

## **DRAFT 'ROAD MAP' ON PV/T SYSTEMS**

### **- FOR DISCUSSION -**

This document serves as a draft and was discussed at the 2<sup>nd</sup> meeting of IEA SHC and PVPS Joint Working group on PV/Thermal Solar Systems, Rapperswil 6. October 2000.

The contents of the document will be edited by participating experts and will have to be approved by Exco-members of IEA SHC and PVPS before being considered official working document of the group.

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**November 2000**

Supported by:  
 The Netherlands Agency  
 for Energy and the Environment B.V.  
 Novem (report no. follows)

## SUMMARY

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The idea to develop a road map on PV/T systems originates from the first IEA SHCP and PVPS workshop on PV/T systems (September 1999 in Amersfoort, The Netherlands). This workshop was attended by representatives from Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, The Netherlands, Norway, Sweden, Switzerland, The United Kingdom and the USA. During the second workshop (June 2000 in Copenhagen, Denmark), attended by Australia, Denmark, Israel, The Netherlands, South Korea, Sweden and Switzerland, a set up of the road map was prepared, which was further elaborated towards this document, containing the draft road map. The draft road map sets the strategy in terms of objectives and important issues to be addressed in order to develop PV/T to a mature technology. Based on this road map, a work plan will be prepared with concrete activities, deliverables and milestones.

A PV/T system integrates a PV panel and Solar Thermal collector in one product/system. A typical hybrid PV/T system contains a thermal collector in which a PV laminate is used as a thermal absorber. The system produces both usable electricity and thermal energy.

The joint application of PV and solar thermal technologies may favour both industries, joint advantages can be reached:

- each others market experiences can be used,
- cost reductions are expected thanks to the combined production, installation and mounting and
- in future the limitation of availability of roof area is prevented.

At the moment, however, the development stages of PV/T systems are premature. Although some niche markets do exist, full-scale introduction of domestic PV/T systems can not yet be justified. In practise, the integration of PV and solar thermal leads to problems: both technologies are still under development, combining them provides extra problems. PV panels usually have higher efficiencies at low temperatures, whereas the thermal collector features high temperatures. The long-term scope is to arrive at PV/T products or systems that economically combine a PV panel and a thermal collector in one system. Those PV/T systems must suit to the energy systems present in the building. For now, the priority seems to focus on

water collectors for temperatures above 60 °C (tap water heating) as this will serve a large market.

The draft road map defines objectives for the long, medium and short term and issues to reach those objectives. The long-term scope is to arrive at new, complete integrated PV/T products or systems that economically combine a PV panel and a thermal collector in one system, compared to non-renewables. The mid-term objective is defined as to start the market introduction of PV/T systems that can compete with separate PV & solar thermal systems on costs, aesthetics, comfort, etc. The short-term objective is to create an international environment that enables / convinces industry to develop PV/T systems.

To reach those objectives, the following issues have been identified and need to be elaborated during the coming years:

- R&D network
- Market Analysis
- Design specifications
- Design tools, simulation tools
- Test methods
- Component Research
- Stability of the materials
- Performance optimisation
- Product development
- Market introduction projects
- Demonstration projects
- ...

To develop the defined PV/T activities effectively and organise them efficiently, it is proposed to initiate an international working group, e.g. by a joint working group between the IEA SHCP and PVPS programmes. The working group functions as a platform of specialists, i.e. researchers, building professionals and manufacturers, similar to other IEA working groups. The internet may play a key role in the working group to organise the information exchange among the experts and interested parties efficiently.

## **TABLE OF CONTENTS**

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<b>1. INTRODUCTION .....</b>	<b>1</b>
1.1    Definition of PV/T systems	1
1.2    Background	1
<b>2. THE 'STATE OF THE ART' OF PV/T SYSTEMS - MOTIVATION .....</b>	<b>2</b>
2.1    Introduction	2
2.2    products	2
2.3    Research & Development	3
2.4    The Market Needs	3
2.5    International collaboration	5
<b>3. OBJECTIVES OF THE ROAD MAP .....</b>	<b>6</b>
3.1    Introduction	6
3.2    Long Term (7~10 years)	7
3.3    Mid Term (3~7 years)	7
3.4    Short Term (0~3 years)	7
<b>4. ISSUES .....</b>	<b>8</b>
4.1    Introduction	8
4.2    Issues	9
4.2.1    R&D network	9
4.2.2    Market analysis	9
4.2.3    Technical PV/T design requirements	10
4.2.4    Uniform design tools	10
4.2.5    Common test standards	11
4.2.6    Component research	11
4.2.7    Stability of the materials	11
4.2.8    Performance optimisation	12
4.2.9    Product Development	12
4.2.10    Demonstration projects	12
4.2.11    Market introduction projects	12
4.3    Time scale	13

