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PV Catapult

European Collaboration for identification of PV research and markets opportunities, socio-economic studies, performance assessment, and dissemination of PV and PV-thermal technology

Coordination Action

SES6

D3-4: Report PVT Workshop 2

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Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

workshop title:	PVT workshop 2
workshop date:	June 24, 2004
workshop location:	Freiburg (connected to EuroSun 2004, 5th ISES-Europe Solar Congress)
report author:	Wolfgang Eisenmann, ISFH
report editor:	Herbert Zondag, ECN

This report documents the findings at the second PVTF-workshop on PVT Solar Systems. It is part of the reporting of the project PV Catapult, supported by the European Union, with the aim of setting up an overall road map for marketing and research and development on PVT for the short, medium and long term, in order to enlarge the market penetration of PVT products on the long-term.

More information on the project can be found at:

www.pvtforum.org

Contents

1 Introduction

PVT stands for PV-Thermal (modules in which not only the electricity but also the heat is extracted from the PV). Within the EU supported project PV-Catapult, the PVTF activity is aiming at setting up a roadmap for marketing and research and development on PVT for the short, medium and long term, in order to enlarge the market penetration of PVT products on the long-term. In order to obtain input for this roadmap, two workshops were organised to make an inventory of issues that were identified by solar thermal and PV experts.

This report documents the preparation, the activities and the outcome of the second workshop carried out within the PVTF project. This workshop was held on June 24, 2004, in connection to the EuroSun 2004 (5th ISES-Europe Solar Congress, 20th to 23rd June 2004, Freiburg), and focused on a SWOT analysis of PVT technology and its future market potential.

The first workshop was held in connection to the 19th European PV Conference and Exhibition (7th to 11th June 2004, Paris), 8th June 2004. This workshop is described in a separate workshop report.

The present report is prepared by Institut für Solarenergieforschung GmbH Hameln/Emmerthal (ISFH), Dr. Wolfgang Eisenmann, in close co-operation with the Energy research Centre of the Netherlands ECN.

2 Aim and program of the workshop

The overall aim of the workshops was to provide a forum for discussion of PVT technologies, the potential, the challenges, the barriers and the long term commercial aspects, in order to provide information and input for the roadmap for PVT, being developed within the PV Catapult workpackage 3: PVTForum.

It was decided to have workshops in both Paris at the European PVSEC Conference and in Freiburg at the EuroSun conference, in order to obtain input from both the PV community and the solar thermal community, which are both of vital importance for the development of PVT.

The workshops in Paris and in Freiburg had the same basic program:

- introductory presentations (technology, industry, commercial)
- active part:
    - phase one: inventory
    - phase two: discussion
- conclusions

However, in the active part of the workshop different exercises were conducted in Paris and in Freiburg.

- Paris: focus on the driving forces having influence on the overall development of the technology

- Freiburg: focus on a SWOT-analysis of the technology, where the audience provides input on how to overcome barriers and views on the potential of the technology.

Invitations for the workshop had been sent to experts in the solar thermal community and the PV community. In addition, posters had been put up at the conference. The invitation for participation is shown in section 6.1 and the list of participants in section 6.2.

In order to have experts and specialists being part of the audience, the project team also sent out special invitations to a few selected experts and specialists in the field of PVT systems, who were expected to be able to give an especially valuable contribution to the discussion because of their specific knowledge and experience. The following 8 invited experts participated in the Freiburg workshop:

- Teun Bokhoven, ESTIF, Netherlands
- Henk Koning, Heliomax, Netherlands
- Klaus Heidler, Solar Consulting, Germany
- Klaus Lambrecht, Econsult, Germany
- Ursula Eicker, Stuttgart University of Applied Sciences, Germany
- Soteris Kalogirou, Higher Technical Institute (Nicosia), Cyprus
- Siegfried Schröpf, Grammer (Solar Air Collectors), Germany
- Krystian Kurowski, RECEPOL, Poland

3 Summary on presentations

As an introduction to PVT, four presentations were given. This was considered necessary because the technique of PVT is still relatively little known and it was important to give everyone the same basic knowledge on PVT, both from the technical and the commercial side, as a starting point for the active participation of the public.

Figure 1: Klaus Heidler during his presentation at the PVT workshop in Freiburg.

