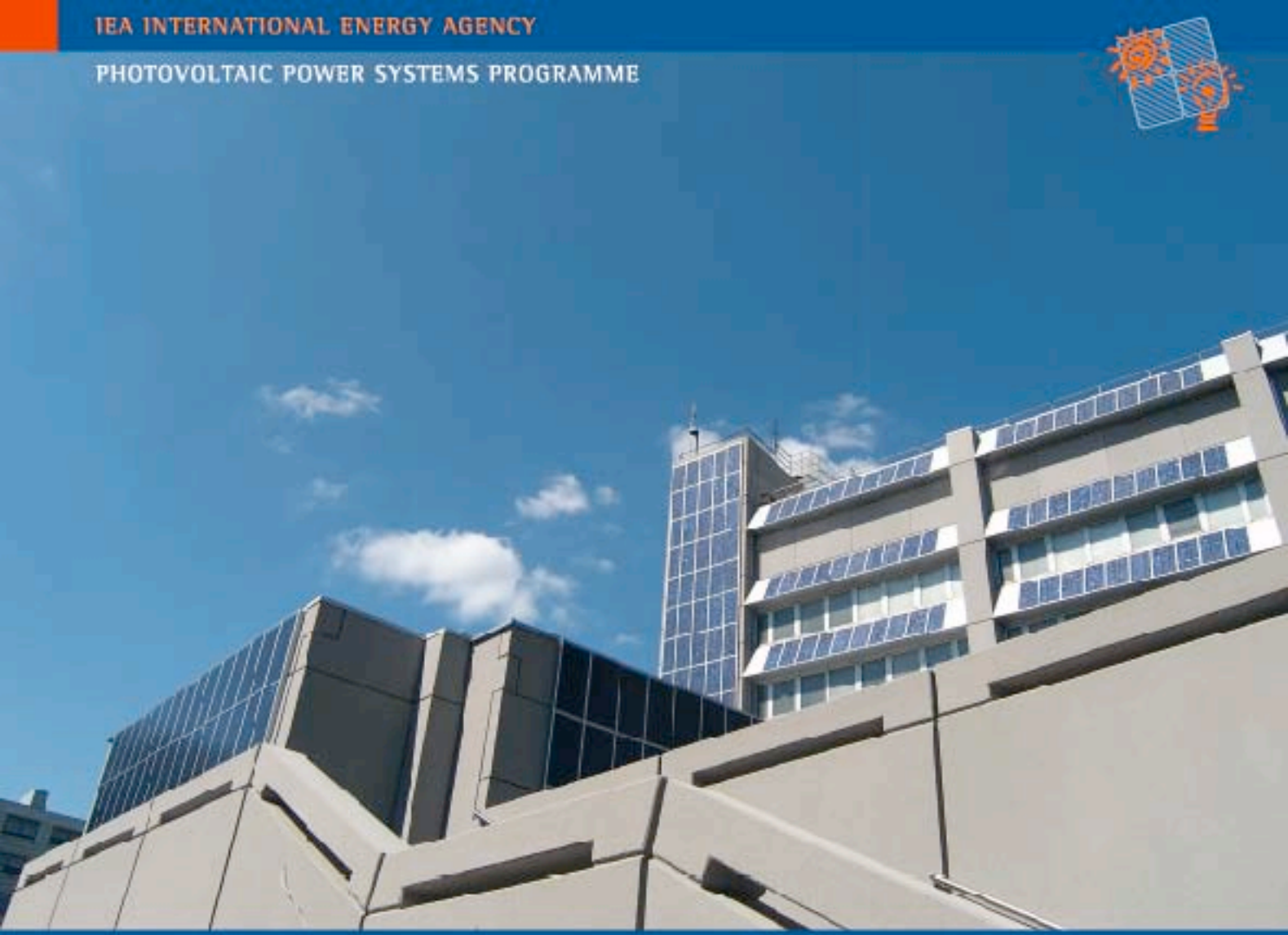
IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



PVPS annual report 2005

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2005

CHAIRMAN'S MESSAGE

I am pleased to present the annual report of the IEA Photovoltaic Power Systems Programme covering the year 2005. With new activities within the programme and stronger outreach beyond the programme, this year has closely followed our strategic plan. Both on the Executive Committee level as well as on the Task level, the network was systematically extended towards new target groups, new members as well as new work items and accompanied by increased communication efforts.

During 2005, the European Photovoltaic Industry Association (EPIA) has formally joined the PVPS Programme as a sponsor member. We would welcome industry associations from other regions in order to intensify our relationships and co-operation. Contacts for potential country participation in IEA PVPS have taken place with China and Hong Kong, Malaysia, Turkey, Greece and Poland. On the other hand, Finland has terminated its membership in the PVPS Programme during 2005.

On the Task level, increased co-operation and communication can be summarised as follows:

- Led by Australia, Task 1 on "Exchange and Dissemination of Information on Photovoltaic Power Systems," held a workshop on environmental issues of PV power systems at the 20th European Photovoltaic Solar Energy Conference in Barcelona as well as a regional workshop at the 15th International Photovoltaic Science and Engineering Conference in Shanghai;
- Led by Germany, Task 2 on "Performance, Reliability and Analysis of Photovoltaic Power Systems," now has participation from 10 member countries and 1 observer. New work was started on economic analysis of PV power systems. In September 2005, an industry workshop was held in Germany;
- Led by Japan, Task 8 on "Study on Very Large Scale Photovoltaic Power Generation System," has extended its activities into a third phase;
- Led by the United Kingdom, Task 9 on "Photovoltaic Services for Developing Countries," has organised or participated in 6 events in 2005;
- Led by the United States, Task 10 on "Urban Scale PV Applications," held a workshop in France.

As a follow-up of Task 3 on "Use of Photovoltaic Power Systems in Stand-Alone and Island Applications," a new Task 11 on "PV Hybrid Systems within Mini-Grids," was established during 2005. I am grateful to Canada which has taken the lead for this new activity which will start in 2006. Another important topic on the agenda for new activities is the subject of environmental issues related to photovoltaics. Due to the rapid global market expansion, it is felt that continuous analysis and communication on facts and figures is needed for this important subject. This could form the basis of a new Task or, alternatively, take place within one of the existing Tasks.

The overall communication efforts were continued through systematic distribution of PVPS products (flyer, newsletter, annual report and topical reports) at conferences, workshops and by means of direct mailings. Communication was supported by the PVPS website www.iea-pvps.org. Moreover, a booth at the industry exhibition of the 20th European Photovoltaic Solar Energy Conference in Barcelona attracted a large number of visitors and interesting feedback on the programme activities.

With many new results from the various ongoing projects, 2005 was another productive year for PVPS. The detailed results are given in the Task reports of this annual report and all publications can be found at the PVPS website. I would like to congratulate all Tasks on their progress and achievements. The current status of photovoltaics in the PVPS member countries is described within the country section of this annual report.

A number of Executive Committee members have left us during the year, heading for new responsibilities or horizons. I would like to thank them for their strong support and valuable contributions. With this, I take the opportunity to thank all Executive Committee members, Operating Agents and Task Experts who by their dedicated effort contribute to the collaborative work and success of PVPS.

Stefan Nowak
Chairman

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA

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 member countries. The European Union also participates in the work of the IEA.

Collaboration in research, development and demonstration of new technologies has been an important part of the Agency's Programme. The IEA R&D activities are headed by the Committee on Research and Technology (CERT), supported by a small secretariat staff, with headquarters in Paris. In addition, four Working Parties on End Use, Renewable Energy, Fossil Fuels and Fusion, are charged with monitoring the various collaborative energy agreements, identifying new areas for co-operation and advising the CERT on policy matters. The Renewable Energy Working Party (REWP), chaired by the first PVPS chairman, Mr. Roberto Vigotti, oversees the work of ten renewable energy agreementsand is supported by a Renewable Energy Unit at the IEA secretariat in Paris.

IEA-PVPS

The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D Agreements established within the IEA, and since its establishment in 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaic conversion of solar energy into electricity.

The overall programme is headed by an Executive Committee composed of representatives from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. By the end of 2005, ten Tasks were established within the PVPS programme, of which one was completed in 1997 (Task 6), two were completed in 2001 (Task 5 and Task 7), one was completed in 2004 (Task 3) and one is not operational (Task 4). A new task began in 2004 (Task 10), which is a follow-up to Task 7. The Workplan for a new Task was approved in 2005 (Task 11), which is a follow up to Task 3.

The twenty-one PVPS members are: Australia, Austria, Canada, Denmark, EPIA, European Union, France, Germany, Israel, Italy, Japan, Korea, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States. Turkey has shown an interest to revive its membership. The European Photovoltaic Industry Association (EPIA) joined PVPS in 2005.

IEA-PVPS MISSION

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.

The underlying assumption is that the market for PV systems is gradually expanding from the present niche markets of remote applications and consumer products, to the rapidly growing markets for building-integrated and other diffused and centralised PV generation systems.

This market expansion requires the availability of and access to reliable information on the performance of PV systems, technical and design guidelines, planning methods, financing, etc. to be shared with the various actors.

IEA-PVPS OBJECTIVES

The IEA-PVPS programme aims to realise the above mission by adopting the following objectives related to reliable PV power system applications for the target groups: governments, utilities, energy service providers and other public and private users:

1. To stimulate activities that will lead to a cost reduction of PV power systems applications

National RD&D programmes, industrial R&D and expansion of PV manufacturing capacity as well as utility investments in PV projects are examples of activities with a direct effect on the cost of PV systems and their application. International co-operation within IEA PVPS can indirectly contribute to cost reduction by undertaking or supporting activities such as: sharing the activities and results of national RD&D programmes, objective information and operational experience, creating and facilitating networks as well as providing guidelines.

