

## THE IEA PVPS PROGRAMME – TOWARDS SUSTAINABLE GLOBAL DEPLOYMENT OF PV

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**ABSTRACT:** The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D Agreements established within the International Energy Agency (IEA), and since its inception in 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaics. This contribution describes the present IEA PVPS strategy and its implementation through the different activities. Highlights on recent achievements of the international co-operation in the various IEA PVPS Tasks, ongoing activities and analysis, emerging trends, case studies, and recommended practices are presented. The contribution provides a comprehensive global overview on photovoltaics as analysed by the IEA PVPS Programme. It addresses important issues for future co-operative work and identifies some of the global challenges.

**Keywords:** Global co-operation, International Energy Agency, market deployment

### 1 INTRODUCTION

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the collaborative R & D “implementing agreements” (R&D co-operation programmes) established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), the Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), the United Kingdom (GBR) and the United States of America (USA). The European Commission is also a member. Very recently, the European Photovoltaic Industry Association EPIA has joined IEA PVPS as a sponsor member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website <http://www.iea-pvps.org>.

### 2 STRATEGY, MISSION AND OBJECTIVES

In 2003, IEA PVPS celebrated its ten year anniversary following two successful 5 year terms with an international conference [1] held in Osaka in conjunction with the 3<sup>rd</sup> PV world conference. At this occasion, a new strategy was presented and discussed for the third term of IEA PVPS. This strategy is characterized by the following main aspects:

#### 2.1 Mission statement

The mission of the IEA PVPS Programme is to enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option.

#### 2.2 Objectives

Under this mission statement, IEA PVPS has the following distinct objectives:

1. To stimulate activities that will lead to a cost reduction of PV power systems applications
2. To increase the awareness of their potential and value and thereby provide advice to decision makers from government, utilities and international organisations
3. To foster the removal of technical and non-technical barriers of PV power systems for the emerging applications in OECD countries
4. To enhance co-operation with non-OECD countries and address both technical and non-technical issues of PV applications in those countries

#### 2.3 Guiding principles

For the strategy in the third term of the IEA PVPS Implementing Agreement, the following principles guide the present co-operation activities:

- A stronger focus on the requirements for successful implementation of PV power systems in different applications;
- Working with a broader set of stakeholders, organisations and industry (including co-operation with other IEA implementing agreements);
- Supporting the transition towards sustainable markets.

#### 2.4 Subjects and applications

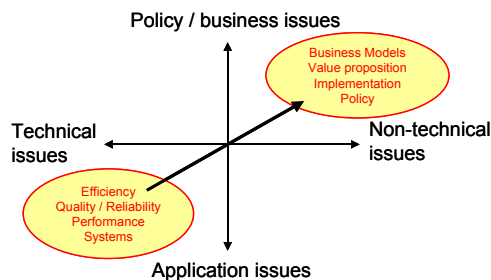
The strategy covers as widely as possible the needs of the emerging photovoltaic markets, focussing on relevant technical and non-technical aspects and the following applications:

- Energy performance, quality and reliability of stand-alone, grid-connected, and hybrid PV power systems;
- Large scale implementation in building integrated, urban scale applications;

- Sustainable deployment of PV power systems in developing countries, including PV power systems in weak grids;
- The role of PV power systems in medium and long-term energy scenarios (energy, environment, and economic issues).

### 2.5 Strategy dimensions

Over time, IEA PVPS has considerably evolved, thereby following the changing needs of a growing global technology and industry. Fig. 1 illustrates this gradual change in the different strategy dimensions of the programme.



**Figure 1:** IEA PVPS strategy dimensions

### 2.6 Assets

IEA PVPS continuously strives for an objective and neutral assessment of key issues related to PV technology and market deployment, thereby providing independent and credible information and recommendations in the different work areas. Using various means of communication, different stakeholders are systematically being addressed. With its global operations, IEA PVPS thus provides unique features in the expanding PV sector:

- a global network of expertise;
- a broad variety of stakeholders;
- independent, objective and neutral analysis;
- country based, task shared operations;
- reference and credibility;
- carefully prepared recommendations;
- strong communication and interaction.

## 3 ACTIVITIES AND RESULTS

IEA PVPS activities are undertaken in different projects, so called tasks, in which the member countries participate according to their needs and priorities.

