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Annual report 2018

IEA SHC Task 60: PVT systems

Application of PVT collectors and new solutions in HVAC systems

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The author of this report bears the entire responsibility for the content and for the conclusions drawn there from.

Summary

The Solar Heating and Cooling Programme of the IEA has started Task 60 on PVT systems in 2018, The Task will end in December 2020.

The Task is focused on classifying and optimizing PVT collectors applications. During 2018, frameworks and templates for all participants have been set up during 2 meetings.

First results show that several types of PVT collectors are on the market already and that the PVT systems are developing still on market niches for the moment.

Zusammenfassung

Das Programm für solares Heizen und Kühlen der IEA hat 2018 mit Task 60 zu PVT-Systemen begonnen. Die Task endet im Dezember 2020.

Die Aufgabe konzentriert sich auf die Klassifizierung und Optimierung von PVT-Kollektoranwendungen. Im Laufe des Jahres 2018 wurden in zwei Sitzungen Rahmen und Vorlagen für alle Teilnehmer eingerichtet.

Erste Ergebnisse zeigen, dass bereits mehrere Arten von PVT-Kollektoren auf dem Markt sind und sich die PVT-Systeme derzeit noch in Marktnischen entwickeln.

Résumé

Le programme de chauffage et de climatisation solaires (SHC) de l'AIE a démarré la tâche 60 sur les systèmes PVT en 2018. Elle se terminera en décembre 2020.

La tâche est axée sur la classification et l'optimisation des applications des capteurs PVT. En 2018, des maquettes et des modèles pour tous les participants ont été mis en place au cours de 2 réunions.

Les premiers résultats montrent que plusieurs types de capteurs PVT sont déjà sur le marché et que les systèmes PVT se développent actuellement sur des niches de marché.

Contents

List of abbreviations

SFOE	Swiss Federal Office of Energy
SHC	Solar Heating and Cooling
IEA	International Energy Agency
PVT	Photovoltaic and Thermal

1 Introduction

Task 60 focuses on the application of PVT collectors. The aim is to assess existing solutions and to develop new system solutions principles in which the PVT technology really offers advantages over classical “side by side installations” of solar thermal collectors and PV modules.
Energy yield, exergetic efficiency, KPIs, simulation tools, sensitivity analysis, benefits, competitive cost, safety and reliability of systems are therefore in the scope of the Task.
Increasing awareness of the PVT solutions to all stakeholders is also a key objective.

2 Context

2.1 Background / State of the art

Solar markets are subject to a shift from solar thermal solutions to solar photovoltaic (PV) solutions since 3 years mainly due to cost reductions in PV systems, simplicity of installation and versatility of electricity. This must not be forever since solar thermal has huge advantages in terms of efficiency and of storage. Well designed “PVT technologies” have the potential to combine the best of the two systems in an hybrid system.

The combination started in early 2000 but the products were lacking reliability, were much too expensive and the heat pumps were not a big market yet. There has been new industrial development in PVT collectors continuously and systems using PVT and heat pumps are in line to compete with other renewable technologies.
These developments open up new possibilities in the field of PVT collectors and applications. Today, the integration of different renewable energy components into systems is much more in the focus than the further development of the basic components of the different technologies (i.e. solar thermal collectors, PV-panels, heat pumps, bore hole storages etc.). This intensification of renewable energy system aspects provide a broader basis for the PVT technology as it offers - and often even requires - more possibilities to provide heat and electricity at the same time to a system and to store the daily production of solar energy.

PVT systems start to be found in many applications: one family houses, dwellings, industrial processes and even district heating. The collector must combine PV technology with a thermal component, working with air or liquid, with a front cover or not, and even it can be under light concentration. To support this emerging market for solar industries, an IEA Task is welcome by the industry and was asked at several occasions in international conferences (Eurosun, OTTI symposium).

2.2 Motivation of the project

The development of new PVT collectors is a matter of the industrial sector and new collectors are on the market with industries willing to participate in our IEA activity.