2. To increase the awareness of their potential and value and thereby provide advice to decision makers from government, utilities and international organisations

Key issues for the awareness of the potential and value of PV power systems among target groups are: cost/performance indicators, market developments, innovations and breakthroughs, new applications and services, national and international programmes and initiatives, policy and financing schemes, developments and standards.

3. To foster the removal of technical and non-technical barriers of PV power systems for the emerging applications in OECD countries

Over time, photovoltaic-based electricity supply can play a key role in urban-scale developments. Such developments should follow a holistic approach to maximise society's total energy efficiency and use of renewable energy opportunities. There is already increasing awareness of the principles of sustainable design and maximum use of (active) solar energy potential but this can be further expanded. PV power systems can play a key role in providing the reduced electrical energy services needs of houses and buildings and have the potential to become a major grid-connected electricity supply source. Through effective knowledge sharing, PVPS aims to enhance

TABLE 1 – STRATEGIES AND DELIVERABLES OF THE FOUR IEA-PVPS OBJECTIVES

In Table 1 the strategies and deliverables for each of these objectives are given.

OBJECTIVE	STRATEGIES	DELIVERABLES
1 – To stimulate activities that will lead to a cost reduction of PV power systems applications.	• To collect, analyze and disseminate information on the technical performance and cost structure of PV systems and their applications. • To share the knowledge and experience gained in monitoring selected national and international PV projects. • To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems. • To contribute to the development of improved photovoltaic systems and subsystems.	• Objective information on the technical performance, reliability and cost structure of PV systems, in an accessible form; • Recommended practices for improved design, construction and operation and maintenance of PV systems and subsystems, in an accessible form; • Recommendations concerning remaining technical issues for the interconnection to the grid of small-dispersed systems as well as large and very large PV systems; • Recommended practices for the main components of PV systems.
2 – To increase the awareness of their potential and value and thereby provide advice to decision makers from government, utilities and international organizations.	• To collect and analyse information on key awareness issues, such as policies, markets, applications, experiences, barriers and success stories; • To present/publish the reliable and relevant parts of this information in appropriate forms (brochures, reports, books, internet etc.); • To disseminate these information products, relevant for the deployment of PV systems, to target groups; • To monitor the use of this information and the effects on the awareness among target groups; • To bring actors of different groups together, and to encourage the creation of national and international networks; • To identify the most successful policy mechanisms leading to a self-sustained market growth; • To provide objective policy advice to governments, utilities and international organisations; • To encourage private and public sector investments that are required to bring PV Power systems into the main stream market.	• Continuous update of the web page content and accessibility to ensure that the information developed by PVPS is readily available for all stakeholders, at the website: www.iea-pvps.org; • PVPS fact sheets covering the development of key parameters and issues, e.g. industry shipments, installed capacity, potential, cost, etc. ; • The Trends In Photovoltaic Applications Report intends to present and interpret year-to-year trends in both the PV systems and components being used in the utility sector, as well as the changing applications within that sector, in the context of business situations, policies and relevant non-technical factors in the reporting countries. The Trends report is to present an accurate, comprehensive and useful description of the PV products, applications and markets in the reporting countries. The Trends report is published in printed form on an annual basis; • The Annual Report, which describes the main outcomes of the PVPS programme, the status of each task, the concise description of the status and prospects of each participating country's PV programme. The Annual Report is published in printed form in the spring of the following year; • The PVPS Newsletter, published twice a year, informs the main target groups on the results of the collaborative work of the PVPS programme as well as on other important issues and initiatives regarding the deployment of PV power systems; • An overview of the activities, available information such as reports and contact points of the PVPS programme on the Internet; • A Flyer describing the objectives and the structure of the programme and containing a list of the contact persons in each country is updated regularly; • International (executive) conferences are organised together with other national or international, private or public organisations. They are intended to provide information and enhance awareness on key issues for the deployment of PV power systems. The participants are carefully selected among important decision-makers in the different target groups in order to assure maximum benefit of the outcomes; • International workshops on important specific (technical and non-technical) issues are organised. They are intended to actively enhance the discussion and information exchange with participation from the concerned target groups; • Input to national workshops is provided by the participation of PVPS experts;
3 – To foster the removal of technical and non-technical barriers of PV power systems for the emerging applications in OECD countries.	• To develop a major education and awareness effort to remove informational barriers among key target audiences, including consumers, developers and utilities; • To conduct occupant surveys and gather key market data on targeted projects managed within participating countries; • To evaluate the inclusion of PV within the standard design and construction process in selected communities worldwide; • To assess the buildability, saleability, pricing and financing options for BIPV rooftop products and providing feedback to industry and manufacturers; • To assess the impact of BIPV rooftop products on the distribution network and other connection issues, particularly benefits dealing with time of day pricing and summer time demand side management; • To develop material that will assist in the development of standardised net metering contractual agreements between homeowners and utilities; • To address mortgage and insurance issues; • To identify steps in streamlining installation procedures and electrical inspections.	• Summaries of the outcomes of the PVPS programme in national information networks and media are encouraged. • Compilation of jurisdiction within participating countries where net billing and net metering has increased the accessibility; • Compilation of homebuilders providing solar home options to customers; • Overview of PV financing methods in OECD countries; • Planning methods to evaluate and maximise the benefits of grid-connected photovoltaic systems to the electric grid and to the customers;
4 – To enhance co-operation with non-OECD countries and address both technical and non-technical issues of PV applications in those countries.	• To stimulate the awareness and interest of multilateral and bilateral agencies and development banks on the technical and economic potential and best practice of PV systems; • To stimulate co-operation between IEA PVPS members and selected non-IEA countries; • To increase awareness on the opportunities of PV systems amongst targeted groups in developing countries via workshops, missions and publications; • To stimulate PVPS membership of selected non-IEA countries; • To identify opportunities and provide best practice for emerging applications (non-domestic systems, community systems, hybrids, mini-grids, weak grids); • To promote adequate measures for quality assurance and standards; • To identify the opportunities and conditions to implement adequate mechanisms of the Kyoto protocol as well as WSSD initiatives.	• Specific studies on important issues (e.g. non-technical barriers, financing, potential assessments, PV in competitive energy markets, etc.). • Collation and analysis of relevant existing publications on PV in developing countries; • Guidance and documents to foster the successful introduction and expansion of PV systems drawing from past experiences and lessons learned from technology cooperation projects and programmes. These will be disseminated by appropriate means in selected developing countries; • A regular electronic newsletter containing an information update on the CDM process and latest news on Task 9 publications, workshops and other relevant events; • Staff workshops for multilateral and bilateral agencies; • Workshops in non-IEA countries, co-ordinated with bilateral and/or multilateral agencies and/or NGOs; • Active participation of target groups in selected developing countries; • Dialogue and contact point with staff of multilateral and bilateral agencies.

IEA PVPS Executive Committee, Paris, France, October 2005.

the opportunities for large-scale application of grid-connected photovoltaics in the urban environment as part of an integrated approach that maximises building energy efficiency, use of solar thermal and photovoltaics. There is a significant learning investment in many of the participating countries that have undertaken rooftop programmes and other sustainable community development initiatives.

4. To enhance co-operation with non-OECD countries and address both technical and non-technical issues of PV applications in those countries

PV power systems in non-OECD countries represent a fast growing market segment, both in remote areas for rural electrification as well as increasingly in urban environments of these countries. Applications of PV in those countries move gradually from domestic applications (typically solar home systems) to non-domestic applications, community systems, mini-grids and applications in weak grid areas. Depending on the local framework conditions, the infrastructure available as well as appropriate quality management, financing and capacity building schemes, such applications represent new opportunities where PV can increasingly provide the required energy service on a competitive basis. Some of the Kyoto mechanisms may in future provide additional opportunities for PV applications, in particular if they can be aggregated to larger volumes. The sustainable and large-scale introduction of PV is supported by bilateral and multilateral agencies and development banks. At the same time, this large-scale introduction is hampered by various barriers such as acceptable accessible financing structures, institutional and social barriers, infrastructure issues and sometimes technical problems. PVPS expertise can be instrumental to help overcome some of these barriers.

IEA-PVPS TASKS

In order to obtain these objectives, specific research projects, so-called Tasks, are being executed. The management of these Tasks is the responsibility of the Operating Agents. Within IEA PVPS the following Tasks have been established:

- Task 1. Exchange and Dissemination of Information on PV Power Systems;
- Task 2. Performance, Reliability and Analysis of Photovoltaic Systems;
- Task 3. Use of PV Power Systems in Stand-Alone and Island Applications (concluded in 2004);
- Task 4. Modelling of Distributed PV Power Generation for Grid Support (not operational);
- Task 5. Grid Interconnection of Building Integrated and other Dispersed PV Systems (concluded in 2001);
- Task 6. Design and Operation of Modular PV Plants for Large Scale Power Generation (concluded in 1997);
- Task 7. PV Power Systems in the Built Environment (concluded in 2001);
- Task 8. Very Large Scale PV Power Generation Systems;
- Task 9. PV Services for Developing Countries;
- Task 10. Urban Scale PV Applications. Begun in 2004. Follow-up of Task 7.
- Task 11. PV Hybrid Systems Within Mini-Grids Workplan approved in 2005. Follow-up of Task 3.

The **Operating Agent** is the manager of his or her Task, and responsible for implementing, operating and managing the collaborative project. As such the Operating Agent compiles a status report, with results achieved in the last six months, as well as a work plan for the coming period. These are being discussed at the Executive Committee meeting, where all participating countries have a seat. Based on the work plan, the Executive Committee decides whether activities in the coming period should continue, or intensify, or stop. In case the Executive Committee decides to continue the activities within the Task, the participating countries in this Task commit their respective countries to an active involvement by national experts. In this way, a close co-operation can be achieved, whereas duplication of work is avoided.