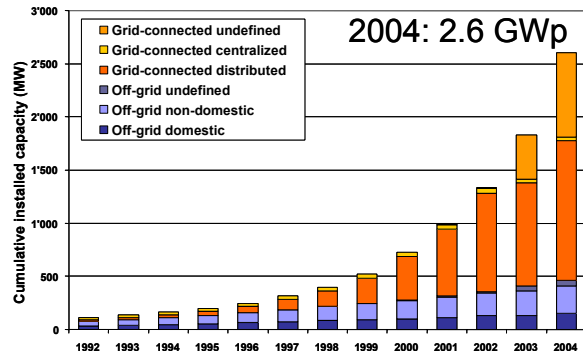
### 3.1 Task 1 – the information team

Task 1 deals with the subject *Exchange and dissemination of information on photovoltaic power systems*. This Task is compulsory for all PVPS member countries and represents a major cross-cutting activity throughout the entire IEA PVPS programme. The Task is responsible for some of the best known IEA PVPS activities, in particular:

- the regular IEA PVPS newsletter;
- the IEA PVPS website <http://www.iea-pvps.org>;
- the regular trends report on photovoltaic applications.

The trends report [2] has become a widely cited reference for the PV market development in the participating countries; more recently, non-member country data have also been included. This activity provides important

results such as tracking the individual markets by their characteristic numbers and the trends in the different applications. Besides the analysis of markets and applications, increasing effort is spent to understand and document the global industry structure and the relevant developments in this area, e.g. the strategic field of feedstock material. Finally, the report provides important information on countries' efforts, programmes and frameworks.



**Figure 2:** Installed PV power by application in IEA countries

Based on the preliminary data collection and analysis, installed PV capacity in IEA PVPS countries is estimated to be 2.6 GWp by the end of 2004. The analysis confirms 2004 as the first year of a global shipment of PV modules greater than 1'000 MWp. On a global scale, the PV installed capacity is estimated to be around 3.2 GWp which corresponds to an estimated energy production of greater than 2 TWh.

### 3.2 Task 2 – the performance team

Task 2 deals with the subject *Performance, reliability and analysis of photovoltaic systems*. The overall objective of Task 2 is to improve the operation, sizing, electrical and economical output of photovoltaic power systems and subsystems by collecting, analysing and disseminating information on their performance and reliability, providing a basis for their assessment, and developing practical recommendations.

This Task fulfils a vital role for the future of photovoltaic systems in the energy supply. Indeed, while it is good to know that the installed PV capacity is growing rapidly on a global scale, it is only if these systems perform well and reliably that they will really contribute to a sustainable energy supply. The Task has set up a substantial data base with more than 400 systems and long data sets which allow to analyse and compare PV systems in different regions of the world.

The analysis of this database allows for interesting conclusions: for example, by comparing the performance ratio of grid connected systems in different countries, one can observe differences which either point to different system concepts or different loss mechanisms. As an other example, one can also observe that the average performance of PV systems has increased for more recent systems, indicating that progress has indeed been made over time on the level of system design and operation.

Most recently, Task 2 has set up a survey on life cycle costs of photovoltaic systems; the survey can be accessed through the website <http://www.iea-pvps-task2.org>.

### 3.3 Task 3 – the team which doesn't stand alone

Task 3 dealt with the subject *Use of photovoltaic power systems in stand-alone and island applications* and was concluded in 2004. This Task had a focused technical profile, and particularly dealt with the eminent issue of quality assurance for stand-alone PV power systems.

While the installed PV capacity in stand-alone systems has continuously reduced in relative terms, making up for less than 20% of the installed PV capacity in IEA countries in 2004, due to the limited size of these systems, there is a very large number of such systems in operation for numerous applications. In some countries, these applications strongly dominate the market. Moreover, this market constitutes one of the economically viable segments and thus also represents an important driver for sustainable PV markets.

It is well known that stand-alone PV systems can be complex in their technical aspects, due to the number of components involved and the energy management issue within such systems. Hence, quality assurance and proper design of such systems is of great importance.

The Task has focused on two main areas, namely:

- quality assurance of stand-alone systems,
- technical issues, in particular concerning load management, appliances and energy storage.

A broad range of technical reports on these subjects can be found at the IEA PVPS website <http://www.iea-pvps.org>.

### 3.4 Task 5 – the team which was well connected

Task 5 dealt with the subject *Grid interconnection of building integrated and other dispersed photovoltaic systems* and was concluded in 2002. The overall objective of Task 5 was to develop and verify technical requirements which will serve as the technical guidelines for grid interconnection with building integrated and other dispersed power systems. The development of these technical requirements include safety and reliable linkage to the electric grid at the lowest possible cost.

Grid connected systems largely dominate the present global PV market, making up for more than 80% of the installed capacity in IEA countries in 2004. Task 5 was a pioneering activity of IEA PVPS at a time when grid interconnection was hardly possible or at its very beginning in many participating countries. The Task was the first global activity to extensively explore issues such as islanding of grid connected PV power systems, effects on the electricity network with high PV penetration or the value of solar electricity in the electric grid.