Task 60 therefore concentrates on the application of PVT collectors. The aim is to assess existing solutions and to develop new system solutions principles in which the PVT technology really offers advantages over classical “side by side installations” of solar thermal collectors and PV modules. Energy production, competitive cost, safety and reliability of systems are therefore in the scope of our Task.

Two obvious recent developments of influence towards this direction may be mentioned here:

1. Strong and increasing interest in Building Integrated PV (BIPV) and Façade integrated PV (FIPV) not only in office buildings but also in dwellings where electricity and heat is required.

2. The positive development of heat pumps opens up many more possibilities to make use of the low exergy heat source of uncovered PVT collectors and reduce the energy cost for the user.

The scope is therefore focused on applications with PVT collecting devices in systems of any size and any type of consumers. This will depend on the participants’ projects. But the Task works on finding the best applications boundaries for PVT collectors.

2.3 Scope and objectives

The scope is on applications with PVT collecting devices in systems of any size and any type of consumers.
The goals of the Task are to:

1. Provide a state-of-the-art of the PVT technology worldwide.
2. Gather operating experience with existing PVT systems.
3. Improve the testing, modeling and adequate technical characterization of PVT collectors.
5. Find typical PVT solutions
6. Explore potential cost reductions in the balance of PVT systems.

3 Approach and methodology

3.1 Organisation of the Task

The Task is organised in four subtasks.

<u>Subtask A: PVT Systems in operation</u>
Lead Country: Austria
Subtask Leader: Thomas Ramschak, AEE Intec
Objective: to gather data and report information on heating and cooling systems with PVT collectors in operation.

<u>Subtask B: PVT Performance characterization</u>
Lead Country: Germany
Subtask Leader: Korbinian Kramer, Fraunhofer ISE
Objective: to provide testing methods of PVT collectors of all kind that can become an international standard.

Subtask C: PVT Systems modelling
Lead Country: Spain
Subtask Leader: Asier Sanz, Tecnalia
Objective: to provide models of systems with PVT collectors

Subtask D: PVT Systems design examples and dissemination and market support
Lead Country: Switzerland
Subtask Leader: Andreas Haeberle, SPF
Objective: to evaluate the overall performance of PVT systems and designs and to disseminate the Task produced information and knowledge to all identified stakeholders

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3.2 Goals for each target of the Task

The main goals of the activity are to:

PVT Collectors:

- Improve knowledge of current collectors and evaluate their risks
- Improve collector designs and cost
- Improve collectors and collector fields design for hot and humid climate with mostly a cooling demand (The PV production is highly impacted by high collector temperature)
- Improve PVT collectors modelling
- Provide a basis for the comparison of collectors with respect to technical and economical conditions.
- Give useful recommendations for standardized testing procedures and pave ways to new standards if needed

PVT applications:

- Identify current PVT examples
- Identify most interesting PVT applications in all type of climates
- Develop system models
- Validate models against monitored systems
- Improve the PVT collection efficiencies and/or economics

Design Guidelines, Case Studies and Dissemination:

- Provide a large overview of results and experiences from PVT solutions in order to lower the barriers for market deployment and to disseminate the knowledge to all target groups.
- Support current industry and future project stakeholders by providing design guidelines and definition of performance assessment of the hybrid PVT technology (using also methods developed in other Tasks like Task 54)
- Investigate risks in stagnation behaviour, control and hydraulics of PVT systems.

3.3 Activities

3.3.1 Subtask A : PVT systems in operation

A1. Inventory and information data sheet on existing PVT systems and solutions on the market

- Identify market segments and examples of PVT systems in those segments (Housing, BIPV, Industrial, District heating, …)
- Define reporting formats and Key Performance Indicators for PVT systems and applications in all market segments
- Gather systems description and specifications
- Gather and prepare monitoring data at least for 1 year on all examples
- Classify the examples in term of quality of data (best, average, bad)
- Build a data base of data for subtask D validation mission

A2. Comparison of systems with respect to technical and economical considerations (with Subtask D)