TASK STATUS REPORTS

TASK 1 - EXCHANGE AND DISSEMINATION OF INFORMATION ON PHOTOVOLTAIC POWER SYSTEMS

OVERALL OBJECTIVES

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives that relate to contributing to cost reduction of PV power applications, increasing awareness of the potential and value of PV power systems, fostering the removal of both technical and non-technical barriers and enhancing technology co-operation.

All countries participating in the PVPS Programme are members of Task 1. To meet the Task 1 objective and deliver the expected outcomes, Task 1 participants focus on understanding the needs of their stakeholders and target audiences for the various Task 1 deliverables and establishing mechanisms for communication both within and outside the PVPS Programme. The public website www.iea-pvps.org will continue to be developed to reflect the requirements for information that are identified by Task 1 participants and others.

Task 1 activities are organized into the following subtasks:

SUBTASK 1.1: Status Survey Reports

A published report, Trends in Photovoltaic Applications, is compiled from the National Survey Reports (NSRs) produced annually by all countries participating in the IEA-PVPS Programme. The national reports can be found on the public website. The Trends report presents the current status and interprets trends relating to systems and components being used in the various PV power systems markets, the changing applications within those markets and aspects of the PV industry value chain. This is reported in the context of the business environment, policies and relevant non-technical factors mainly, but not exclusively, in the participating countries.

Trends reports were initially produced every two years, but a shorter report is now produced annually to provide more timely information. The first issue was printed in March 1995 and a further nine issues had been published by the end of 2005.

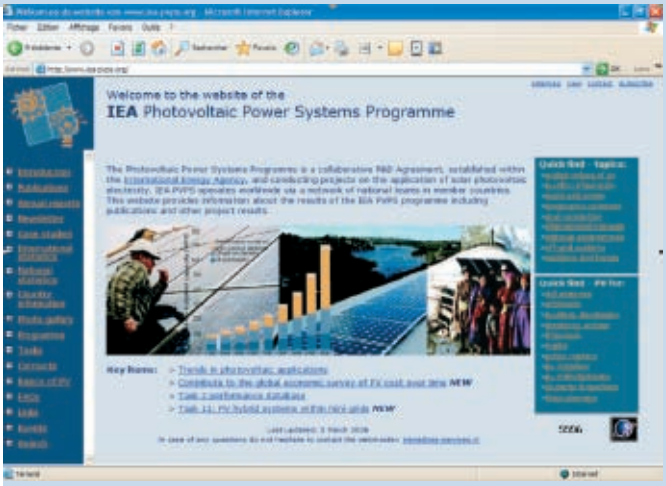
SUBTASK 1.2: Newsletter

A printed, colour newsletter, PVPower, is prepared and distributed to stakeholders by post and also via the website each six months to present highlights of the IEA-PVPS Programme as well as general features of interest about PV systems and components and market applications. Task 1 participants provide material of interest to the newsletter editor and ensure that the newsletter reaches its target audience in the respective countries.

Twenty three issues of the newsletter had been published by the end of 2005.

SUBTASK 1.3: Special Information Activities

A range of activities, including workshops and documents, provide analysis and summary assessment of special topics. These are directed at technical, economic, environmental and social aspects of PV systems and applications and are usually managed by a specific country or a group of countries from the Task 1 membership. Activities to date include workshops and published reports on Environmental aspects of PV power systems, Photovoltaics in competitive electricity markets, Added values of photovoltaic power systems, PV industry roadmaps, Environmental Safety and Health issues and International PV collaboration and market developments. Other activities include Buy back rates for grid-connected photovoltaic power systems, Photovoltaic components and systems: Status of R&D in IEA countries and Photovoltaics in cold climates.



IEA PVPS Website, Homepage.

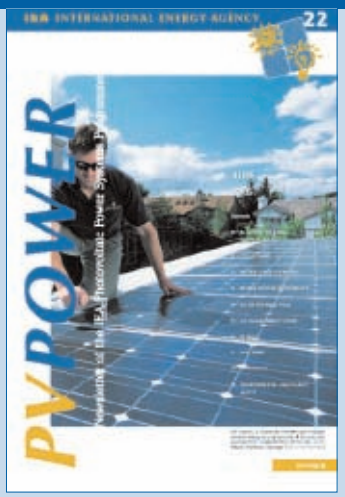
SUMMARY OF TASK 1 ACCOMPLISHMENTS FOR 2005

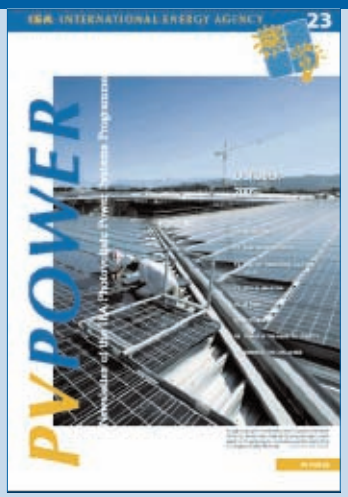
A key Task 1 priority is meeting the information needs of the various stakeholders and target audiences, within the context of the objectives of the PVPS Programme. The public PVPS website enables PVPS information to be provided quickly and at a reasonable cost. The website remains a priority activity for Task 1, and its management is carried out within the framework of the guiding principles and agreed policy for the website. The website (and its various links) also provides other PVPS participants with valuable information on the programme as a whole, enhancing inter-task communication.

SUBTASK 1.1: Status Survey Reports

The 10th issue of the Trends in Photovoltaic Applications report was published in September 2005 and analyzed data collected between 1992 and the end of 2004. The 2005 report contained more information on the upstream production issues, markets and production in non-PVPS countries and the popular topic of public support measures. The 32 page report was prepared by a small group from within Task 1 on the basis of the annual National Survey Reports prepared by all Task 1 participants and was funded by the IEA-PVPS Programme. The report was available on the public website from July 2005, can be downloaded as a complete document, and figures and

Trends in photovoltaic applications. Survey report of selected IEA countries between 1992 and 2004.





Newsletter PV Power issues 22 and 23.

Joint International Workshop, PVSEC-15, 13 October 2005, Shangai, China.

tables can be downloaded separately. Copies are distributed by post by Task 1 participants to their identified national target audiences and are provided at selected conferences and meetings.

The National Survey Reports are funded by the participating countries and provide a wealth of information. The latest versions are available from the PVPS public website and are a key component of the collaborative work carried out within the PVPS Programme. Task 1 participants share information on how to most effectively gather data in their respective countries including information on national market frameworks, public budgets, the industry value chain, prices, economic benefits, new initiatives, electricity utility interests, standards and codes, and an overview of R&D activities.

SUBTASK 1.2: Newsletter

Editorial policy for the newsletter continued to emphasize that projects and products -both PVPS and other - must be tangible to be included. PVPower issue 22 was published in June 2005; issue 23 was prepared to be available for the Shanghai PVSEC Conference (October 2005) and presented an Asian and international market flavour with considerable material from the Trends report plus information on Malaysia's BiPV project. Current and back issues of PVPower are available on the public website.

SUBTASK 1.3: Special Information Activities

A workshop on PV Environmental Safety and Health (ES&H) issues was held in conjunction with the European PV Solar Energy Conference in Barcelona on 8th June 2005, was well attended and regarded as successful by all involved. The workshop performed the function of a 'task definition meeting' whereby the framework for a new PVPS research activity could be developed. In particular the focus was the presentation of selected ES&H activities, identification of opportunities for ES&H activities and their scope within the IEA-PVPS Programme, agreement on possible topics for co-operation and agreement on follow-up activities. Presentations from the workshop were made available via the PVPS website.

A workshop was held on 13th October 2005 at the Shanghai International Convention Centre, in conjunction with the Photovoltaic Science and Engineering Conference. The workshop was well attended (between 40 and 80 participants throughout the day) and was well received. The workshop highlighted international collaboration on PV activities and outlined recent market developments worldwide.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2006

Task 1 activities will continue to closely reflect the broader strategy for the PVPS Programme. Market implementation is an important focus for PVPS activities, as is a close working relationship with the PV industry and other stakeholders (including non-IEA-PVPS countries).

SUBTASK 1.1: Status Survey Reports

The target date for publication of the 11th issue of the Trends in Photovoltaic Applications report is August 2006, with electronic versions of the information to be made available on the public website in July 2006. The report will be refined to reflect any feedback from key stakeholders, and will include further information from non-PVPS countries (in conjunction with Task 9) and further discussion of PV market support efforts (in particular, the role of green power schemes and renewable portfolio standards). National Survey Reports will be completed before the end of May 2006, based on the revised template, so that the information can be incorporated in and analyzed for the Trends report.

SUBTASK 1.2: Newsletter

Task 1 participants will continue to review and update the target audiences within their countries, and to seek feedback regarding preferred format (e.g. electronic or printed) and content from these audiences. It is planned to develop strategies during 2006 to more fully capture the newsletter's full potential for PVPS information outreach, both within and outside the IEA-PVPS countries.

PVPower Nos. 24 & 25 will be published in April 2006 and October 2006 respectively, maintaining current editorial policy.

SUBTASK 1.3: Special Information Activities

The matters of interest to Task 1 participants are increasingly being incorporated into existing activities - such as the newsletter, the survey reports, the website - and as input to other tasks except where dedicated activities, for example a PV Utility Forum or industry workshops might be supported. An industry workshop is being planned for the European PV Conference in Dresden, Germany possibly discussing the findings from the latest round of survey reports. Task 1 interests will also benefit from a close working relationship with new participants in the task, such as the European Photovoltaic Industry Association and Malaysia's PTM (Malaysia Energy Centre).

LIST OF PARTICIPATING COUNTRIES, KEY TASK 1 PARTICIPANTS IN 2005 AND THEIR ORGANISATIONS

In many cases the following participants were supported by one or more experts from their respective countries.

