a broader validity than Europe alone, and if the vision of the PVT manufacturers contributing to the task was in agreement with these conclusions. In the present document, an overview is presented of the issues mentioned by 4 manufacturers and this is compared to the conclusions in the PVT roadmap.

In chapter 7 of the PV-Catapult roadmap on PVT [1], a number of issues have been identified as being of importance to the development of PVT. The issues were split up in three groups; general issues (e.g. certification, awareness and financing), technical issues (thermal efficiency, stagnation temperature resistance and solar cell performance) and integration issues (aesthetics, plug-and-play, design tools, system integration).

In IEA SHC task 35, 4 manufacturers (PVTWINS, Sunwatt, Arontis and Millennium Electric) have indicated which issues are seen by them as the most important. In general, it was found that in their answers Arontis and Sunwatt focused on the technical aspects, while Millennium Electric and PVTWINS focused more on the marketing issues.

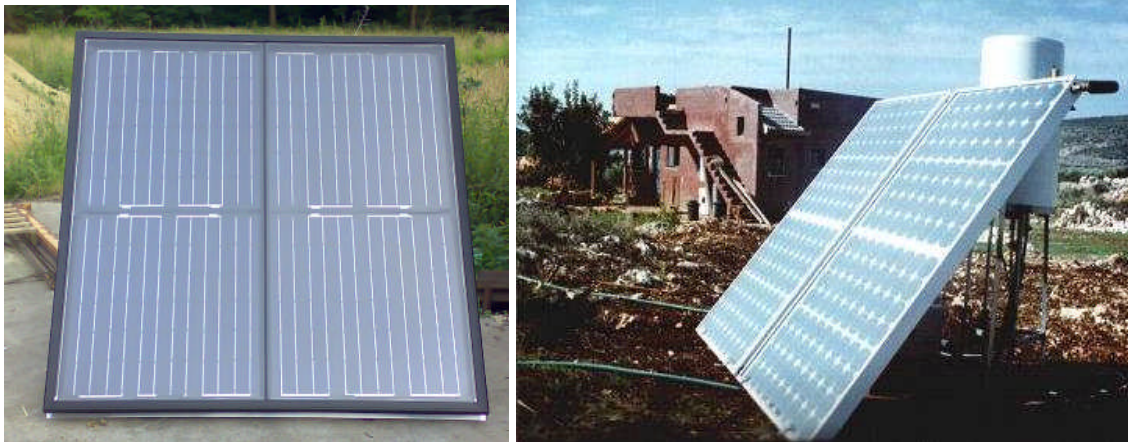


Figure 1: PVTWINS module (left), Millennium Electric module (right)



Figure 2: Arontis module (left), Sunwatt module (right)

General issues

Millennium Electric emphasizes the importance of realized projects in cooperation with the solar industry. It is indicated that more realized projects would lead to more companies active in this market and more innovative solutions for integration issues and practical problems. In order to realize demonstration projects, they indicate as very important that incentives for PVT research and PVT demonstration projects would be available.

PVTWINS indicates that the importance of the different issues (certification, subsidies, training etc) depends very much on the phase in which the product development is, which, according to PVTWINS, for PVT is presently the preparation phase (see Figure 3). In this stage, the most important issues to realize a market are introduction projects, which are projects carried out in a protective niche (together with motivated project partners to learn from experiences in a protective environment in which some mistakes are still allowed). For these projects dedicated subsidies should be available. PVTWINS indicated that in the preparation phase, the product will not yet be certified, due to the high costs and the inflexibility of a full certification with respect to variations in size or PV-type, and the project partners should be willing to accept this. Also, the project partners should be willing to accept a limited warranty (e.g. 1 year product warranty and 5 year power warranty). If such projects are carried out and conditions such as awareness generation and cost effectiveness are fulfilled (together with integration issues such as easy installation and aesthetics), more interest will develop in time. In the speeding up phase, consumer subsidies and more extensive warranties become important, as well as the development of documentation for installers etc.