<b>5. ORGANISATION OF THE WORKING GROUP ...</b>	<b>15</b>
5.1 Introduction	15
5.2 Activities in the working group	15
5.3 The role of the working group in the market	17
<b>6. CONCLUSIONS .....</b>	<b>18</b>
<b>7. REFERENCES .....</b>	<b>19</b>

# 1. INTRODUCTION

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*This introduction presents a definition of PV/T system, the motivation to develop PV/T and the background to develop this draft road map. The idea of a road map on PV/T systems originates from the first workshop on PV/T systems (September 1999 in Amersfoort, The Netherlands). During the second workshop (June 2000 in Copenhagen, Denmark) a set up of the road map was prepared, which was further elaborated towards this document, containing the draft road map.*

## 1.1 DEFINITION OF PV/T SYSTEMS

A PV/T system integrates a PV panel and Solar Thermal collector in one product/system. A typical hybrid PV/T system contains a thermal collector in which a PV laminate is used as a thermal absorber. The system produces both usable electricity and thermal energy.

## 1.2 BACKGROUND

The idea of a road map on PV/T systems originates from the first workshop on PV/T systems which was organised in September 1999 in Amersfoort in the Netherlands. Mr. Erik Lysen (PVPS) and Mr. Lex Bosselaar (SHCP) chaired this workshop. The workshop concluded that this was the first time that the experts from the SHCP and PVPS got together and discussed this important topic. All experts experienced the exchange of information on PV/T systems as very successful. Thus, it was agreed to initiate the preparations of a joint working group between the two implementing agreements. First task of the joint working group would be to prepare a road map, which identifies the necessary steps to develop PV/T systems and products and market them successfully. During the second workshop, held in June 2000 in Copenhagen (Denmark), an outline of the road map was proposed. This outline is elaborated towards this draft document by Ecofys and supported by Novem, The Netherlands Agency for Energy and the Environment. The draft road map is ready for commenting by the international experts of the SHCP and PVPS programme. The next chapters present the short, medium and long term objectives and possible (international) activities.

## 2. THE 'STATE OF THE ART' OF PV/T SYSTEMS - MOTIVATION

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*In practise, the integration of PV and solar thermal leads to problems: both technologies are still under development, combining them provides extra problems. The most important technical problem, is the fact that PV panels usually have higher efficiencies at low temperatures, whereas the thermal collector features high temperatures. The long-term scope is to arrive at PV/T products or systems that economically combine a PV panel and a thermal collector in one system. Those PV/T systems must suit to the energy systems present in the building. For now, the priority seems to focus on water collectors for temperatures above 60 °C (tap water heating) as this will serve a large market. In future, it is expected that the joint application of PV and solar thermal technologies may favour both industries.*

### 2.1 INTRODUCTION

During the last years, the interest in PV/T systems that combine a PV system and a solar thermal collector has grown. The reason for the growing interest in PV/T is probably that Building Integrated PV (BIPV) is an important item in many countries and that many of these BIPV projects are often combined with a roof integrated solar thermal collector. This causes several technical and architectural problems. Therefore, the idea has developed to integrate both technologies. An argument from the market side for integration, is the availability of roof area and the expected cost reduction thanks to the combined production, installation and mounting. A technical argument is the relative low efficiency of PV systems that lay in the range of 10 to 20 %. The rest of the collected solar energy is converted into heat. In principle, this heat can be used. This chapter presents a short summary of today's status of PV/T.

### 2.2 PRODUCTS

Within IEA Task VII of the PVPS programme, Esbensen Consulting (DK) has performed an extensive study towards existing PV/T systems and those under development. Together with the knowledge gained during the technology review on PV/T systems of Ecofys (NL), it appeared that only few standard PV/T products are commercially available.

PV/T systems are often constructed on a project-base, e.g. domestic housing projects integrating a separate solar thermal collector and a PV system in one roof or e.g. ventilated

PV facades. The first standard products are now being developed. Some of the standard PV/T products use air as heat-collecting medium, e.g. ventilated pv facades (Solarwall, CAN) and a PV driven air-collector (Grammer KG, GE). Other standard products use water as heat transferring medium and are mostly used as domestic hot water systems, i.e. the integration of a solar water heater with PV panel. Products are available from Chromagen Solar Energy Systems (ISR), Zenith Energietechnik (GE), Solarwerk (GE) and Solarwatt Solar systems GmbH (GE). Comparison of these products is hard, as no test method is available. Furthermore, it is noted that the climate is very determining for its' performance.