COUNTRY	NAME	ORGANISATION
Australia	Greg Watt	Australian PVPS Consortium
Austria	Roland Bruendlinger	Arsenal Research
Canada	Josef Ayoub	Natural Resources Canada
Denmark	Peter Ahm	PA Energy A/S
European Union	Rolf Öström	DG Research
France	André Claverie	ADEME
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer	The Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	CESI S.p.A.
Japan	Osamu Ikki	RTS Corporation
	Izumi Kaizuka	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
Mexico	Jaime Agredano Diaz	IIE
Netherlands	Job Swens	NOVEM
Norway	Fritjof Salvesen	KanEnergi AS
Portugal	Luis Silva	ADENE
Spain	Javier Sanz	CENER
Sweden	Lars Stolt	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
United Kingdom	Sarah Davidson	IT Power Ltd
USA	Ward Bower	Sandia National Laboratories
	Susannah Pedigo	NREL

Up-dated contact details for Task 1 participants can be found on the IEA-PVPS website www.iea-pvps.org.

INDUSTRY INVOLVEMENT

Task 1 activities continue to rely on close co-operation with government agencies, PV industries, electricity utilities and other parties, both for collection and analysis of quality information and for dissemination of PVPS information to stakeholders and target audiences. This is achieved through the networks developed in each country by the Task 1 participants. While the target audience for PVPS information has broadened considerably, it is important to ensure that two significant groups are effectively engaged - the PV industry and the electricity utilities. The latter requires a more concerted effort on both the national and IEA-PVPS levels than has been forthcoming in recent years.

KEY DELIVERABLES (2005 AND PLANNED)

The following were published and also made available on the public website during 2005:

Trends in photovoltaic applications in selected IEA countries between 1992 and 2004. Report IEA-PVPS T1-14: 2005;

Newsletter - *PVPower issues 22 and 23.*

Individual National Survey Reports are included each year under 'Country information' on the public website, with tables and graphs able to be downloaded. A template and data collection pro forma for the NSRs are produced and updated each year.

During 2006 it is planned to produce the eleventh issue of the Trends in Photovoltaic Applications report, PVPower issues 24 and 25, a broad range of country information, case studies and key topics on the website, to progress the PV Utility Forum and to organize a PVPS / industry workshop in conjunction with the European PV conference in Dresden, Germany in September 2006.

MEETING SCHEDULE (2005 AND PLANNED 2006)

The 26th Task 1 participants' meeting was held in Lyon, France, 3-4 June 2005, immediately before the European PV Conference in Barcelona, Spain.
The 27th Task 1 meeting will be held in Vancouver, Canada 27-28 March 2006.
The 28th Task 1 meeting will be held in Vienna, Austria 11-12 September 2006.

TASK 2 - PERFORMANCE, RELIABILITY AND ANALYSIS OF PHOTOVOLTAIC SYSTEMS

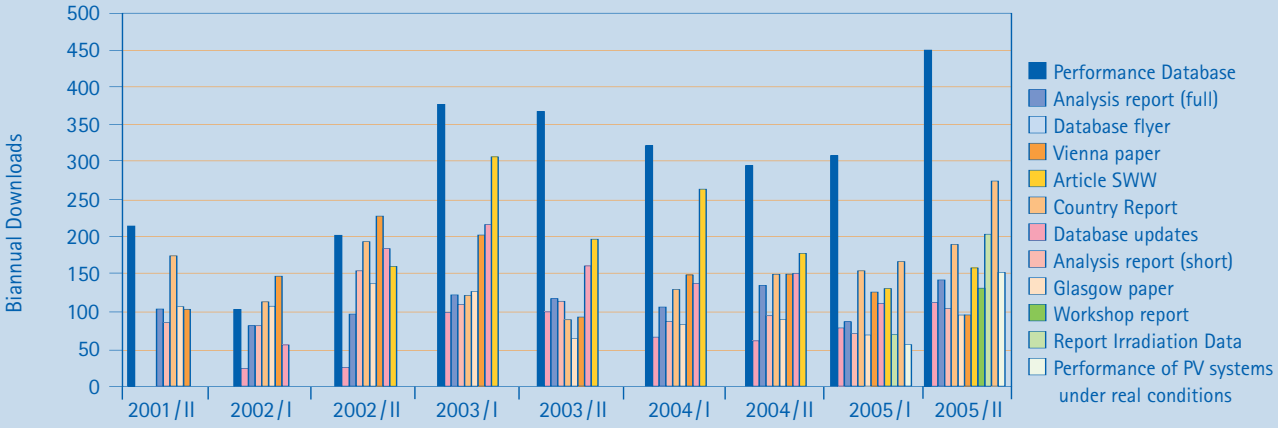


Fig. 1 – Statistics on information retrieval of different Task 2 products (database, reports, conference proceedings) from public Task 2 website "http://www.iea-pvps-task2.org."

OVERALL OBJECTIVE

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

The scope of Task 2 has concerned the information exchange about activities already in progress in the participants' national programmes. Technical and economic information on performance and long-term reliability are very important for an emerging technology such as PV. Task 2 aims to provide performance data for both general assessments of PV system technologies and improvements of system design and operation.

Task 2 officially started the current work programme in September 2004 for a period of three years, building on previous accomplishments in PV system performance analysis. Task 2 activities are organised into the following Subtasks:

SUBTASK 1: International Database

This is achieved through the development of the PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV systems and subsystems located worldwide. The information is gathered and presented by means of standard data collection formats and definitions. The database user can select PV system data, present monitoring data and calculated results, and in addition export these data into spreadsheet programmes. A collection of such a variety of high quality operational data presents a unique tool for PV system performance analysis. The database is updated regularly, and can be downloaded from the website http://www.iea-pvps-task2.org.

SUBTASK 5: Technical Assessments and Technology Trends of PV Systems

Participants analyse and validate expertise and performance results from grid-connected (GCS), stand-alone (SAS) and PV-based hybrid systems. The aims of this subtask are to demonstrate up-to-date performance validation criteria for a qualitative ranking of PV grid-connected, stand-alone and PV-based hybrid systems. It will also identify high performance products, technologies and design methodology in order to foster the development of maximum conversion efficiency and optimum integration of PV.

SUBTASK 6: PV System Cost over Time

Task 2 will identify and evaluate the important elements, which are responsible for the life cycle economic performance of PV systems by investigating economic data for all key components of PV systems and by gathering information about real life costs of maintenance of PV systems.

SUMMARY OF TASK 2 ACCOMPLISHMENTS FOR 2005

During 2005, Task 2 focused on performance analysis, characterization and prediction of PV systems for exchanging Task 2 results with other groups and networks (e.g. EU projects: PVSAT-2, PV Catapult, IP Performance). Task 2 put enhanced efforts on the dissemination of Task 2 results & deliverables to target audiences on national and international level by conference and seminar presentations, training courses and European master course. For the dissemination of Task 2 deliverables, the public Task website enables downloads and technical information to be provided quickly and cost-effective to the users. The information retrieval of PVPS Task 2 products is being tracked to measure the extent to which the website is visited and the products are used (Figure 1).

SUBTASK 1: International Database

The **PV Performance Database** was updated and the programme was released in June 2005 as a tool for planning, sizing and improving PV systems with respect to operational performance and reliability. The new Performance Database contains high quality data of 431 PV systems of different system technologies, located in 21 countries. The Performance Database programme (47 MB) is available on CD-ROM and can be downloaded from the Task website http://www.iea-pvps-task2.org.

Task 2 focused on the dissemination and promotion of the Task 2 database. As a result, 3 185 database users from 90 different countries and a broad range of sectors are making best use of the Task 2 database for their applications in planning & consulting, education, production and research. In 2005, highest demand for the Performance Database came from the engineering sector and the private sector, followed by the education and industry sector (Figure 2).

SUBTASK 5: Technical Assessments and Technology Trends of PV Systems

Long-term reliability of PV Systems

Based on the extended Performance Database, long-term "performance continuity" of the PV systems was investigated using monitoring data of 26 PV systems operating over 75 years. Both, monitoring data including hourly values of in-plane irradiance, module temperature and energy output of inverter of 26 individual PV systems, as well as several years of maintenance and failure information were employed to extract "correct" data sets of PV systems (Figure 3). PV system performance was analysed and compared at identical climatic conditions such as in-plane irradiance and module temperature. As first results, it was found that many PV installations present a constant performance level over time, while a strong shift of performance ratio over time was found for some PV systems.

User's Awareness of PV System Performance

Activity leader Japan (AIST and JET) conducted a survey on technical problems of PV systems and on the users' awareness for grid-connected and for stand-alone PV systems. In a first step, the survey addressed grid-connected PV systems and users of the residential programme in Japan in November 2004 (104 replies). Intermediate results of the questionnaire survey on Japanese systems were prepared and presented during the Task meetings. Differences between expected and actual energy yield seem to be one reason for a pessimistic view on the PV systems in general. In a second step, the questionnaire survey was extended to stand-alone systems (SAS) investigating the troubles of SAS and the users' perception of PV systems in Mongolia in July 2005 (359 replies). First results were presented during the PV Quality Workshop in September 2005. The questionaire will be extended to grid-connected and SAS systems in different countries.