- Wim van Helden introduced the project and provided an overview of the principal technologies and the technical challenges. The presentation highlighted the technical challenges and the work carried out so far and demonstrated in full-scale projects.
- Pascal Affolter provided an overview and issues for discussions regarding the added value of combining PV and Solar Thermal technologies. Key issues are the match between the demand for energy and the availability of energy, both thermal and electrical, through solar technologies that can be integrated in the building shell.
- Klaus Heidler provided general recommendations regarding marketing of solar technologies, and used examples on PVT technologies to illustrate the process of segmentation of the market and the key selling points to various customers. The overall strategies for marketing of solar technologies were addressed, with focus on the careful selection of value propositions for the different markets.
- Henrik Sørensen presented the IEA SHC Task 35, which is dedicated to PVT systems. Information on the scope, the aims and the subtasks was given.

As the presentations given at the two workshops were identical, hand-outs from the presentations are provided only in the report of the Paris workshop.

4 Active part of the Workshop

The active part of the workshop consisted of two phases. In the first phase an analysis of the strengths, weaknesses, opportunities and threats (SWOT analysis) of PVT technology was carried out. In the second phase, a few particularly interesting opportunities were discussed in the plenum.

4.1 Phase 1

4.1.1 Method

After the introductory session, the active part of the workshop was carried out. The audience was asked to gather all their thoughts and ideas on strengths, weaknesses, opportunities and threats of PVT technology, with regard to future market potential. The participants worked in groups of two persons and wrote down their ideas on small PostIt™-notes.
As the next step, these notes were collected on the wall and sorted into the four SWOT categories.
More than 150 notes were brought in, sorted and discussed.

4.1.2 Results phase 1

The first phase led to a high number of ideas and statements. The inputs from the audience for the four SWOT categories are quoted in the figures below. The comments are displayed as they were put on the post-it notes by the participants.
To obtain a better overview, the notes have been sorted according to the aspects they addressed. Comments whose text was equal or at least very similar, are displayed in the tables with a number (e.g. (2)) to indicate the number of post-its with this text. A high number therefore gives an indication of the amount of importance attributed to the issue.

The notes regarding the **strengths** of PVT technology are shown in Figure 2. The collection of opinions regarding its **weaknesses** can be found in Figure 3. The **opportunities** found are displayed in Figure 4, and the **threats** are shown in Figure 5.

Strength	
less area / higher efficiency	Less surface area needed (6)
	PVT can be used on limited available surfaces
	Efficient use of roof
	Higher overall energy efficiency than side-by-side PV and solar thermal systems (6)
	Combine systems > compact > easier to use
	1. it is beneficial and have good way to reduce our dependence on electricity; 2. Reduce the emission of CO2
	Environmental
increase eff. PV	Seasonal adv of PV for cooling
	Higher efficiency than PV like ultimate multi-junction PV cells
	Could improve PV efficiency
	Strength - higher efficiency of the PV system?
efficient material use	Strength using same materials reduces module and installation costs
	Saves on support structures (but those are small part of costs)
	Saves material > life cycle energy balance improves > energy payback time reduces
installation	Strength using same materials reduces module and installation costs
	It is easier to sell - to install
	Strength > two things in one (to buy, to install, to see)
marketing	Easier to promote in countries with good SWH penetration. Hot water production from solar energy is embedded in people's mind. So PVT would be easier to promote than PV alone
	It is easier to sell - to install
consumer	1 product 2 needs
	Like Co-gen provides heat and power
	Building integrated ventilated PV (air) as warm facade > daylight > PV electricity > heat
	It is logical
	STR > Logic > own image (ISO.TWO)
	Unique answer to double demand
	Two functions in one
	One system on a roof
	Strength > two things in one (to buy, to install, to see)
	Finally 1 solar system that produces all
	It is cheaper
energy infrastructure	Different price for day vs night electricity
architects	More design options
	Strength: visualisation is better
	Nicer design opps.
	More design opportunities
	Flexibility of use
	Attractive to architects to have one system for aesthetical aspects
	Compact multifunctional building element
	One system on a roof
	Attractive with one system for the builders
	Strength > two things in one (to buy, to install, to see)
	Finally 1 solar system that produces all
	PV can hide the ugly thermal system