Arontis emphasizes the importance of a specific PVT subsidy to help this emerging technology. They suggest that a specific PVT subsidy could be part of the feed-in tariff structure; at present some countries have a higher feed-in tariff for building integrated PV, and similarly an even higher tariff could be defined for PV systems in which the heat is also used.

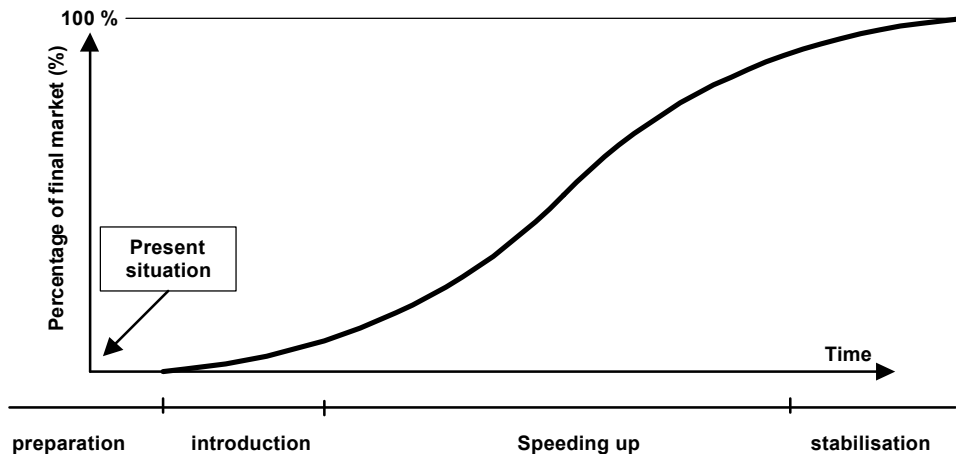


Figure 3: Phases in market development.

Technical issues

Arontis indicated that issues such as the resistance to stagnation temperature, an optimal heat transfer between PV and the collector liquid without compromising the electrical insulation, and highly absorbing solar cells are very important, and that the use of a low-e coating to improve the

Final draft – March 2008

thermal performance would be interesting. Also, Arontis indicated that their system was designed for easy replacement of non-functioning PV cells.

Sunwatt indicated that they also designed their systems for easy replacement of PV cells. They had several PVT collectors over 20 years old and still functioning; the most critical issue seemed bad solder joints, that would be apparent within the first few months. Problems with PV cells fingers that were oxidized after years of stagnation, were solved by spraying a thin coating of clear silicone lacquer. Silicones were used for encapsulation, providing a good electrical insulation and, due to the large area available for heat transfer, a low thermal resistance, while stagnation temperatures of over 180 °C could be withstood.

PVTWINS also indicated that further improvements in thermal and electrical performance are interesting. However, as long as a certain cost effectiveness and a satisfactory level of reliability can be guaranteed, these are not the main issue for the first market generation, and other issues are more important (see the paragraphs on general issues and integration issues).

Integration issues

With respect to integration issues, Arontis indicated that their concentrating PVT system is bulky and not suitable for smooth integration. With regards to system design, they indicated that the system preferably should be as large as possible, within the constraints given by the roof and the thermal demand, and that an inverter would then be found to match the voltage/current characteristics. With regard to the control strategy of the system, Arontis indicated that a conventional solar collector control was considered suitable for their domestic PVT systems.

Sunwatt indicated that they designed the cell configuration of their PVT's to match conventional PV modules (36, 72 or 108 cells per case), and that the operating temperature of 60 °C was low enough not to require specific measures. With respect to building integration, length and width of the collector cases (but not height) are the same as conventional solar thermal collectors. No detailed study was carried out on the control; the pump was simply directly connected to one of the PV strings, regulating the pump speed to the irradiation available and using blockage diodes to prevent the pump to run from the storage battery. The sizing of the system was carried out to supply the domestic hot water demand during the summer and use a backup in winter (e.g. woodstove). In order to reduce the winter heat demand, passive solar design should be applied with overhangs to block the sun during summer.