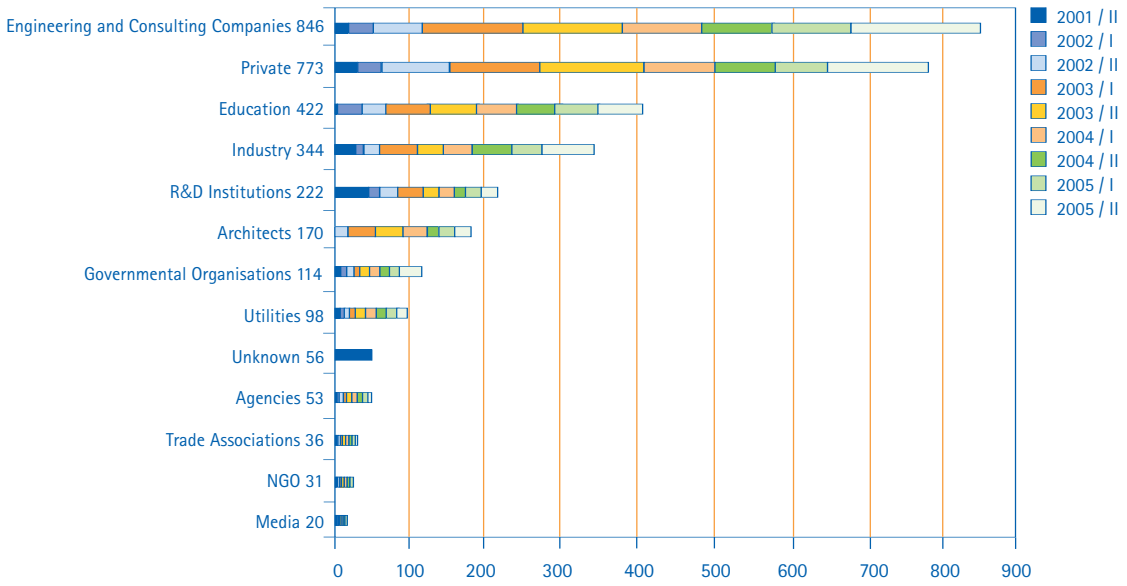


Fig. 2 - IEA-PVPS Task 2 Performance Database programme dissemination between 2001 and 2005: 3 185 registrations of different users in 90 countries.

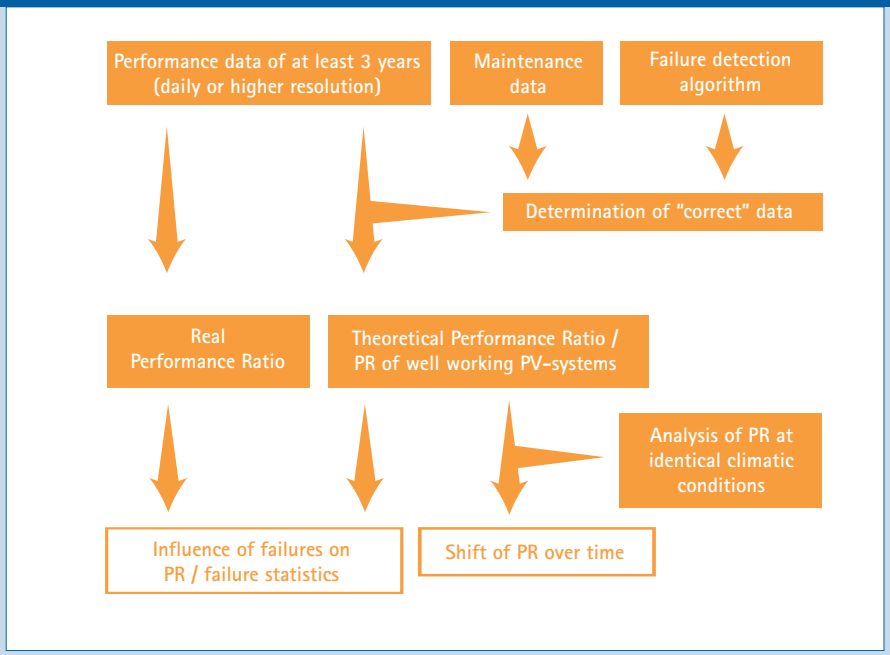


Fig. 3 – Block diagram of data processing and analysis for the current Task 2 activity "Long-term Reliability of PV Systems."

Performance Prediction

The collaboration with IEA Solar Heating and Cooling programme's Task 36 was carried on and a description of the potential transfer criteria of PV monitoring system insolation data into existing insolation mapping databases was developed. The PVPS Task 2 database will thus be compliant with the user-oriented structure for assessing resource data developed by SHC Task 36 and this will enable the qualification of the PVPS Task 2 database. In reverse, the PVPS Task 2 database will help SHC Task 36:

- To define measures of the quality of models deriving irradiances from satellite observation and procedures for comparison,
- To develop methodology for benchmarking and testing models.

In addition, an overview of the existing on-going activities in the field of performance prediction was presented at the Task 2 September meeting held in Hameln.

SUBTASK 6: PV System Cost over Time

The global Economic Survey aims at gathering information on plants, technical performance, maintenance and cost of as many PV systems as possible. The Internet-based survey tool was developed by Switzerland, tested (online) by Task 2 members and translated from English to German, Italian, Spanish, Japanese and French language.

The Economic Survey was started during the European Photovoltaic Conference in Barcelona in June 2005 by making the data acquisition tool to function on the public website www.iea-pvps-task2.org. Task 2 presentations at the Barcelona conference, individual invitations as well as publications in newsletters and magazines were used to motivate and attract people to give their input to this Economic Survey. The Economic Database includes the capability to search, sort and export information towards a free excel environment and allows Task 2 members to analyse all collected economic data.

SUMMARY OF TASK 2 ACTIVITIES PLANNED FOR 2006

Task 2 activities for 2006 will focus on the technical assessments and technology trends of PV systems (Subtask 5) and on the collection and analysis of performance and cost data of PV systems (Subtask 6).

SUBTASK 1: International Database

Performance Database on the Web

In addition to the Performance Database programme, which needs to be installed locally on a personal computer, Task 2 has started to build up an online database for public Internet access, which will be beneficial to new and additional target groups. This online Performance Database will contain an extract from the original database and will be optimized for fast Internet access. Further structural changes and modifications are necessary in order to use this database on a standard Internet server. Suitable presentations of the database information and results will be developed to make this Performance Database more understandable for a larger target audience.

SUBTASK 5: Technical Assessments and Technology Trends of PV Systems

PV in the Built Environment

Task 2 will review PV system cases from the Performance Database with respect to shading effects. Case studies on shading losses on the PV array will be filtered out of the extended Performance Database and the literature. Methods and tools to determine shading losses will be analysed and validated. First recommendations how to minimise yield losses due to shading will be developed making use of existing simulation programmes. The usefulness of recommendations will be tested against typical cases of shading from the extended database, and better guidelines will be the deliverable where appropriate.

Fig. 4 - PVPS Task 2 Meeting, Institute for Solar Energy Research (ISFH), Hameln, Germany, September 2005.

Long-term Reliability of PV Systems
Further long-term monotoring data will be collected to gain quantified information and results on the systems' reliability and learning curves. The results of other failure detection algorithm (e.g. Failure Detection Routine of PVSAT) will be compared to the analysed performance & failure curves for different examples. The influence of the incidence angle of irradiance on the Performance Ratio (PR) will be investigated. Further analysis of failure diagnosis aims at a detailed failure statistics of PV systems which enables to determine the effect a single failure type on the PR. A draft report including case studies as well as general information on the operational performance and reliability of PV systems will be presented.

Performance Prediction
The efforts on this activity will focus on two areas, the first being the evaluation of the performance of the solar irradiation estimation tools where satellite data prediction will be compared with ground based measurements from the PVPS task 2 database. Through the performance database, it will be possible to identify PV systems for which hourly values of the solar irradiation on the tilted array plane as well as those of the array output are available. The task will consist in comparing such values with the ones calculated from satellite data onto the tilted plane.
The second part of this activity will focus on the PV array performance prediction. For this part, the array output data from the database will be compared to that using satellite data and PV array performance models.

SUBTASK 6: PV System Cost over Time

During 2006 Task 2 will start to analyse the available information/ data in the PV System Cost over Time database. The number of reported systems (171 in 16 countries) will have to be enlarged, whereas the data update capability of the locally installed (PV System Cost over Time) databases by the task members will be useful. The algorithm to understand und analyse the date will be developed in parallel to the ongoing data collecting process. First results shall be available by the end of 2006.

INDUSTRY INVOLVEMENT

PV industry organizations, particularly, the European PV industry (EPIA) and the German Solar Industry Association (BSi), clearly support Task 2 work and gain first-hand technical and non-technical information on performance and reliability issues. Task 2 organized a PV industry workshop on performance and economic issues for the direct exchange of experiences, results and expectations. The workshop titled "Quality for PV Systems" was held at the ISFH in Hameln, Germany, on 28 September 2005.

The workshop was attended by 40 invited people from German speaking countries with a high technical or scientific background. The contributions of the invited presenters - mainly from PV industry - and fruitful discussions between PV industry, agencies, system specialists and Task 2 members on the session topics PV System Technology and Reliability of PV Systems and on Economic Factors of the PV Industry led to reflections on a broader outcome of the Task 2 work. The quality aspect of PV systems and components is considered to be a major issue for the PV industry.

KEY DELIVERABLES (2005 AND PLANNED 2006)

The following publications were prepared and presented during 2005:

- "Performance of PV Systems: Results from the IEA PVPS Projekt" (in German), Austrian Energy Economic Forum, Vienna, Austria, February 2005.
- "Performance of Grid-connected PV Systems: Overview of PVPS Task 2". In: 20th European Photovoltaic Solar Energy Conference, Barcelona, Spain, June 2005.

- "Task 2 Achievements on Performance, Reliability and Analysis of PV Systems", Solar Energy Society of Canada Inc. (SESCI) Conference 2005, Vancouver, Canada, August 2005.
- "PV System Performance Analysis", Solar Power 2005 Conference, Washington DC, USA, October 2005.
- „Quality for Photovoltaic Systems - Proceedings of Task 2 /Industry Workshop", ISFH, Hameln/Emmerthal, Germany, September 2005
- "Long-term Experiences of PV Systems", Workshop PV Module Technology (in German), TÜV Rheinland Group, Cologne, Germany, December 2005
- PVPS Task 2 Performance Database programme update with collected data from 431 PV systems, released in June 2005.