Figure 2: SWOT analysis, part 1: strengths of PVT technology

Weakness

technical	**reliability**	PV system Max t vs stagnant t Th collector
		Sustainability does it work for 25 years? Like PV - T
		Current materials to electrically insulate and at the same time conduct heat is very difficult and expensive
		Thermal shock e.g. power failure restart at high sun causes circulation of cold fluid through hot panel
		Durability of PVT due to thermal coupling?
		Temperature resistance of encapsulant
	efficiency	Reduced water temperature
		Low opp T of Th system
		The compromise = eroding the essential performance characteristics
		Weakness low thermal and with optimal electrical output
		At interesting temperature levels electricity drops down
		PVT are less efficient than good thermal collectors
		Loss of PV performance is too expensive no glazed collector!!
		Efficiency reduction vs sep. Systems
		For hot water we need as high temp as possible > for PV we need to have as low temp. As possible > conflict of temperature level required
		Less thermal performance than standard thermal collector AND less PV output (for covered PVT)
		Different optimal working temperature
		PV drops in efficiency if high temperatures ar needed
		High parasitic power consumption for air-based PVT
	storage	Th. Sys cannot be "grid connected
market	**industry**	Necessary to join PV + Th producers
		Weakness > expensive > PV is not ready to combine with solar collector
		Weakness: different inverters are necessary
		Too difficult and expensive to manufacture with a 25 years expected life with continuous output in xxxx and xxxx
	installation	PV easy to put anywhere Th is hard of place of use correctly
		More complicated systems
		Complex system mix
		PVT should be part of an integrated system powered by renewable energy (heat pump!)
	architects	PVT must be very flexible in dimensions and colours
	regulations	Not enough developed > not appropriate standards
	marketing	Almost 40 products on the market (no experience, no public awareness)
		Image issue: PV is considered modern Th is considered old (might help Th be better?)
		Add expense
	cost	Weakness: PVT price still too high by comparison to PV + T side by side
		Economics suck!
	general	The answer to a non-asked question
		Coupling of 2 not similar needs
		Two very different systems (pot 3) combined in one
		Can not be used in a larger scale electricity-generation system
		Balance between thermal and electrical needs to be quantified
		Co-generation

Figure 3: SWOT analysis, part 2: weaknesses of PVT technology

Opportunity		
technologies	**module**	Other PV technologies with positive temp co-efficient
		Solar air collectors could be combined with PV + sorption-storage systems
		Development of high T PV cell > allows concentrators to be used . Combined PV/thermal electricity + heat. Would be enabler
		Development of fully transparent (polymer?) PV cell. Can act as cover for collector. Would be enabler
	system	Heat pump
		SDHW > to produce heat less imported electricity
		Combination PVT with heat pump
		Systems for domestic market DHW/heat pump
		Reheating & nat. Vent
		PV-T as a natural ventilation system
		PV-T as a component for a cooling system
		Cooling
		PVT plus active solar cooling application
		Coupling with solar cooling
		PVT coupled by desiccant small scale cooling cycle
marketing	**aesthetics**	Building integration
		Different colours for PV-T systems
		Building integration (not only modules)
		It is nice
	market development	Opportunity: the period of cheap fossil fuel is possibly coming to an end
		Once PV becomes really cheap and glass plate/frame/supports become significant cost elements then PVT starts to make economic sense
		Oil price (long term) goes up!
		Economy
	subsidies	High feed-in tariffs (Germany)
		Get advantage of heavy subsidies given to PV's to promote also solar thermal applications
	image	Opportunities 1. Strength ……. Between nature and human 2. Create cooperation
		The "feel" = good; people still do not know the differences PV/ST > PVT = solution
		Opp. PVT a packaged deal
		PVT systems are of lower energy-payback time
markets	**regions**	3. World
		Wide application field. If the systems modified can be used in solar cooking.
		Developing countries
		Countries with solar radiation but low temperature > Scandinavia > Greenland? > Alaska?? Need a lot of low T heat
	utility	Commercial & industries
		Commercial buildings > need heat and electricity during day
		Hybrid system as cladding for facades
		High tech building skins > high performance > high design quality
		To apply PV-T in mainly seasonal summer building (sailing club, beach services, etc.)
	industrial processes	Opportunities: drying processes for industries
		Commercial & industries
		Industrial plants? Problem - need high econ benefits
	consumers	Leisure homes, mobile homes
		To apply PV-T in mobile homes or winter/summer camping areas
		Summer cottages (Finland…)