Among the most important results, the issue of islanding could be experimentally explored and quantified in terms of probability of occurrence. It could be clearly demonstrated that, if proper measures are taken, islanding of PV systems is not a real issue of concern. A broad range of technical reports on these subjects can again be found at the IEA PVPS website <http://www.iea-pvps.org>.

### 3.5 Task 6 – the team dealing with larger scale

Task 6 dealt with the subject *Design and operation of modular photovoltaic plants for large scale power generation*. It is mentioned here for completeness although its work was concluded as early as 1998. Building on the utility experience from the early 1990's, the main objective of this Task was to analyse and support the devel-

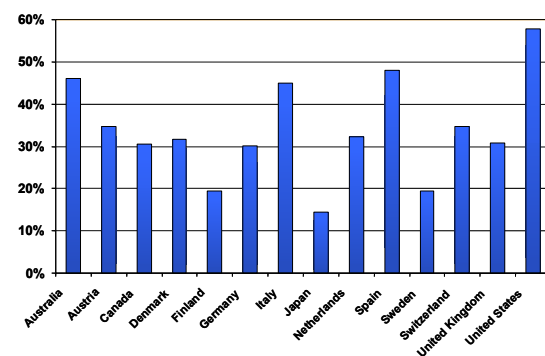
opment of large-scale modular photovoltaic plants for peaking and long-term baseload power generation in connection with the medium-voltage grid. Its main outcome was the first world-wide review and analysis of existing large scale PV plants, similar to the ones which are presently being built in some countries. The results are documented in a number of reports and publications [3]. In addition, Task 6 served to prepare the later Task 8 (see below).

### 3.5 Task 7 – the team which focused on BIPV

Task 7 dealt with the subject *Photovoltaic power systems in the built environment* and was concluded in 2001. The objective of Task 7 was to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment and to assess and remove non-technical barriers for their introduction as an energy-significant option.

The primary focus of the Task was on the integration of PV into the architectural design of buildings (roofs and façades) and other structures in the built environment, such as noise barriers, parking areas and railway canopies. In addition to integration issues, Task 7 also addressed market factors, of both technical and non-technical kind.

The Task, which enjoyed a broad participation from the member countries and different stakeholders, resulted in numerous reports which can be found at the IEA PVPS website <http://www.iea-pvps.org>. These reports cover topics such as economic evaluation and market deployment models of BIPV, applications in non-building structures or the reliability of BIPV systems.



**Figure 3:** Achievable levels of the electricity supply on suitable building surfaces by BIPV

One report analysed the potential of BIPV in different member countries, indicating that between 15% (Japan) and over 50% (US) of the present electricity supply in those countries could be covered by suitable surfaces on the existing building stock (Fig. 3).

Finally, the Task put important emphasis on interaction with the world of architecture and building design. This work resulted in training material (CD-ROM) for architects and a recent book on design with solar power [4].

### 3.6 Task 8 – the team which looks into very large scale

Task 8 deals with the subject of *Very large-scale photovoltaic power generation systems in remote areas*. The objective of Task 8 is to examine and evaluate the feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems in desert areas, which have a capacity ranging from over multi megawatt to gigawatt, and develop practical project proposals for demonstrative research toward realisation of VLS-PV systems in the future.

Task 8 looks more into the future of PV as a means for large scale power production. Indeed, it can easily be shown that arid regions in desert areas around the globe bear sufficient surfaces to cover substantial amounts of the worlds electricity supply. Task 8 undertook, for the first time, a thorough analysis of all factors of such applications and thus provides a comprehensive assessment of the topic. These results have been published in a book entitled *Energy from the desert* [5]. More recently, the Task is focusing on different case studies, thereby investigating in more detail how such systems could be deployed.

Despite the apparent mid to long term nature of this activity, it is worthwhile noting that this Task has considerable interest and participation from the industry, both PV and utilities.

### 3.7 Task 9 – the global network team

Task 9 deals with the subject of *Photovoltaic Services for Developing Countries (PVSDC)*. The objective of PVSDC is to increase the rate of successful deployment of PV systems in developing countries. PVSDC is an outreach activity of IEA PVPS, both in looking beyond the IEA constituency countries as well as regarding the technologies covered. This is being promoted through enhanced co-operation and flow of information between the IEA PVPS Programme and the other international development stakeholders. PVSDC has drawn upon the experience of the participating countries aid and technical assistance programmes, as well as the work of agencies, such as the Global Environment Facility (GEF), World Bank and United National Development Programme (UNDP).