Public reports and other materials are made available on the PVPS website http://iea-pvps.org. The Performance Database programme, database updates and Task 2 publications can be downloaded from the Task website http://www.iea-pvps-task2.org.

MEETING SCHEDULE (2005 AND PLANNED 2006)

The 2nd **Task 2 Participants' Meeting** was held in Cocoa, Florida, USA, 28 February - 02 March 2005.
The **3rd Task 2 Participants' Meeting** was held in Hameln, Germany, 26-28 September 2005.
The **4th Task 2 Participants' Meeting** will be held in Vancouver, Canada, 27-28 March 2006 as a Joint PVPS Task meeting.
The **5th Task 2 Participants' Meeting** will be held in Vienna, Austria, September 2006.

TABLE 1 - LIST OF PARTICIPATING COUNTRIES, TASK 2 PARTICIPANTS IN 2005 AND THEIR ORGANISATIONS

COUNTRY	PARTICIPANT	ORGANISATION
Austria	Stefan Mau	Arsenal Research, Vienna
Canada	Yves Poissant	CANMET Energy Technology Centre, Varennes
European Commission	Harald Scholz	DG Joint Research Centre (JRC), Ispra
France	Didier Mayer	Centre d' Energétique, Ecole Des Mines de Paris
Germany	Ulrike Jahn (Operating Agent)* Daniel Münster Wolfgang Nasse Burchard Decker	Institut für Solarenergieforschung GmbH Hameln / Emmerthal (ISFH) Institut für Solarenergieforschung GmbH Hamel / Ememerthal (ISFH) Solar Engineering Decker & Mack GmbH Solar Engineering Decker & Mack GmbH
Italy	Salvatore Castello	ENEA C.R. Casaccia
Japan	Kenji Otani Takeshi Igarashi	National Institute of Advanced Industrial Science and Technology (AIST) Japan Electrical Safety & Environment Technology Laboratories (JET)
Poland (Observer)	Tadeusz Zdanowicz	Wroclaw University of Technology
Sweden	Jonas Hedström	Energibanken AB, Stockholm
Switzerland	Thomas Nordmann Luzi Clavadetscher	TNC Consulting AG TNC Consulting AG
The United States of America	Andrew L. Rosenthal Kevin Lynn	Southwest Technology Development Institute (STDI), New Mexico Florida Solar Energy Center (FSEC), Cocoa

Updated contact details for Task 2 participants can be found on the Task 2 website www.iea-pvps-task2.org.

**Since 1 January 2006: Bavarian Center for Applied Energy Research (ZAE Bayern), Erlangen.*

TASK 8 - STUDY ON VERY LARGE SCALE PHOTOVOLTAIC POWER GENERATION SYSTEM

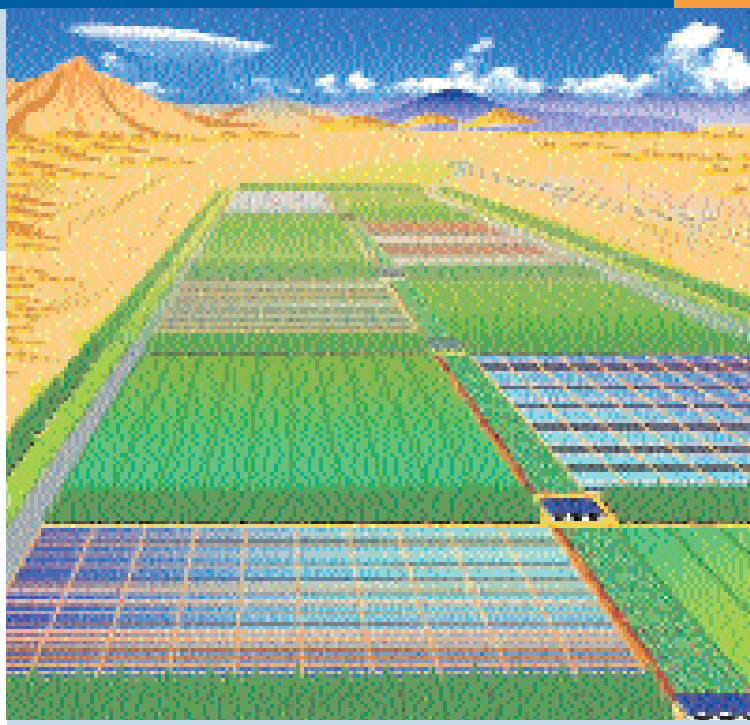


Fig. 1 - Image of a VLS-PV System in a Desert Area.

OVERALL OBJECTIVES

The objective of Task 8 is to examine and evaluate the feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems on desert areas, which have a capacity ranging from over multi megawatt to gigawatt, and develop practical project proposals for demonstrative research toward realization of the VLS-PV Systems in the future (See Fig. 1).

For this purpose, in Phase I (1999-2002), key factors that enable VLS-PV systems feasibility were identified and the benefits of this system's applications for neighbouring regions were clarified as well as the potential contribution of system application to global environment protection and renewable energy utilization in the long term was clarified. Mid- and long term scenario options for making VLS-PV systems feasible in some given areas were also proposed.

In Phase II (2003-2005), case studies on VLS-PV systems were carried out in depth and practical proposals for demonstrative research projects on pilot PV systems suitable for selected regions, which enable sustainable growth into VLS-PV Systems in the future, and general instruction to propose practical projects for large-scale PV system are discussed.

MEANS

Subtask 2: Case studies for selected regions for installation of VLS-PV system on deserts
Subtask 4: Proposals of practical project for sustainable development
Subtask 5: General instruction for project proposals to realize VLS-PV systems in the future

SUBTASK 2: Case Studies for Selected Regions for Installation of VLS-PV System on Deserts

Objective

Employing the concepts of VLS-PV and the criteria and other results obtained in the first phase, case studies on VLS-PV systems for the selected regions are undertaken and the effects, benefits and environmental impact of VLS-PV systems are evaluated.

Major Activities

The following case studies were carried out and drafted for a technical report.

- A Life-Cycle Analysis for Various Very Large-Scale Photovoltaic Power Generation (VLS-PV) Systems in World Deserts
- Resource Analysis of Solar Energy by Using Satellite Image
- The Highest Efficiency PV Module by Practical Concentrator Technologies, Performance, Reliability and Applications to Deserts (HCPV)
- Recent Development in Low-Concentration Photovoltaics (LCPV)
- Application of Bifacial PV Cells to VLS-PV
- Large Scale PV Plant Experience in Arizona Desert and Evaluation of the Energy Payback Time
- Photovoltaic and Solar Thermal Systems: Similarities and Differences
- Impact Assessment of VLS-PV on Global Climate

SUBTASK 4: Proposals of Pratical Projects for Substainable Development

Objectives

Practical project proposals for the initial stage of VLS-PV systems, which will enable sustainable growth of VLS-PV systems toward the future, are developed for some desert areas.

Major Activities

The following projects are proposed and drafted for the technical report.

- The Mediterranean Region: Case Study of Very Large Scale PV in the Mediterranean Region
- The Middle East region: A Top-Down Approach for Introducing VLS-PV Plants to the Middle-East
- Demonstrative Research Project for VLS-PV on the Gobi Desert of Mongolia
- Feasibility Study on 8MW Large-Scale PV System in Dunhuang, China
- Oceania Region: Realising VLS-PV Power Generation System at Perenjori
- Desert Region Community Development (See Fig. 2)

SUBTASK 5: General Instructions for Project Proposals to Realize Systems in the Future

Objectives

By extracting essential knowledge from the Subtask 4, detailed practical instructions and a training kit for the development of other practical project proposals are discussed to enable others to implement sustainable VLS-PV systems in the future.

Major Activities

Based on experts' experiences in the field of PV and large-scale renewable technology including industry, project developers, investors, policy-makers, etc., successful and un-successful factors

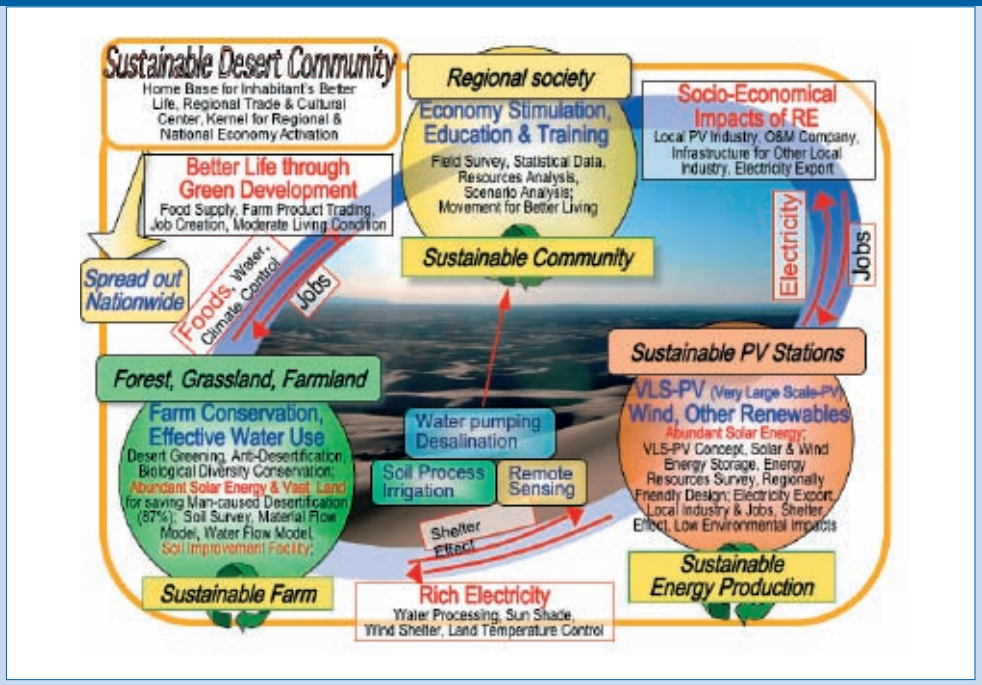


Fig. 2 - Framework of desert community development and research topic.

for the VLS-PV project, on both technical and non-technical aspects, are clarified. Existing financial schemes are overviewed and available financial and institutional scenarios and case studies are also discussed.