An integrated PV/T system is more cost effective than a separate PV and thermal system, when the saved production and installation costs matches the costs of lost performances. Today, this is generally not the case: the electrical yield of a PV/T system may at best be similar to separate PV systems; the thermal yield is never better than that one of a non selective thermal collector. PV and solar thermal technologies are not yet adapted to each other. Fundamental research may help to overcome this problem to a great extent. Simple adding the two systems together sets a fixed, unbalanced relationship between electricity and thermal energy supply, not matching the energy demand. Added systems also cause a mis-match in the current availability of roof area. This situation is likely to change in future. The overall performance may be improved as the PV and solar thermal technology will be better adapted to each other, e.g. through improved materials, better integration in the building energy systems, improved system performances etc. In the end, better aesthetic, technical and economical performances should be attained to open the market.

### **2.3 RESEARCH & DEVELOPMENT**

Next to the commercial products and projects, a lot of research and development activities are going on. Most of these activities are performed within governmental founded programmes as the PV Bonus programme in the USA and the Joule programme in EU. National research institutes perform important work as well, e.g. ISE and ISFH (GE), ECN (NL) and EPFL (CH) showed relevant performed work. The match between supply / demand, lifetime performance and aesthetics are the primary design factors; the choice of components and materials used should result from this. Proper research is required, international dissemination of results and knowledge transfer is highly appreciated by the involved parties.

### **2.4 THE MARKET NEEDS**

There definitely is a market need for combined heat and electricity. However, the question here is, which PV/T technology suits (best) to this market need.

Ecofys (NL) developed a method to assess the market opportunities of ‘promising’ PV/T systems, using today’s technologies and being applicable in the Dutch climate. The proposed systems involved industrial appliances, domestic appliances and swimming pool applications. From this study, it was concluded that first market niches may occur at the PV facades, thanks to low surplus costs and large material savings. Also, low temperature applications like (pre)heating of swimming pool water and heat pump applications are suitable for PV/T applications, from technical point of view.

Current niche markets can be divided in two groups: solar collectors with a little PV (e.g. PV driven air collectors) and PV applications with little solar thermal (PV facades). The moment prices reduce, both niche markets are expected to emerge to larger markets. The identified niche markets are:

- PV driven air collectors, e.g. crop drying on remote locations like tobacco huts
- Heat pump appliances (cooling PV and regenerate soil heat)
- Pool heating (low temperature)
- Private households, domestic hot water (especially at lower solar fractions)
- Current markets for solar air collectors
- Facades
- Remote locations (hotels in tropical countries)

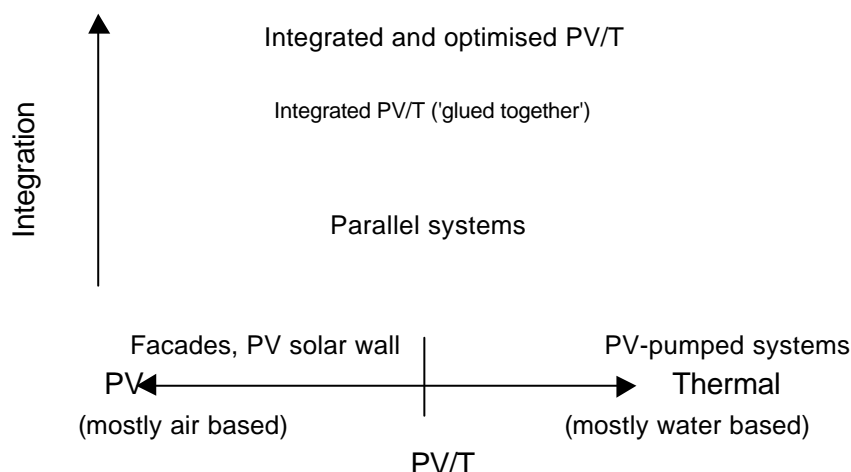


Figure 1: Schematic overview of the PV/T developments.