PVTWINS indicates that important integration issues in the present market phase are plug-and-play (easy replacement of a non-functioning PVT absorber, easy installation of in particular the electrical part so that this can be done by a heating installer), building integration (the roofing contractor should be able to guarantee the roof, and this sets demands for the PVT products) and aesthetics. In the later speeding-up market phase (see Figure 3), also design software, training of installers and installation manuals become more important.

Conclusions

It can be concluded that realized projects are of primary importance for the development of the PVT market, because they provide experience to manufacturers and installers, give awareness and confidence to the public, show 'best practices' and result in installers and solar suppliers familiar with PVT. It is therefore very important that dedicated subsidies for such market introduction projects are available. This can be boosted further by targeted awareness campaigns. Also in an early phase, important issues are the easy installation of the system, as well as construction measures that do not compromise the ability of the roofing contractor to guarantee the roof.

For the next phase in the market development, training of installers and other people involved becomes important, as well as the development of installation manuals, design guidelines and the development of testing standards (both for inspiring confidence and as a requirement for

Final draft – March 2008

subsidies). Also important are dedicated subsidy schemes that take into consideration the specific characteristics of PVT.

With respect to technical aspects, both reliability and efficiency are important. For reliability, it can be concluded that stagnation issues and electrical insulation are the most important issues. The application of silicones may be a solution, but is labour-intensive and relatively expensive. Also research to increase the thermal module efficiency and find optimal PV types for PVT are considered very interesting, and the PVT roadmap gives a number of R&D topics for this issue. The issue of electrical output optimization receives little attention from the manufacturers, since they consider the electrical loss to be a relatively minor issue as long as the PV does not get too hot, and because they focus all on DHW systems and cSi, which have the largest market share.

In terms of integration issues, it was indicated that this was done by letting the PVT's as much as possible resemble conventional PV modules and solar collectors. It should be realized here that the present manufacturers focus largely on the retrofit DHW market, where the systems are installed either by the manufacturers themselves or with very close involvement of the manufacturers, which is characteristic for the early stages in the market development. For a later stage, the PVT roadmap gives a number of additional issues that would be important for the large-scale introduction of PVT into the newly built market, where the systems are designed and installed by non-PVT-specialists, addressing design tools for engineering companies and architects, plug-and-play installation of modules and more sophisticated system combinations, such as PVT with a heat pump or solar cooling.

Comparing the PVT roadmap with issues mentioned by manufacturers, a few items were found that do not overlap. On one hand, manufacturers mention the issue of designing for easy replacement of non-functional PV cells, which is an issue that is not addressed in the PVT roadmap. This issue was mentioned by both Arontis and Sunwatt. However, this is seen as an issue that is specific for concentrating systems that are more-or-less custom made and installed and maintained by the manufacturers themselves, and are not applicable for a standard product on a fully developed market. Nevertheless, the replacement of modules in a system is an issue of general importance and should receive attention under the issues of standardization and plug-and-play design.

On the other hand, the PVT roadmap mentions issues such as financing constructions or regulations with respect to the installation of thermal and electrical systems, which are issues that have not been mentioned by the manufacturers. For financing constructions, this can be explained by the fact that this can be considered as a general issue for the affordability of renewable energy systems. Installation regulations may be less problematic in the market preparation phase, since the installations are carried out on a small scale with close involvement of the manufacturer, who either has all the skills required to do the installation himself, or has chosen an installer that can fully carry out the installation. However, in a later stage in the market development, more problems may occur if regulations prescribe that the installation of a PVT requires both a PV installer and a solar thermal installer, since it is inconvenient if two different installers are required on the roof and, in addition, in some countries it is uncommon to have both types of installers in the same company (as is apparent from the results of subtask A).

[1] [1] PVT ROADMAP - A European guide for the development and market introduction of PV-Thermal technology, www.PVTforum.org