The instructions comprise non-technical issues as well as technical issues, to enable others to implement sustainable VLS-PV systems in the future.

OTHER ACTIVITIES

Publication of the Technical Report

The final draft of the Task 8 technical report based on the Phase II activities has been completed. The report will be published by James and James in 2006.

Extended Workplan for Phase III (2006-2008)

A 3-year extension of Task 8 activity was discussed and approved. The extended workplan consists of the following three subtasks:

- Subtask 2: Case Studies for Selected Regions for Installation of VLS-PV Systems
- Subtask 5: General Instruction for Practical Project Proposals to Realise VLS-PV Systems in the Future
- Subtask 6: Future technical options for implementing VLS-PV systems

DELIVERABLES

Internal Publications

Report: A Preliminary Analysis of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems: Report IEA-PVPS VI-5 1999:1

External Publications

Book: "ENERGY FROM THE DESERT", James and James, 2003 (ISBN 1 902916 417)
Report: "Summary - ENERGY FROM THE DESERT", 2003
Book: "ENERGY FROM THE DESERT II: Practical Proposals for Very Large Scale Photovoltaic Systems" (to be published by James and James in 2006).

MEETING SCHEDULE

Meetings Held

1st 28-29 June 1999, Paris (France)
2nd 1-2 December 1999, Utrecht (The Netherlands)
3rd 30 April 2000, Glasgow (UK)
4th 15-16 September 2000, Sacramento (USA)
5th 9-10 June 2001, Cheju Is. (Korea)
6th 2-4 September 2001, Ulan Bator (Mongolia)
7th 27 February - 1 March 2002, Utrecht (The Netherlands)
8th 12-13 September 2002, Warsaw (Poland)
9th June 30-July 1, 2003, Lens (France)
10th 2-5 February 2004, Perth (Australia)
11th 5-6 June 2004, Paris (France)
12th 9-11 January 2005, Scottsdale (USA)
13th 2-4 June 2005, Leipzig (Germany)
14th 8-10 September 2005, Vancouver (Canada)

Meetings Planned

15th 5-6 May 2006, Hawaii Island (USA)
16th 6-8 October 2006, Makuhari (Japan)
International Symposium, 9 October, Makuhari (Japan) (as a side event of Renewable Energy 2006)

Fig. 3 - 13th meeting's technical visit to 4.7MW Leipziger Land Solar Park.

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	Mr. John S MacDonald	Day4 Energy Inc.
Germany	Mr. Claus Beneking Mr. Matthias Ermer	ErSol Solar Energy Shell Solar GmbH
Israel	Mr. David Faiman	Ben-Gurion University of the Negev
Italy	Mr. Fabrizio Paletta Mr. Angelo Sarno	CESI SFR-REI ENEA
Japan	Mr. Masakazu Ito Mr. Kazuhiko Kato Mr. Kosuke Kurokawa Mr. Keiichi Komoto Mr. Masanori Ishimura (secretary)	Tokyo University of Agriculture and Technology (TUAT) The National Institute of Advanced Industrial Science and Technology (AIST) Tokyo University of Agriculture and Technology (TUAT) Mizuho Information & Research Institute (MHIR) Photovoltaic Power Generation Technology Research Association (PVTEC)
Korea	Mr. Jinsoo Song	Korea Institute of Energy Research (KIER)
The Netherlands	Mr. Leendert Verhoef Mr. Peter van der Vleuten	New-Energy-Works Free Energy International bv
Spain	no participation	
USA	Mr. Tom Hansen Mr. Herb Hayden	Tucson Electric Power Company Arizona Public Service
Mongolia (observer)	Mr. Namjil Enebish	Ministry of Fuel and Energy

TASK 9 - PHOTOVOLTAIC SERVICES FOR DEVELOPING COUNTRIES

Fig. 1 - Task 9 Exhibition in the Atrium of the World Bank during Energy Week.

Fig. 2 - Mark Fitzgerald (1955 - 2005) was a member of the Task 9 team from its launch in 1999 and made a major contributor to its work until he passed away on 16th June.

RATIONALE AND OBJECTIVE

There are around 2 billion people in the world who do not have access to adequate clean water supplies, electric lighting, primary health care, education and other basic services. At the Millennium Assembly of the United Nations in 2000, the international community adopted the eight Millennium Development Goals (MDGs), and set clear and ambitious targets for improving the conditions of these disadvantaged people. The focus of the programmes of the world's development assistance agencies (bilateral and multilateral donors, development banks, NGOs) are now clearly aimed at poverty alleviation in general, and at achieving the MDG targets in particular. The MDGs were reaffirmed at the UN Summit in 2005, and the G8 Summit at Gleneagles in 2005 agreed a Plan of Action, including clean energy for the developing world.

PV is uniquely attractive as an energy source to provide basic services, such as lighting, drinking water and power for income-generating work, for the people without access to electricity. After its first five year phase of work, PVPS Task 9 (PVSDC) 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*. Other Renewable Energy Technologies (RETs) can also be used for electrification and basic services. The work of Task 9 is also relevant to these RETs, and in 2005 the Renewable Energy and Energy Efficiency Partnership (REEEP) began providing additional support to include other RETs.

The objective of PVSDC is to increase the rate of successful deployment of PV systems (and other RETs, when appropriate) in developing countries. This is being achieved 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). By this means, objective and impartial information is published and disseminated through workshops and seminars.

ACHIEVEMENTS IN 2005

Task 9 has been operational since 1999. The Phase 1 Workplan was completed, in 2004.

SUBTASK 10: Deployment Infrastructure

This work contributes to overcoming the critical barriers to wide-spread PV deployment and implementation through the development, dissemination and application of a series of guideline documents to promote the necessary infrastructure requirements in developing countries. The aim has been to develop and disseminate a coherent series of reports to promote the necessary infrastructure requirements in developing countries to help overcome the critical barriers to widespread PV deployment and implementation. Six Recommended Practice Guides (RPGs) have been published by Task 9. Subtask 10 was essentially completed in Phase 1.

The overview document on issues for photovoltaics in developing countries 'Photovoltaics for Development:' the Key to Success,' has been expanded to include micro-hydro and wind energy technologies. The document will present a short overview of PV deployment in developing countries and the key points and messages of Task 9. It has also been realigned to emphasise the linkages to the Millennium Development Goals and the International Action Programme that emerged from Renewables 2004 in Bonn and the G8 summit in the UK in 2005. This document will be published in 2006.

New, extended Executive Summaries for each of the RPGs were published in 2005. The RPG's have been promoted at a number of Workshops (see below), and are all available for download from the main IEA-PVPS website. A French translation of the RPG Executive Summaries was also published in 2005.

Fig. 3 - PV village electrification, Lao PDR.

Fig. 4 - Use of PV System in Lao PDR - entertainment TV and music is very important.

Task 9 supports Task 1 in the collection of PV market data for non-PVPS (developing) countries.

SUBTASK 20: Support and Co-operation

PVSDC stimulates awareness and interest amongst the multi- and bilateral agencies, NGOs and other target sectors on the technical and economic potential and opportunities arising for RETs. This enables decision-makers to obtain the expertise and knowledge that is required for the appropriate RET system deployment.

The first Task 9 meeting of 2005 was held at the World Bank in Washington DC, in conjunction with Energy Week. This was an important gathering of stakeholders concerned with energy in the developing world and included a number of other events, such as a meeting of the Renewable Energy Financing and Policy Network Forum, which is a World Bank input to the Renewable Energy Global Policy Network (REGPN), which was a key outcome of the Renewables 2004 conference in Bonn. Task 9 made a presentation in the session entitled Energy and the Millennium Development Goals. Task 9 also contributed a booth to the Energy Week Exhibition, in the atrium of the World Bank. This is shown in Figure 1. A total of around 750 participated in Energy Week. The Washington meeting was co-organised by the US Expert. This was his last contribution to Task 9. See Figure 2. The Washington meeting included an expert from Zambia, supported by Sweden.

A regional Workshop was held in Vientiane, Lao PDR in April. Laos has one of Asia's lowest per capita electrification rates, with less than 30 % of rural households having access to electricity. At the same time, the country exports more electricity, generated by hydro, to neighbouring countries Thailand and Vietnam, than it consumes domestically. There is a lot of experience with small PV systems and micro hydro, and ambitious plans to electrify the whole country, the government target being 90 % electrification by 2020. Typical use of PV in a village is illustrated in Figure 3, with the use of the electricity shown in Figure 4. The workshop was organised by the French expert and supported by ADEME, and focused on delivery models and non-technical aspects of rural electrification. The 40 delegates included representatives from Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam, as illustrated in Figure 5.

The work of Task 9 was presented at the 20th European Photovoltaic Solar Energy Conference in Barcelona in June.