Figure 4: SWOT analysis, part 3: opportunities of PVT technology

Threat	
policy	O > T political decisions
R&D	High development cost of glazed PVT
reliability	Lot of uncertainties with respect to technical life expectation is due to t C
costs	PVT are not of low cost.
	Initial cost of PV need to be reduced drastically
	Economics are too thin!
	Economical system?
	Threat: no financial payback
market	No market for water PV-T…. Solution: air PV-T for low demand building
	No large PV or solar thermal company will go into PV-T market
	Reduction thermal demand buildings > battle on roof diminishes
	Advanced need of heat due to improve of building
	Threats: no market for temperature heat
	Threats: fuel cells > co-generation
distribution	Marketing channels heating + electr. = 2 different sales, marketing + skill - channels preferred = heating channel
installation	Not enough knowledge the installers about systems
	System integration
architects	Building material integration progresses > I (need to, or at least can) cover large area to cover entire roof area

Figure 5: SWOT analysis, part 4: threats to PVT technology

4.2 Phase 2

After the collecting and sorting of the post-it notes had been finished, there was a plenary discussion, presided by Henrik Soerensen from Esbensen Consulting Engineers. In this discussion, the focus was on 'opportunities'. It was decided to focus on four selected opportunities that were regarded as particularly important. The following aspects were discussed:

- “PVT is nice”
- building integration
- technological developments that could / would enlarge the opportunities of PVT
- applications for developing countries

For each of these topics, a number of issues were raised by the public. The results are displayed in Figure 6 t/m Figure 9.