- Project achievement
- System Design principles both for PV and T
- Industrial approach
- Economical performance
- Energy performances
- Operating conditions
- Stagnation risks
- Maintenance Issues
- Reports failures and barriers in the development of projects
- Life cycle considerations
- Recycling possibilities

A3. Comprehensive recommendations for improvements of future PVT systems

- Provide recommendations for designing, operating and maintaining, monitoring of PVT systems
- Provide a basis for the standardized comparison of systems
- Provide recommendations for testing procedures

3.3.2 Subtask B: PVT Performance characterization

B1: Describe or develop standardized method for testing all kinds of PVT collectors and for reporting the characteristic curves, based on existing or new standards or data

- Current standards for PV collectors
- Current standards for T collectors
- Current standards or practice for PVT collectors and gap analysis
- Alternative ways and methods to test PVT collectors and report performances (literature, ideas,…)
- Proposed standards for PVT testing and reporting for all types of collectors: water, air, concentrated.

B2: Consider equations and methods for testing day time and night time operations of PVT collectors and systems if necessary

- Current used equations and gap analysis
- Current methods to test PVT collectors
- Proposed new equations to take care of all parameters and observations for all types of PVT collectors, for combined heat and electricity production.
- Differences between day and night operations, with and without heat pumps
- Equations at system level if different than at component level. Influence on simulation models.

B3: Develop definitions of PVT systems efficiency

- Current definitions in standards and practice (at system level)
- Gap analysis between current and need
- Proposition of a set of equations defining the PVT system efficiency to be implemented in Subtask C models.

B4: Design Guidelines

- Analysis of current literature and gaps
- Make comprehensive recommendations to designers of PVT collectors based on observations during testing
- Publish them on internet with Subtask D

3.3.3 Subtask C: PVT systems modelling

C1: Numerical Simulation Tools for the simulation of PVT collectors based on Subtask B results

- Current tools to simulate PVT collectors: list and features
- Gap analysis compared to Subtask B recommendations
- Tool development for a PVT collector model in simulation models like Trnsys or equivalent

C2: Numerical Simulation Tools for the simulation of PVT systems based on Subtask B recommendations for definitions of efficiency

- Cuurent simulation tools for systems with PVT production (Trnsys, Polysun, etc…): features
- Gap analysis with Subtask A and B recommendations
- Tool development or modification or adaptation to be able to simulate Subtask A projects under Subtask B definitions requirements.

C3: Simulate existing PVT systems monitored in Subtask A and validate the tools

- Simulation Subtask A projects with local weather data
- Compare to monitored results
- Gap analysis
- Validation of simulation tools with parameter and/or model adjustment – Feedback to Subtask B
- Publication of results with Subtask D

C4: Conduct sensitivity analyses on simulated systems to find and report optimal solutions, including control strategies

- Sensitivity analysis after validation: parameters variations
- What could have been done better in the project ?
- Looking for a more optimal performance solutions in the boundary conditions of the real project.
- Recommendations for future projects and applications in PVT

C5: Find most efficient systems in different market segments through simulations and conduct economical analysis if possible

- Define relevant market segments with Subtask D
- Design best in class solutions for each segment and plant sizes (2 or 3 classes)
- Simulate the solutions with a validated tool from C4
- Find optimal solution and energy and economical performances of the best solution for each segment / size

3.3.4 Subtask D: PVT systems design examples and dissemination

D1: Define performance assessment methodology for PVT systems and all KPIs necessary and useful.

- This activity is important for evaluating PVT systems solutions and comparing them. A set of KIPs or criteria is needed for an assessment and can be derived also form other SHC Tasks that have tackled a similar problem (Task 44, Task 53).

D2: Use the methodology to assess PVT systems of Subtask A, with a relevant reference as benchmark.

- All systems described and followed in Subtask A that have sufficient relevant data and information to be assessed comparatively should be studied here. For comparison purposes, a reference case should be defined. This is a difficult mission since a reference solution can mean different visions for different countries (is it a gas boiler, a heat pump, a PV + T solution or else ?). The reference case is a system that delivers the same quality of energies to a demand but is more current practice than the newer PVT solutions.