Although, today’s domestic PV/T appliances are far from economic in most North West European countries, these systems are *the* market. Here, large volumes can be reached. Moreover, architects already integrate a solar thermal collector and a PV system in one casing (projects wise). However, is there a need for a “compressed version”, combining both technologies in one product? This is clearly a matter of costs, aesthetics and availability of products, and in future availability of roof area. Combining the two in one product may favour both industries: PV may add a high-tech appearance to the solar thermal collector. Solar thermal will profit from the large, and still raising interest, in PV. On the other hand, PV can profit from the existing market channels of solar thermal systems,

solar thermal stands closer to the end-user than PV. Moreover, the end-consumer is not interested in PV or solar thermal, but in solar energy. Smart marketing is required.

Another argument to combine the two systems is that there is still plenty of roof area available, but sooner or later, when both systems get more cost effective, a competition for the availability of roof area might start. Governmental policies on renewables, like e.g. the Dutch objective to attain a 10 % supply of renewable energy in 2020, will favour and enhance the solar applications in the built environment. To suit these developments, systems must be developed which integrate both products in one roof. This may either be accomplished by combining two separate products next to each other in one roofing element (project and/or product wise, feasible on relatively short term) or by the total integration of two products in one PV/T system (feasible in the long term). In both cases, the key criteria is to develop full solar energy roof that meets the architectural requirements, i.e. watertight, uniform colour scheme, modular, simple to mount, etc. and fits to the other energy systems of the house

## **2.5 INTERNATIONAL COLLABORATION**

Many PV/T activities are initiated but hardly any dissemination and knowledge transfer among the specialists take place, but is strongly appreciated as was shown in the workshops in Amersfoort (NL) and Copenhagen (DK).

It is recommended to join (fundamental) R&D activities to use the resources efficiently and effectively. For example, by developing rules and guide-lines to assess the various PV/T systems equally. Apart from R&D, many other activities will profit from international collaboration. For instance, the market assessment tool as developed by Ecofys for The Netherlands might well be extrapolated to other countries and help them identifying proper product market combinations. Also, building integration experiences on design and aesthetics may well favour PV/T developments. The next chapter will further address issues to be developed to enhance the international PV/T market to develop.

### 3. OBJECTIVES OF THE ROAD MAP

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*This chapter presents the strategy of the road map (draft) i.e. objectives for the long, medium and short term. The long-term scope is to arrive at new, complete integrated PV/T products or systems that economically combine a PV panel and a thermal collector in one system, compared to non-renewables. The mid term objective is defined as to start the market introduction of PV/T systems that can compete with separate PV & solar thermal systems on costs, aesthetics, comfort, etc. The short-term objective is to create an international environment that enables / convinces industry to develop PV/T systems.*

#### 3.1 INTRODUCTION

The objective of the road map is to identify a strategy to develop PV/T systems and products towards a mature market. The necessary (international) steps will be identified, but first the objectives need to be clear. In section 2.4, market needs, it was concluded that *the* market exists in the domestic applications. Here, the long-term scope, i.e. in 7 to 10 years, is to arrive at PV/T products or systems that economically combine a PV panel and a thermal collector in one system. For niche markets, like the PV facade, this situation may well occur earlier. The IEA working group will support both.

To reach the long term objective various activities need to be started, to which different experts will contribute: three groups of experts are discerned to be involved with PV/T developments:

- building professionals (engineers, installers, architects, etc. )
- industrial parties
- researchers

Although, the various experts have different interests in participating in the development of PV/T products and systems, the long-term objective is identical to all of them: to set products on the market that will satisfy the end-user. To reach this goal it is essential that the experts communicate their results and adjust their activities among each other. A working group (with representatives) of all (international) experts could well establish this role. The organisation of this working group will be explained in chapter 5, after the presentation of the objectives (chapter 3) and the related activities (chapter 4).

### **3.2 LONG TERM (7~10 YEARS)**

The long-term scope is to arrive at new, complete integrated PV/T products or systems that economically combine a PV panel and a thermal collector in one system. In 7 ~10 years, it is generally expected that both PV and solar thermal technologies can compete with non-renewable technologies. For domestic PV/T systems a similar objective is set.

### **3.3 MID TERM (3~7 YEARS)**

The mid term objective is defined as to start the market introduction of PV/T systems that can compete with separate PV & solar thermal systems on costs, aesthetics, comfort, etc.

### **3.4 SHORT TERM (0~3 YEARS)**

The short-term objective is to create an international environment that enables / convinces industry to develop PV/T systems. Dissemination and knowledge transfer are important topics, as well as the formation of working groups who will jointly start the various required activities (see chapter 4).