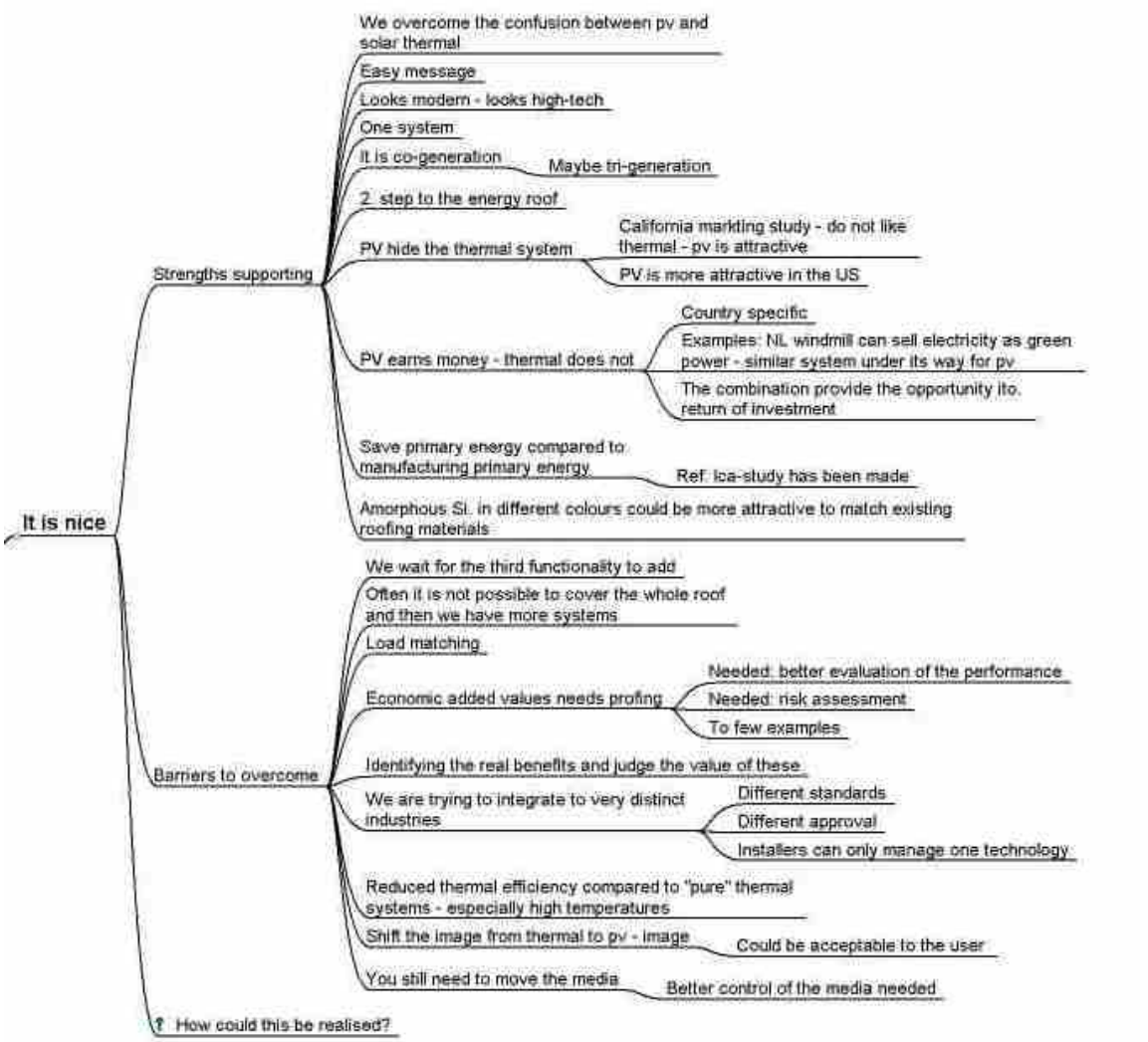

Figure 6: Detailed analysis of PVT opportunity 'It is nice'.

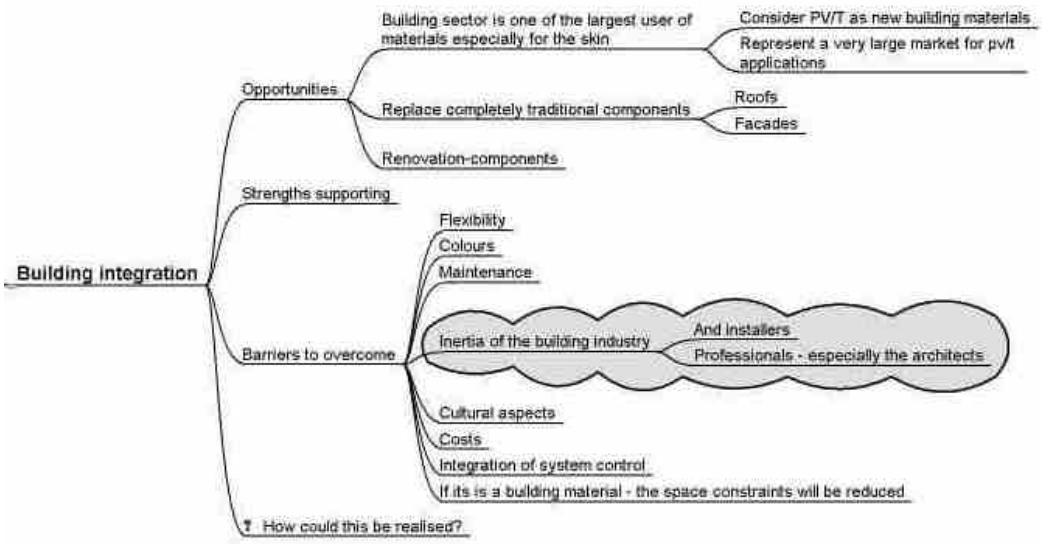

Figure 7: Detailed analysis of PVT opportunity 'building integration'.