D3: Analyze best control strategies for PVT systems with economical boundaries (with Subtask C and B) and provide recommendations to the industry.

- For best solutions identified in E2, it can be possible to refine or simplify the control strategy to get to better results in terms of some of the performance KPIs. This activity will pick up a few systems to look for more advanced control concepts if this is possible and relevant, using new IT technologies for instance and big data algorithms.

D4: Prepare and manage industry workshops

- When our meetings are in conjunction with solar conferences ion a particular country, industry workshops on PVT solutions will be organized. At the SPF dedicated PVT workshops can also be set up during one of our working years, probably the last one to present more results. This will also be done during SHC conferences as stated under (c).

D5: Prepare documentation for industry and market and disseminate documentation and task results along the course of the Task.

- This activity is important to make understandable and usefull for a broad audience the outcome of all the other Subtasks. Format should be similar and ease of reading is also required.

4 Results in 2018

Two meetings have been held with more than 45 participants in each.

Subtask A

1. List of PVT projects was set up and has currently 11 projects. Subtask A has set a format of a Task 60 “infosheet”, a total of 31 projects could be in during 2019.
2. The past Task 44 square view system to describe a concept has been selected as the tool of Task 60 and was enhanced to accommodate for PV elements
3. Classifications of PVT systems has been done and will be issued with the report 1
4. A manufacturer questionnaire was developed and distributed to more than 60 companies. Results are expected for 2019.

Subtask B

1. Current equations for collectors yield used by each research group and industry participants have been gathered in a draft report 1
2. Gaps or simplification are still being identified between model and reality (condensation, snow, rain, temperature effect on PV module, etc…)

3. Standard test procedures have been described and gaps with market needs will be identified n 2019
4. Labels for PVT were discussed and gaps identified. Solar keymark committee will be approached during 2019.

Subtask C

1. Modeling needs for system simulation of all types of collectors have been discussed
2. Current modeling tools of participants have been listed
3. Reference system discussion was initiated: Are one or many references needed ? A air heat pump system might be the most interesting "competitor".
4. Criteria to evaluate systems against a reference system to deliver the same service have been discussed and transmitted to Subtask D.

Subtask D

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1. Linkedin link on PVT systems was recognized as important and will be run by Task 60.
2. The existing Wikipedia page on PVT systems will be enhanced
3. A logo was elected and used since Eurosun 2018
4. A Task leaflet was issued and distributed at Eurosun 2018
5. 2 PVT sessions were organized at Eurosun 2018 and chaired by Task 60 leaders.
6. A solar keymark discussion and/or labeling discussion about PVT requirements with industry will be organized in March 2019 and during the industry Workshop of meeting 3 in Eindhoven NL.
7. KPIs were set up with contributions from several participants.

5 Discussion of results

Task 60 has set up a community of scientists and researchers during 2018. The discussions are on the way.

First results show that there is a growing market for PVT systems yet still in a niche in 2018.

France is leading with air PVT systems.

Switzerland could be a market since PVT systems replace air or borehole heat pump sources and offer several advantages over them in cities.

6 Conclusions and outlook

6.1 2018

Task 60 is on track.

There will be results starting in 2019 in form of:

- infosheets on several PVT projects in the world
- equations for PVT collectors
- model of PVT systems
- KPIs for evaluation.

Optimisation of existing and future PVT systems is foreseen for 2020.

End of project will be in December 2020.

Dissemination of results will take place so that PVT systems are more reliable and less expensive.

The PVT applications and solutions are very relevant for the Swiss market since they save space, noise and boreholes when combined with heat pumps.
They also tend to help to save the thermal knowledge of swiss solar companies and installers.

6.2 Next steps after end of project

End of project will be in December 2020.

Dissemination of results will take place so that PVT systems are more reliable and less expensive.

7 Publications [within the project]

B1_2018 Task 60 report B1 draft

Eurosum_2018 14 papers from participants at Eurosun 2018, Rapperswil

Expected reports are listed in this table.