PVSDC's work with PV also takes account of other renewable energy technologies, such as micro-hydro and wind. The team advocates use of the most appropriate technology in particular circumstances and does not simply promote PV.

A series of recommended practice guides on a number of non-technical issues of rural electrification programmes (such as quality management, financing, capacity building and programme implementation) have been published and are accessible through the IEA PVPS website <http://www.iea-pvps.org>. In addition, objective and impartial information is published and disseminated through workshops and seminars held in all five continents.

More recently, PVSDC has increased its focus on PV as an energy source for basic services, such as lighting, drinking water and power for income-generating work, for the people without access to electricity. PVSDC has adopted the primary mission of increasing the sustainable use of PV in developing countries in support of meeting the targets of the Millennium Development Goals.

### 3.8 Task 10 – the team which goes to the city

Task 10 is the most recent IEA PVPS activity and deals with the subject of *Urban scale photovoltaic applications*. The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented application of PV in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and photovoltaics usage. Value analysis, policy incentives, analysis tools as well as system design and integration that have proven successful in the participating countries will be developed to the extent possible into a uniform international set of tools for the global market.

By its very nature, Task 10 is a wide activity involving a broad set of stakeholders. The Task thereby recognizes the needs as they emerge when implementing PV in the urban context. The Task has taken the challenge to move this subject further and to provide a global network of experience to build upon.

Most recently, Task 10 has launched a new competition, the *Lisbon Ideas Challenge* [6]. This is an international design competition aimed at fostering innovative ideas relevant to the development of urban structures integrating photovoltaic systems and technologies. The main novelty compared with earlier initiatives (e.g. IEA PVPS Task 7 Design Competition) is that the ideas should not only have a technological potential but also business potential; the latter should be demonstrated through a business plan.

## 4 INFORMATION AND NETWORKING

### 3.8 Stakeholders

IEA PVPS benefits from the global participation of a variety of stakeholders. Depending on the kind of subject, these comprise:

- Research centres - for R,D&D;
- Manufacturers - for technology development;
- System designers, installers and project developers;
- Utilities - for demonstration and access to the grid;
- Building engineering, architects and urban planners-for building integration;
- Financial institutions - for involvement of venture capital and third party financing;
- Local authorities - for demonstration and dissemination;
- Governmental agencies - for policies and legislation;
- Industrial and consumer association - for market penetration;
- Media for dissemination;
- NGO's for system's deployment.

### 3.9 General information activities

The IEA PVPS programme dedicates a strong effort to information and communication issues. These comprise different levels and means. On the international level, the Programme as a whole as well as the individual Tasks frequently combine their meetings with the organization of workshops and conferences. On the national level, many countries involve IEA PVPS experts in their information initiatives and events. IEA PVPS now regularly has an exhibition booth at major PV conferences.

A number of high-level international conferences



have been organized by the IEA PVPS Programme [1,7]. These conferences serve as outreach to new stakeholders and new initiatives.

Increasingly, the information from the IEA PVPS Programme is available in different languages. Task 2 for example has a multilingual Task website <http://www.iea-pvps-task2.org>. Task 9 will make the summaries of their recommended practice guides available in French and Spanish, thereby facilitating the access to this information in key areas relevant to the Task's focus on developing countries.

General information sources about the IEA PVPS Programme include:

- the IEA PVPS website <http://www.iea-pvps.org>;
- the IEA PVPS newsletter, in printed and electronic form;
- the IEA PVPS annual report, covering the activities of all Task and the individual countries.

#### 4 OUTLOOK TO FUTURE ACTIVITIES

The IEA PVPS Programme is presently developing a new Task with the provisional title *Sustainable PV-hybrid minigrids*. This Task will follow-up on the work of Task 3, focusing its efforts on the design and control of PV-hybrid minigrids. It further addresses interconnection and penetration issues of such systems. The Task should likely become operational in 2006.

Due to the increasing need of consistent global information and coordination on issues about environmental sustainability, IEA PVPS is also exploring a new activity on the subject of Environmental, Health and Safety (E,S&H) issues of photovoltaic power systems.

In order to support the sustainable deployment of photovoltaics in the different application areas, the IEA PVPS Programme is intensifying its relationships with different stakeholders. In particular, there is an emphasis on closer cooperation with the industry, as exemplified with the new sponsor membership of the European Photovoltaic Industry Association EPIA.

#### 4 FINAL REMARKS

The overall outcomes of the IEA PVPS Programme are the result of a fruitful and effective global cooperation among many parties and experts. The author acknowledges the support of all Executive Committee members, Operating Agents and Task Experts who by their dedicated effort contribute to the collaborative work and success of IEA PVPS.

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