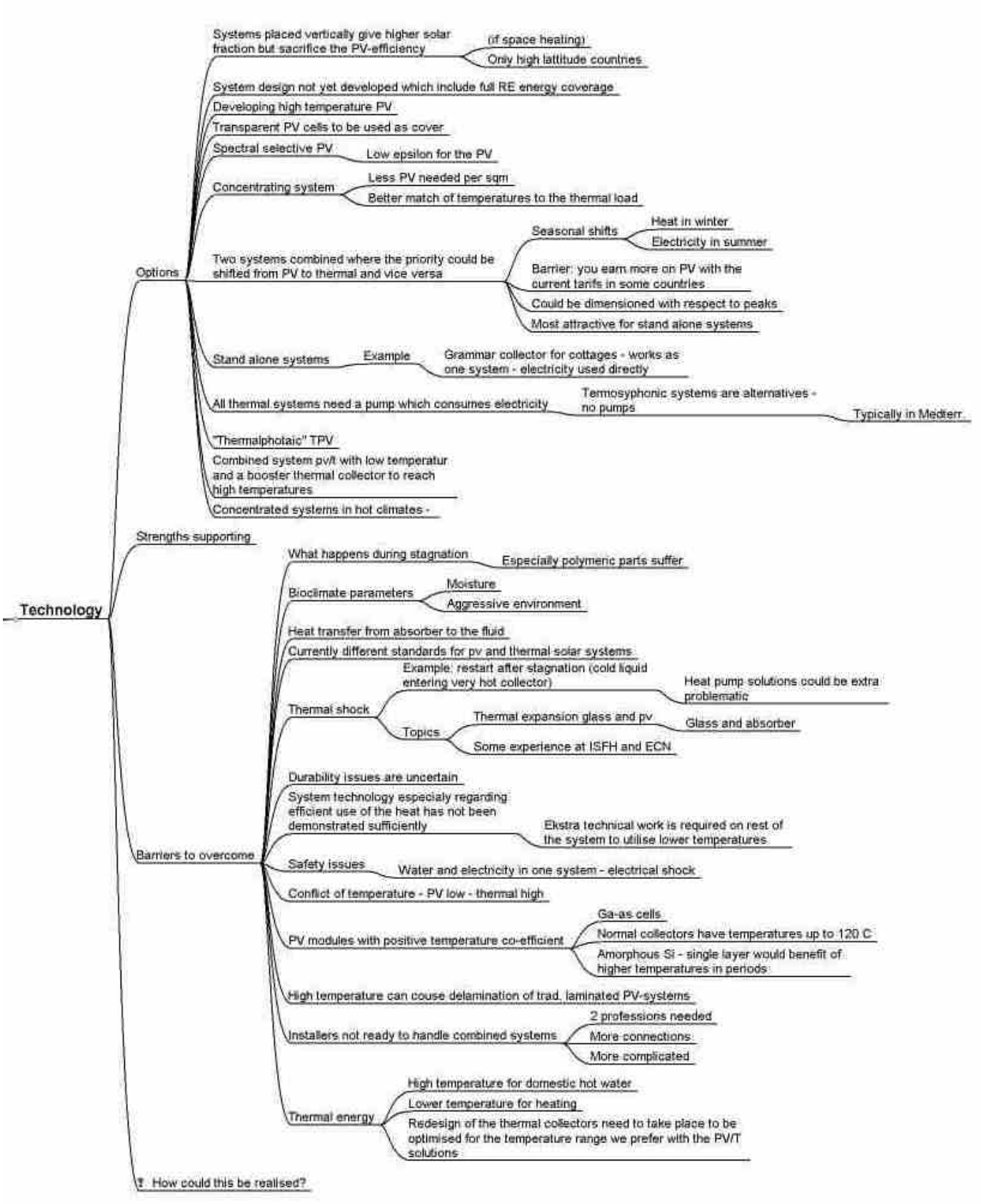

Figure 8: Detailed analysis of PVT opportunity 'technological developments'