## 4. ISSUES

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*To effectively develop integrated PV/T systems that compete with non-renewables, it is essential that activities on the following items are started: R&D network, Market Analysis, Design specifications, Design tools, simulation tools, Test methods, Component Research, Stability of the materials, Performance optimisation, Market introduction projects and Demonstration projects. Dependent on the PV/T technologies these activities will take place in a different time-scale.*

### 4.1 INTRODUCTION

To effectively develop integrated PV/T systems that compete with non-renewables, it is essential that an international R&D network is formed in which the various required research issues are adjusted and research results can be exchanged among the experts. The experts can jointly work together on the stated issues. First, the experts can perform a market analysis to quantify the long-term research goals and try to predict the market developments. This can be based on the existing data from other IEA programmes (e.g. PVPS and SHCP) on market volumes and cost predications for PV, Solar Thermal and non-renewables. Next to the market requirements, it is essential to set the technical scope to the PV/T developments, i.e. the design requirements. In order to reach those requirements efficiently, generic design tools and test methods need to be developed.

The following issues will be presented in more detail:

- R&D network
- Market Analysis
- Design specifications
- Design tools, simulation tools
- Test methods
- Component Research
- Stability of the materials
- Performance optimisation
- Product development
- Market introduction projects
- Demonstration projects
- ...
-

## 4.2 ISSUES

### 4.2.1 R & D NETWORK

The establishment of a working group of (experienced) PV and solar thermal experts, must attain a sound information exchange of results and experiences related to R&D, market developments, design specifications, design tools, test methods, etc. Additionally the R&D network may lead to joint PV/T developments and a clear understanding of the various research problems.

Part of the work on the information exchange has already been started e.g. the previous workshops and the PV/T inventory from IEA PVPS Task 7, activity 2.5. As a result of one of the workshops, Morgan Brazillian (AUS) and Frederik Leenders (NL), presented a joint article on today's PV/T projects and their features to Solar Energy. Moreover, during the earlier working group meetings, the experts expressed a keen interest in the establishment of a R&D network.

### 4.2.2 MARKET ANALYSIS

The analysis of markets is crucial for the development of new products. The analysis can be split principally in two different issues: technical and economical. The following actions consider the more **technical issues** to analyse the technical potential to use PV/T systems:

- Evaluate the market according to the buyers preference.
- Perform a generic market analysis for PV/T systems by extrapolating the methodology developed in The Netherlands (Leenders, 1999).
- Evaluate the technical & economical feasibility per region, i.e. Define products and concepts that are applicable to the various climates.
- Perform case studies for existing products and identify their applicability for the home market, the climatic region, analyse their current and future position in the market, and define lessons to be learned and recommendations (e.g. the Multi Solar product in Israel, or the PV Solarwall from Canada).
- ...

A number of different **economical key-values** are considered to be important for the calculation of the economic viability of PV/T systems. First, typical economical key-values are to be identified.

- $\$/\text{kWh}_{(\text{annual})}$  thermal production price at a certain temperature demand
- $\$/\text{m}^2$  investment costs
- $\text{kWh}_{(\text{annual})} / \text{m}^2$
- net extra costs for building integration (combined, separate systems)
- ...

Experience and data from other tasks in SHCP and PVPS can be used. The result should be a clear definition of feasible systems in the various climates and the technical and economical boundaries to those systems.

#### **4.2.3 TECHNICAL PV/T DESIGN REQUIREMENTS**

The technical PV/T design requirements per system need to be identified and quantified, i.e. what are the expected/required performances of the system:

- Produced MJ of heat (on a hourly, daily , monthly basis?)
- Produced kWh of electricity (on a hourly, daily , monthly basis?)
- Robustness of the system
- Ease of installation
- Guarantees
- Aesthetics
- ...

This research work may be well established jointly by the various international experts, if possible by using a generic method per system. Here, systems are explicitly included as the PV/T product may well be used within a complete system, e.g. in a heat pump system. The market analysis should indicate whether or not it is useful to start developing – such a system for a specific region.

The aesthetics is stated as one of the technical requirements as there will be no future for PV/T systems unless the aesthetical values are at least as good as for PV and active solar. Given the combination of these two systems, the PV/T systems can principally be made physically smaller, which could be attractive to building designers and clients. As a starting point, the evaluation list of criteria for PV projects in the built environment from IEA PVPS Task 7 can be used to set the aesthetical requirements.