Deliverables January 2018	PVT industry	Certification bodies	Policy makers	Architects	HVAC planners	R&D scientists	Teaching	SHC EXCO and IEA	
Subtask A	x						x		R1. Report A1: Collection of data sheet on existing PVT systems and solutions
			x		x				R2. Report A2A3: Comparison of systems with Subtask D with recommendations for improvements of future PVT syst
								x	R3. Subtask report with management issues
Subtask B	x	x				x			R1: Report B1B2B3: methods for testing PVT collectors with measured results and day night time operations , and de
	x			x		x	x		R2: Design Guidelines for PVT collectors and systems
								x	R3: Subtask report with management issues
Subtask C	x	x				x			R1: Report C1C2C3: methods for testing PVT collectors and fields for hot and humid climate
	x			x		x	x		R2: Design Guidelines for PVT collectors and systems for hot and humid climates
								x	R3: Subtask report with management issues
Subtask D	x					x			R1: Report D1D2: Numerical Simulation Tools for the simulation of PVT collectors and systems
	x					x			R2: PVT systems simulation and validation
	x				x				R3: Optimised PVT systems
								x	R4: Subtask report with management issues
Subtask E	x								R1: Report E1E2: performance assessment of PVT systems
	x				x	x			R2: Report E3: Control strategies for PVT systems
	x					x	x		R3: Report E4E5: Collection of documents prepared along the Task for industry and market
								x	R4: Subtask report with management issue
Operating Agent								x	RA 3 annual reports
								x	R4 Final management report
	x			x	x				R5 Presentation at conferences