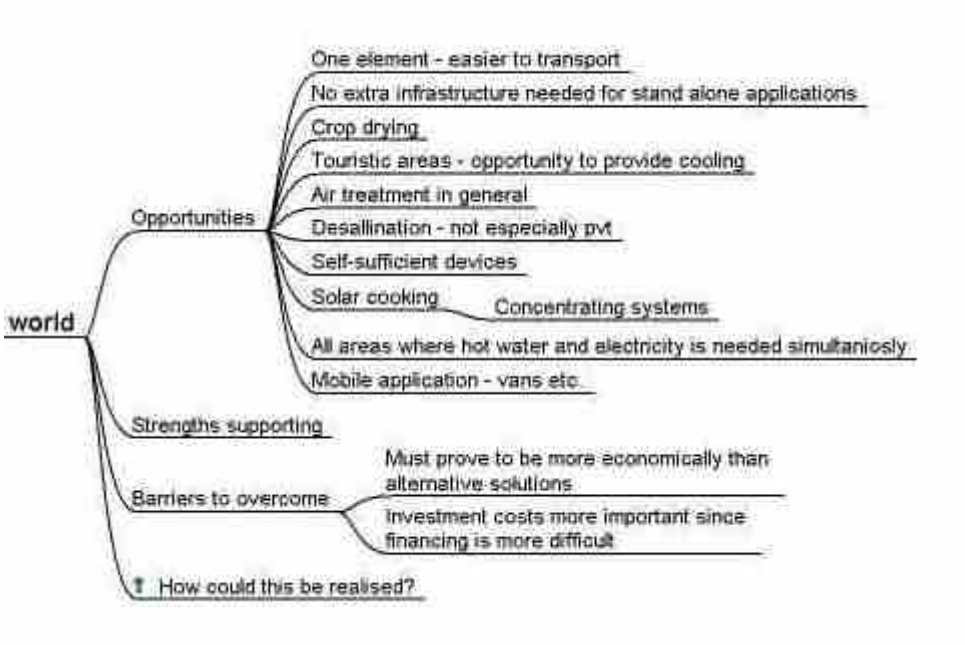

Figure 9: Detailed analysis of PVT opportunity 'applications for developing countries'.

Figure 10: Plenum discussion at the PVT workshop in Freiburg

5 Recommendations and conclusions

In general, the outcome of this workshop was quite similar to the results from the Paris workshop, which are given in the corresponding report. Only new aspects are reported here.

During the SWOT analysis, a large number of issues was raised. In Table 1, an attempt is made to summarise these.

Strength	Weakness
• more efficient use of area & materials • easier to install (single system) • easier to market (one product for all) • aesthetic advantage • PV cooling	• reliability not yet optimised (e.g. stagnation temperature resistance) • coupling of 2 dissimilar needs • economics not sufficiently clear yet • high initial cost • reduced thermal module efficiency • more complicated systems
Opportunity	**Threat**
• increase efficiency by dedicated PV • optimise system design (solar cooling, heat pump) • combined subsidy • interesting niche markets (utility, autonomous systems, BIPVT, recreational homes & mobile homes) • rising price of fuel • feed-in tariffs	• two separate industries required • marketing channels for PV and T are different • industrial involvement is small • standards are lacking • awareness is lacking • practical experience from demonstration projects is lacking • competing technology (e.g. fuel cell) • political support required

Table 1: SWOT analysis of PVT, relative to a system consisting of separate PV and Thermal.

Many of these aspects came back in the second phase of the workshop. In the resulting discussion, a number of recommendations was given.

It is nice	Building integration
• More studies supporting the system economics • Dedicated testing standards • Increase thermal efficiency • profit from the good image of PV • bring PV and solar thermal industries together • More demonstration projects required	• Consider PVT as building material • Ensure good aesthetics and good flexibility of PVT designs • Effort required to overcome inertia of the building and installation sector
Technology	**Developing countries**
• Optimise PVT thermal efficiency (emission, absorption, heat transfer) • develop high temperature PV • R&D on safety and reliability required (thermal shock, stagnation temperature, electrical insulation) • training schemes for installers required • develop optimised thermal systems solutions (regional variations!) • develop combined systems with PVT and booster thermal collectors	• Market studies required for interesting niche markets (crop drying, touristic applications, desalination, self sufficient devices, mobile applications such as vans) • Focus on strength of PVT: one element gives easier transport and less infrastructure required • Difficult financing requires additional effort

Table 2: Analysis summary of selected PVT opportunities.

It can be summarized that PVT Solar Systems are still to be considered as a new and emerging technology and the same route to commercialisation has to be followed as was followed in the past by other techniques such as solar thermal and PV-systems. However, compared to solar thermal and PV, PVT Solar Systems have the advantage of being able

to rely on the knowledge gained for the two other technologies separately, which could be a very important asset regarding the time needed to commercialise the technology. Testing methods, materials knowledge and partly the knowledge on heat and electricity generation on the systems are known – the challenge during the coming years will be for R&D institutes, testing institutes, manufacturers, engineering companies, installers, architects, building companies, policy makers etc. to join forces on the route for commercialisation of PVT.

6 Annex

6.1 Invitations circulated and published

PVT FORUM

Announcement of two workshops on PV-thermal systems

How can PVT strengthen both the PV and the solar thermal future markets in Europe?

In PVT systems, the incoming solar radiation is converted into electricity and heat simultaneously. PVT panels have a higher total efficiency than separately installed PV panels and solar thermal collectors. Other possible advantages are lower installation costs and in the long run lower production costs.