*Question: Perhaps, for the near future the R&D accents must more focus on achieving a well functioning of the system in terms of MJ and kWh?*

#### **4.2.4 UNIFORM DESIGN TOOLS**

Uniform design tools can be very useful in developing new systems and products, e.g. the

- simulation tools like TRNSYS or the exergy calculation based model as developed in Japan, and
- design guide lines as developed / recommended by JRC and / or Universities of Cardiff and Strathclyde
- ..

#### **4.2.5 COMMON TEST STANDARDS**

Common standards for the performance evaluation of PV/T systems need to be developed. A number of activities are required to equally compare the systems. So far, testing of PV/T systems at laboratories are conducted according to own procedures or according to standards for testing thermal solar collectors. Both cases are far from ideal. The comparison of results of different products is impossible in case own procedures are used, and in case thermal standards are used, the results will differ as the electric power output differs from case to case (load connected, temperature dependency, etc.). Thus, new procedures need to be developed and compared to existing standards to find the suitability. The required facilities are available in existing laboratories in Switzerland, Denmark and various other countries. (An agreement on the proper testing methods is to be obtained, i.e. a standard / guide-line (climate independent user profile, system key-values etc.) needs to be developed and validated by the various laboratories). The performances should preferably be normalised according to typical design parameters. The PV Hybrid-Pas project is an example of a project in which a similar approach is used.

#### **4.2.6 COMPONENT RESEARCH**

To reach the objective of integrated PV/T systems on the market that compete with non-renewables various research issues need to be defined and components being developed: e.g. on:

- Stability of the materials
- Performance optimisation
- Adhesive layer with good thermal properties
- PV/T Technology that matches supply and demand criteria
- ...
- ..

Results may become at hand in different periods of time, and research topics may change in time, as long as the objectives are clear: to attain competitive PV/T products in terms of costs, aesthetics, .... Some of the research topics / results will be confidential, others will be generic, for both developments it would be worthwhile that the working group is aware of the specific developments. The issues: stability of the materials and performance optimisation are identified in the following two sections.

#### **4.2.7 STABILITY OF THE MATERIALS**

The lamination technologies of PV and other mounting principles from PV and Thermal applications should be investigated further. The materials in the combined PV/T systems are exposed to more extreme situations than in traditional applications. Especially, the influence of high temperatures, thermal stresses, lamination and performance of mono- and poly-crystalline solar cells is interesting to clarify. Again it is essential that uniform test procedures become available to equally compare the achieved results from the different research centres, laboratories.

#### **4.2.8 PERFORMANCE OPTIMISATION**

Based on better knowledge about the overall performance of the various systems, activities should be initiated to identify critical parameters and target the development or improvement of the systems:

- Identify critical parameters, components, controls etc.
- Optimisation of the performance with optimum use of the energy production
- Thermal interaction between solar cells and absorber, especially the physical contact where electrical isolation is needed and at the same time a high heat conductivity is required
- Thermal stresses (life time long)
- Study of the importance of backside reflection of solar cells laminated to absorbers, since the radiation penetrating the cell now can be used as thermal source.
- Utilisation of new optical components to improve efficiency
- Analyse possibilities to use other types of spectral selective layers

#### **4.2.9 PRODUCT DEVELOPMENT**

Following the fundamental research of specific problems, the results need to be implemented in products. These products need to be optimised to suit the energy specifications, production aspects, installation & mounting requirements, etc.

#### **4.2.10 DEMONSTRATION PROJECTS**

Research results need first to be tested in practise before they can be transferred to products. Therefore, the performance of demonstration projects on future systems is essential to collecting engineering data under practical conditions. After being demonstrated and fully tested and monitored in real-scale conditions, the market introduction phase can start.

#### **4.2.11 MARKET INTRODUCTION PROJECTS**

The mid-term objective is to start the market introduction of PV/T systems that can compete with separate PV & solar thermal systems on costs, aesthetics, comfort, etc. This is best illustrated with an example.

As indicated in the introduction (chapter 1) many BIPV projects are nowadays often combined with a roof integrated solar thermal collector. These projects do combine separate PV and active solar thermal elements on a project oriented base. This causes several technical and architectural problems, which is solved multiple times for each project. Therefore, it might be a challenging objective to combine the two existing products in a new one, based on standard PV and solar thermal components, but with increased performances on costs, aesthetics and comfort. The lessons learned during this early market introduction phase, can be used for the next generation of PV/T products. As stated, this

is an example, other niche market (indicated by the market analysis) may be developed as well, or may be even more promising.