8 References

Task60_2018 http://task60.iea-shc.org

Webinar_2018 Webinar ISES
https://www.youtube.com/watch?v=n1JA-xcclN8&t=3049s

Task60_2018 Minutes of meeting 1, Freiburg, Germany, May 2018

Task60_2018 Minutes of meeting 2, Zaragoza, Spain, October 2018

9 Appendix

9.1 Appendix 1: Table of participation

	Company	First	Name	City	Country	Status	Mngt
1	Sunovate	Glen	Ryan	South Perth	Australia	Industry	
2	FH Wels	Thomas	Aigenbauer	Wels	Austria		
3	3F Solar Technologies GmbH	Alexander	Friedrich		Austria	Industry	
4	AEE Intec	Thomas	Ramschak	Gleisdorf	Austria	Industry	SL A
5	FH Oberösterreich F&E GmbH	Alois	Resch	Wels	Austria		
6	Trigo Energies inc.	Christian	Vachon	Trois-Rivières	Canada	Industry	
7	Czech Technical Univ. Prague, UCEEB	Tomas	Matuska	Bustehrad	Czech	observer	
8	UCEEB CTU	Nikola	Pokorny	Bustehrad	Czech	observer	
9	Technical University of Denmark	Mark	Dannemand	Lyngby	Denmark		
10	Technical University of Denmark	Adam	Jensen	Lyngby	Denmark		
11	Ramboll	Niels	Radisch	Copenhagen	Denmark		
12	SYSTOVI	Mohammed	Benandelkarim	Carquefou	France		
13	CESP - University of Perpignan	Jean-Baptiste	Beyssac	CABESTANY	France		
14	DualSun	Laetitia	Brottier	Marseille	France	Industry	
15	CEA	David	Chèze	Grenoble	France		
16	GSE Integration	Georges	Kanaan	Paris	France		
17	IGTE (former ITW), University of Stuttgart	Sebastian	Asenbeck	Stuttgart	Germany		
18	HTW Berlin	Joseph	Bergner	Berlin	Germany		
19	giz	Joerg	Gaebler	New Delhi	Germany	observer	
20	Institut für Solarenergieforschung GmbH	Sonja	Helbig	Emmerthal	Germany		
21	Universität des Saarlandes	Danny	Jonas	Saarbrücken	Germany		
22	*Universität des Saarlandes*	Danny	Jonnas	Saarbrücken	Germany		
23	HTW Berlin	Andreas	Jurack	Berlin	Germany		
24	SunOyster	Johannes	Kneer		Germany	Industry	
25	Fraunhofer ISE	Korbinian	Kramer	Freiburg	Germany		SL B
26	Fraunhofer ISE	Manuel	Lämmle	Freiburg	Germany		
27	Consolar	Ulrich	Leibfried		Germany	Industry	
28	ISFH GmbH	Matthias	Littwin	Emmerthal	Germany		
29	easy-tnt	Thomas	Noll	Kipfenberg	Germany		
30	ZAE Bayern e.V.	Markus	Pröll	Garching b. München	Germany		
31	htw saar	Danjana	Theis	Saarbruecken	Germany		
32	PRIME LASER TECHNOLOGY	Costa	Travasaros	Keratea	Greece	observer	
33	HDEMIA SRL	Giovanni	Chiappa	Calco	Italy		
34	università di catania	Antonio	Gagliano	Catania	Italy		
35	Univ. Bologna	Marco	Pellegrini	Novafeltria	Italy		
36	università di catania	Giuseppe	Tina	Catania	Italy		
37	Camel Solar Ltd.	Ilija	Nasov	Skopje	Macedonia	observer	
38	SEAC-TNO	Corry	de Keizer	Eindhoven	Netherlands		
39	Eindhoven University of Technology	Len	Rijvers	Eindhoven	Netherlands		
40	BDR Thermea BV	Oscar	Mogro		NL	Industry	
41	Eindhoven University of Technology	Len	Rijvers	Eindhoven	NL		
42	Solarus Sunpower	Manuel	Vargas Evans	Venlo	NL	Industry	
43	Kongju National University	Jun-Tae	Kim	Cheonan	South Korea	observer	
44	ABORA	Alejandro del	Amo Sancho	La Muela, Zaragoza	Spain	Industry	
45	ABORA	Marta	Cañada	La Muela, Zaragoza	Spain	Industry	
46	Universidad de Lleida	Daniel	Chemisana	Lleida	Spain		
47	Abora Solar	Alejandro	del Amo	La Muela	Spain		
48	EndeF	Isabel	Guedea	Zaragoza	Spain	Industry	
49	Universidad de Zaragoza	Maria	Herrando	Zaragoza	Spain		
50	Abora Solar	Fernando	Pérez	La Muela	Spain		
51	Tecnalia	Asier	Sanz		Spain	Industry	SL C
52	EndeF	Raquel	Simon	Zaragoza	Spain	Industry	
53	EndeF	David	Villén	Zaragoza	Spain		
54	Abora Solar	Vicente	Zárate	La Muela	Spain		
55	University of Gävle		Diogo Cabral	Gävle	Sweden		
56	Gävle University / Solarus	Joao	Gomes	Uppsala	Sweden		
57	Högskolan Dalarna	Xingxing	Zhang	Falun	Sweden		
58	DualSun	Gabriel	Blaise	Lausanne	Switzerland	Industry	
59	HSR Hochschule für Technik Rapperswil	Andreas	Häberle	Rapperswil	Switzerland		SL D
60	Hadorn consulting for SFOE Bern	Jean-christophe	Hadorn	Bournens	Switzerland	Industry	OA
61	ZHAW - School of Life Sciences	Jürg	Rohrer	Wädenswil	Switzerland		
62	ZHAW Wädenswil	Maike	Schubert	Wädenswil	Switzerland		
63	SPF	Daniel	Zenhäusern	Rapperswil	Switzerland		
64	Consultant	James	Bererton	Airth	UK	Industry	
65	Solar Speedflex Co LTD	Eric	Hawkins		UK	Industry	
66	Naked Energy	Adrian	Murrell	Horsham	UK	Industry	
67	Naked Energy	Alexander	Mellor	London	United Kingdom	Industry	
68	UNC Charlotte - EPIC	Weimin	Wang	Charlotte	USA	observer	

9.2 Appendix 2: Workplan