PVT panels can contribute to the growth of both markets as they have the same functionality as PV panels and solar thermal collectors.

The EC funded project PV Catapult aims at the elaboration of a marketing and R&D roadmap for PVT. Two workshops are planned to contribute to this roadmap. You are kindly invited to participate. The contents of the two workshops are identical, please choose the one which is more convenient for you.

The strengths, weaknesses, market opportunities and market threats for PVT will be identified in these workshops. Market experts, PV experts and solar thermal experts are invited to give their input to the workshops and discuss the role PVT can play in the market and the future development of PV and solar thermal systems.

The first workshop will be held on **Tuesday 8 June 2004, 8.30 to 12.00h at the Palais de Congrès**, during the European Photovoltaic Solar Energy Conference in Paris (7 to 11 June 2004). For details on this workshop, please contact Henrik Sørensen (*h.soerensen@esbensen.dk*).

The second workshop will be held on **Thursday 24 June 2004, 9.00 to 14.00h at Fraunhofer ISE**, directly after the EUROSUN 2004 conference in Freiburg, Germany, (21 to 23 June 2004). For details on this workshop, please contact Matthias Rommel (*rommel@ise.fraunhofer.de*) or Hermann Laukamp (*hermann.laukamp@ise.fraunhofer.de*).

More information on the PVT marketing and R&D roadmap can be found on the PVT Forum, in which 7 partners from research and industry work together. Please visit *www.pvtforum.org* or contact Wim van Helden (*vanhelden@ecn.nl*).

6.2 List of participants

	Name	Company	Country
1	Marco Bakker	ECN	Netherlands
2	Teun Bokhoven	ESTIF/Solar Systems	Netherlands
3	Anton Schaap	Ecofys	Netherlands
4	Wim van Helden	ECN	Netherlands
5	Steve Harrison	Enerworks Inc.	Canada
6	Soteris Kalogirou	Higher Technical Institute	Cyprus
7	Vasiliki Perraki	University of Patras, Dept. Of Electrical Engineering	Greece
8	Annalisa Corrado	University of Rome "La Sapienza"	Italy
9	Joachim Schmalz		Germany
10	Yiannis Tripanagnostopoulos	University of Patras, Physics Dept.	Greece
11	Andre Gillet	ISES-Belgium	Belgium
12	Siegfried Schröpf	Grammer Solar	Germany
13	Valentina Dessi	Politecnico Milano	Italy
14	Niccolo Aste	Politecnico Milano, Dip. Energetica	Italy
15	Shelly Comer	Univ. College London	England
16	Krystian Kurowski	EC BREC	Poland
17	Yiping Wang	Tianjin University	China
18	Jochen Marwede	Shell Int. Exploration & Production Inc.	USA
19	Mustafa Engin	Ege University	Turkey
20	Anton Driesse	Queen's University	Canada
21	Klaus Lambrecht	Econsult	Germany
22	Markku Uoti	Outo Kumpu	Finland
23	Rüdiger Niewind	Rheinzink	Germany
24	Constantinos Faitatzoyla	Heliodomi SA	Greece
25	Ursula Eicker	HFT Stuttgart	Germany
26	Hassan Motea Al-Nakhli	King Faisal University College of Architecture	Saudi Arabia
27	Alexander Storch	Arsenal Research	Austria
28	Patricia Ferro	ERAA21	Italy
29	Torsten Masseck	CISOL-ETSAV-UPC	Spain
30	Erik Franke	Franke Architekten BV	Netherlands
31	Fabio Brunet Brunner	MIT	USA
32	Arthur de Vries	Heliomax	Netherlands
33	Henk Koning	Heliomax	Netherlands
34	Cully Judd	Sunearth Inc.	USA
35	Geraldine Corredera	EDF	France
36	Akos Nemcsics	Technische Hochschule Budapest	Hungary
37	Herbert Zondag	ECN	Netherlands
38	Henrik Sørensen	Esbensen Consulting	Denmark
39	Matthias Rommel	Fraunhofer ISE	Germany
40	Wolfgang Eisenmann	ISFH	Germany
41	Pascal Affolter	Solstis	Switzerland
42	Klaus Heidler	Solar Consulting	Germany