It may be evident that for the early market introduction projects, a lot of information is required which is also needed for the long term. Consequently, it is essential to start these activities on the short term.

### 4.3 TIME SCALE

Table 1: Time scale to start activities in the issues (r= main results).

<b>Domestic PV/T systems</b>	<b>Short term (0~3 yr)</b>	<b>Medium term (3~7 yr)</b>	<b>Long term (7~10 yr)</b>
R&D network	R R	R	R
Market Analysis		R	
Design specifications		R	
Design tools & Simulation tools		R	R
Test methods		R	
Component Research		R	R R
Stability of the Materials			R
Performance Optimisation			R
Demonstration Projects		R	
Market introduction projects			R

Table 1 presents a rough time schedule of the PV/T activities to be started to develop domestic PV/T systems that integrate PV and solar thermal in such a way that it should be competitive to other technologies which will then be available. It is explicitly noted that such a scheme really depends on the PV/T technology. For example, PV facades seem far closer to market introduction as the economics are calculated differently. With only few added costs, a PV facade is transferred in a PV/T facade. Nonetheless, the formation of a R&D network, the elaboration of design specifications to fully integrate the PV/T facade in the building, development of proper design & simulation tools, and test methods will certainly benefit the PV/T facade. Component research may even lead to

better performances. However, market demonstration already started as first real scale projects are already build and monitored, early market introduction might actually start in the mid term, instead to the long term for domestic PV/T systems. For low, temperature PV/T applications the time-scale of activities will also be different.

One of the first activities of the working group will be to start preparing a working plan, which addresses the specific issues raised. One of the issues will certainly be the market analysis that identifies the various PV/T technologies to be developed (incl. climate dependency) and the related time scales can be elaborated more accurately/realistically.

## **5. ORGANISATION OF THE WORKING GROUP**

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*In order to develop PV/T products and markets, various activities need to be initiated and performed, preferably on an international basis (see chapter 2 and 3). An international working group is preferred to initiate, follow and coordinate these activities. Other important features are dissemination and knowledge transfer. This chapter describes the organisation of this working group.*

### **5.1 INTRODUCTION**

In chapter 4, many PV/T issues are raised for the long, medium and short term. This chapter will propose a method to organise the work related to the activities.

Various experts are active and various parties will influence the PV/T developments. In principal, three main groups of experts are distinguished: engineers (building specialists, architects, climate installation experts etc.), industrial parties and researchers. Next to the experts, other parties are of influence: e.g. end-users, city planners, utilities, installers, municipalities, national governments, etc. The working group must provide a platform to all those parties interested, with the ultimate aim to serve the end-user. However, As PV/T developments are scarcely out of the egg, the role of the end user is limited during the first years. Especially, during the first years, the PV/T development is technology-oriented development. Mainly researchers, building professionals and manufacturers will play a significant role in the working group, they know the possibilities (and drawbacks) of integrating PV and Solar thermal, and can jointly develop products and systems. The collaboration among the various parties will differ from issue to issue. The role of the end-user may not be discarded, although not being part of the working group.

### **5.2 ACTIVITIES IN THE WORKING GROUP**

Figure 3 presents a first impression of the working group could be organised, i.e. the information flows of and among the various experts, related to the earlier identified research issues. The working group plays a central role, as will be explained.

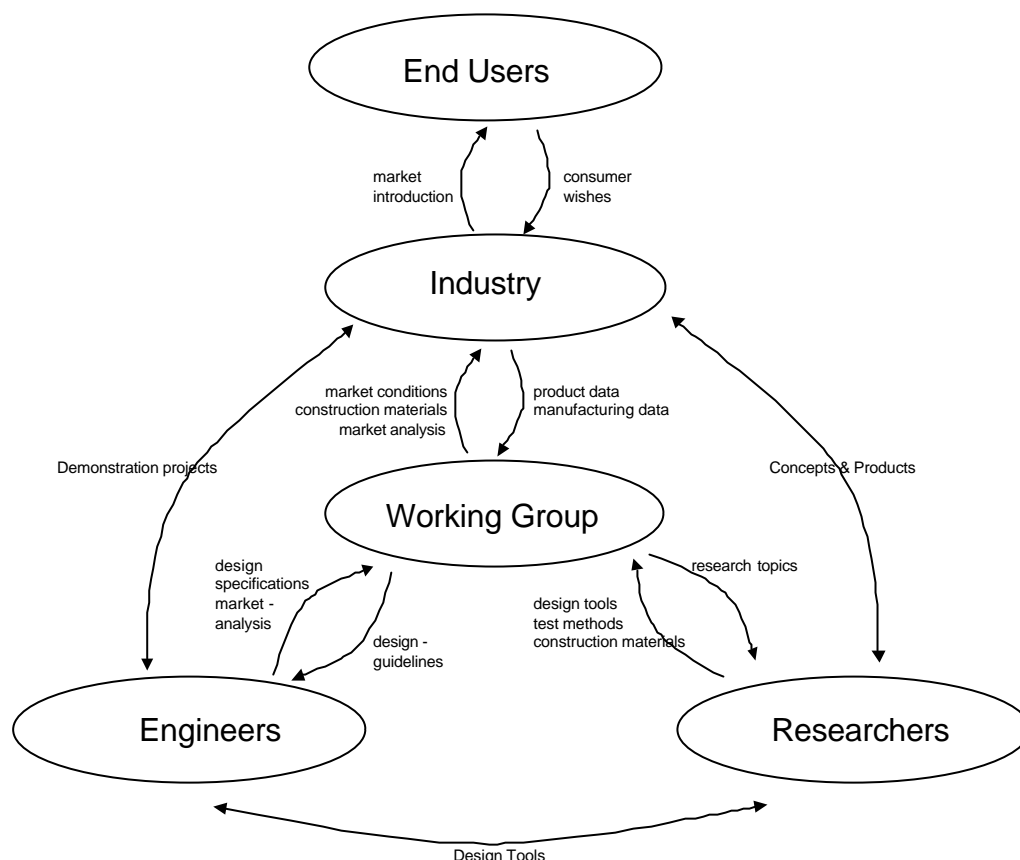


Figure 1: Organisation of the working group.

Nowadays, the first PV/T products are on the market and it is expected that in 3 to 5 years the PV/T market will start to scale up (see chapter 2). The industry will deliver products and services to the end-users.

Engineers (installers, building experts, architects) will assist industry on a project-oriented base with the system integration of early PV/T products / concepts in demonstration projects. Important lessons during design, installation and operation of the systems are put in the final product, being ready for market introduction. As the market grows, consumer confidence will grow and PV/T products will become more and more common, specialised services of building experts are no longer required and the product can be fully served by the industry. For the short term though, industry and building engineers will jointly set the consumer wishes and define and quantify the various technical, economical and market specifications.

The required specifications serve the researchers to define and target their R&D activities on the research topics addressed by the industry. Together they will develop concepts to overcome identified problems. Proper concepts will be developed towards products in a close relationship between researchers (product developers) and the manufacturers. This will be tested according to the developed and validated codes.

Evidently, all parties will work together on different generic and confidential issues. In both cases it is useful to provide a basis to initiate those project initiatives. Links with other programmes SHCP and the PVPS programmes must be maintained by the national representatives. Therefore, a working group that follows or even coordinates all activities can thus be a major asset, even more now PV/T development work and activities are heading off. Dissemination and knowledge transfer can enhance the PV/T developments and are thus included in the working group activities, e.g. by organising workshop parallel to existing PV and Solar thermal conferences, similar to existing IEA working groups.

### **5.3 THE ROLE OF THE WORKING GROUP IN THE MARKET**

In practise, it is suggested to appoint one member per country who promotes the national PV/T interests in the working group and vica versa, i.e. promote the international interest within the national network. This means that the working group member must be well aware of the interests and possibilities of the various national parties (building professionals, researchers and manufacturers) and look for points of cohesion with the international activities (within the working group). The actual work, i.e. the work related to the formulated activities (R&D, market assesement, specifications etc.) will be performed on a national level.

The working group will be an international communication platform, which combines well with the internet as a perfect tool to handle information. A site will be established with a public and confidential part. The working group experts will have acces to the confidential part to include draft documents, comments, discussion points etc. It is important that all national experts have acces to the confidential part to establish cross-links between the experts (build professionals, industry and research areas). Final results are published on the public part, which is available to all, including (future) end-users.

## **6. CONCLUSIONS**

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During the Amersfoort workshop in 1999, where over 30 PV/T experts were present, all participants expressed a keen interest to continue this in a joint working group or joint Task. As a basis for this joint working group a draft road map is proposed. The road map presents the necessary PV/T activities to successfully develop PV/T systems.

The required strategic PV/T objectives and activities are categorised for the long, medium and short term.

## 7. REFERENCES

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