The 2nd Experts Meeting of 2005 was held in Shanghai, in conjunction with the 15th Photovoltaic Science and Engineering Conference (PVSEC-15) and Exhibition. The meeting included several observers from China who also made special presentations on the various major projects in China. Task 9 contributed to a PVPS Workshop within the conference and participated in an Industry workshop. There were around 2 000 delegates at the conference, and the exhibition was the largest PV show ever. Use of PV in China is expanding rapidly, as is PV cell and module manufacture. Total installed capacity has grown rapidly in just a few years, to possibly as much a 75 MWp. China is becoming a major player in the world PV scene and the Task 9 team have developed close relationships over the past several years. China is also the world's largest user of small-hydro power, generating 5 % of it's total electricity requirement from this source. Despite rapid economic progress, there are still around 28 million people in around 7 million homes in 23 000 villages without electricity. The National Township Electrification Programme Song Dian Dao Xiang invested 560 million USD to install about 16 MWp, together with wind and small-hydro (some with back-up diesel) between 2003 and 2005. The successor programme Song Dian Dao Cun, has the goal of electrifying 20 000 villages over 10 years, at a cost of around 5 billion USD. The China Renewable Energy Law, which becomes effective in January 2006, is expected to include a feed-in tariff for PV (and other renewables). It is possible that China could have both urban grid-connection and rural electrification programmes.

Fig. 5 - Participants in the Regional Workshop in Vientiane, Lao PDR.

SUBTASK 40: PV Energy Services for Rural Electrification and Proverty Alleviation

This work reviews and investigates the techno-economic aspects and potential of PV systems for provision of rural services and poverty alleviation. This focuses on the role of PV in the provision of water, health, education and Information & Communication Technologies (ICT) services, PV battery charging stations, hybrids and village mini-grids. The approach is to collate information from topical PV case studies and use the information to develop review documents and guides.

There are five main activities:

- Economic Assessment of PV Energy Services
- PV Based Energy for Water Services
- PV in Health, Education and ICT
- Battery Charging Stations and PV Hybrids and Mini-grids
- Role of PV in the Alleviation of Poverty

Progress with this subtask has been very slow during 2005 because of reduced levels of input by several of the experts. No new publications have been prepared.
The European Photovoltaic Industry Association (EPIA) is a sponsor member of PVPS. EPIA has joined Task 9 as a member and the EPIA Catapult Programme and Task 9 have agreed to work closely together to develop a new joint work plan.

SUBTASK 50: Market Penetration Activities

This investigates technical and economic aspects of PV power packs and large-scale (~ 1 MWp) grid-connected PV plants. There are many locations in the developing world where electricity demand is growing rapidly and lack of capacity frequently results in power cuts or 'brown-outs' caused by indiscriminate load shedding. This Subtask will collate relevant case studies and review situations in developing countries where network capacity and/or generation capacity needs to be increased and where it is cost-effective to install PV (or PV hybrids) as an alternative. The work will also examine emerging grid-connected or grid-support applications for PV in developing countries. The objective is to evaluate the techno-economic aspects of small PV Power Packs (which provide back-up power supply to customers when grid supplies are cut) and Grid support applications in developing countries.
The main outputs will be review documents and a number of relevant case studies.

Australia will lead the work for Subtask 50, commencing with a review of grid-connected systems for developing countries. A draft report was circulated in 2005, and the review process will start in 2006.

SUBTASK 60: PV and the Kyoto Mechanisms

This work collates and disseminates information from the Clean Development Mechanism (CDM) process which may become relevant to the deployment of PV systems in developing countries. Many developing countries are looking to the CDM to help leverage funding to achieve sustainable economic development, through investment in renewable energy and end-use efficiency projects which fit with their developmental needs. This Subtask will provide updated information on the opportunities for PV project developers and governments in developing countries arising from the CDM process. It has become clear that PV cannot significantly compete with other options for CDM projects. An internal Task 9 paper recommends that work on this subtask should be put in abeyance.

Plan for 2006

Task 9 will again participate in the World Bank's Energy Week and provide an exhibit. Renewables will have a more prominent role in the agenda of Energy Week 2006. In 2006, the event will build on the G8 Plan of Action adopted in Gleneagles, i.e. with emphasis on clean energy and Africa. This will be important for Task 9's intention to plan future outreach events for Africa.

Presentations and workshops are being planned, in co-operation with the REEEP, for Brazil, India and South Africa. There is a standing invitation to hold an event in East Africa, probably Uganda but this is expected to be in 2007.

At least two new projects, the Inner Mongolia Alternative Energy Supply for Rural Poor in Remote Areas, supported by the Asian Development Bank, and the Yemen Rural Electrification and Renewable Energy Development Project, supported by GEF/World Bank/GTZ, will make use of the Task 9 RPGs in 2006.

MEETING SCHEDULE (2005 AND PLANNED 2006)

2005:

12th Experts meeting, 14-17 March 2005, Washington, USA (linked with World Bank Energy Week).

13th Experts meeting, 10-14 October 2005, Shanghai, China (linked with PVTEC)

2006:

14th Experts meeting, 27-28 March 2006, Vancouver, Canada

15th Experts meeting 07-08 October 2006, Chiba, Japan (to coincide with Renewable Energy 2006 Conference)

TASK 9 PARTICIPANTS

COUNTRY	NAME	AFFILIATION
Australia	Geoff Stapleton	GSES
Canada	Fayez Malek	CIDA
Denmark	Peter Ahm	PA Energy A/S
France	Anjali Shanker Lara Bertarelli	IED IED
Germany	Rolf Posorski	GTZ
Italy	Francesco Groppi	CESI
Japan	Takayuki Nakajima Tetsuzou Kobayashi Takahito Ilma	JPEA Showa-Shell Shikoku Electric Power Co. Inc
Switzerland	Alex Arter	ENTEC
Sweden	Anders Arvidson	Stockholm Environment Institute
United Kingdom	Bernard McNelis Paul Cowley Rebecca Gunning	IT Power IT Power IT Power
USA	Mark Fitzgerald*	ISP
EPIA	Ernesto Maccias	Isophoton

**Mark Fitzgerald passed away in June 2005 and he has not yet been replaced by another US expert.*

PVPS AND THE MILLENNIUM DEVELOPMENT GOALS

Delivering a real contribution towards achieving the Millennium Development Goals (MDGs) is one of the strong driving principles behind PVSDC.

Neither access to modern energy services in general, nor provision of electricity is recognised as specific goals in themselves. Nevertheless, they can play a central role in poverty alleviation, through impacts on education, health and local enterprise, as well as access to modern telecommunications and information technology resources.

The MDGs and some of the roles for PV are:

1. **Eradicate extreme poverty and hunger** - Lighting allows increased income generation and reliable electricity encourages enterprise development, energy for water supplies for cooking and drinking and water for irrigation increases food production.
2. **Achieve universal primary education** - Electricity enables access to educational media and communications, energy helps create a more child-friendly environment and reduces school drop-out rates and lighting in schools allows evening classes and helps retain teachers.
3. **Promote gender equality and empower women** - Availability of modern energy means that women do not have to carry out survival activities, good quality lighting permits home study and reliable energy services offer scope for women's enterprises to develop.
4. **Reduce child mortality** - Electricity can bring about less indoor air pollution, increased safety, free up more time to be spent on child care and provide pumped water and purification.
5. **Improve maternal health** - Energy services provide access to better medical facilities (vaccine refrigeration, equipment sterilization, operating theatres). Provision of cooked food and space-heating contribute to better health.
6. **Combat HIV/AIDS, malaria and other diseases** - Energy services provide better medical facilities, and energy can help produce and distribute sex education literature and contraceptives.
7. **Ensure environmental sustainability** - Traditional fuel use contributes to erosion, reduced soil fertility and desertification, energy can be used to pump and purify clean ground water.
8. **Develop a global partnership for development** - Energy supply can contribute to the development of information and communication technologies in remote / rural areas.

TASK 10 – URBAN SCALE PV APPLICATIONS

Fig. 1 - EPIA provides a presentation at the Task 10 French stakeholders' workshop, "Solar Cities Around the World."

INTRODUCTION

The workplan for this Task is designed for flexibility towards the fast growing and emerging market. The grid connected PV market requires new financial relationships beyond the network industry and their customers, as well as integration into traditional operations and planning of the broader stakeholder group involved in the market. Task 10 work initiated in January 2004, with a 5 year planned period of work. There has been delay of resource commitment to the Task, but as the second year of the Task is completed, several resolutions have occurred.

- **Japan** has joined the Task with great interest in both the Subtask 1 and Subtask 3 (market values and network benefits)
- **Norway** has joined the Task with focus on Subtask 2 (Urban Planning)
- **Switzerland** has made resource commitments to the Subtasks 2 and 3
- **The European Commission** - Intelligent Energy Europe Programme- awarded a multi country proposal titled PV in Urban Policies: a Strategic and Comprehensive Approach for Long-term Expansion, PV-UP-SCALE which was basically intended to give direct and indirect input to Task 10 from countries not formally participating in Task 10 and enhance some current contributions. Furthermore, dissemination of the results of Task 10 and further outcomes of the PV Upscale project is a major goal. The **Netherlands** leads this project, with coordinated contributions from **Austria, France, Spain, Germany and UK.**

These additional resources and particularly the PV-UP-SCALE project which is a 3 year project beginning in January 2006, will put Task 10 back on schedule.

OVERALL OBJECTIVE

The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented applications 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. This will be accomplished through:

- making connections between the building design and development industry;
- deriving recommendations for stakeholders to remove barriers to mass market uptake of photovoltaics;
- developing system components, design and applications with the largest global market penetration potential, including aesthetic values as well as the mechanical and energy related values;
- expanding successful tools (models, roadmaps, guides, system integration, etc.) and analysis relevant to the needs of the emerging global markets;
- identifying gaps in currently available information and developing products to fill those gaps;
- developing materials and holding events targeted at meeting the needs of specific groups of stakeholders; and
- providing continuous communication, promotion and education throughout the period of the task.

In line with the objectives, the short term goal (5 years post) of the Task is to have a clear definition of the global market and all associated values, resulting in stakeholders considering urban scale PV in their respective spheres of activities. The Task's long term goal

(10 years post) is for urban-scale PV to be a desirable and commonplace feature of the urban environment in IEA PVPS member countries.

APPROACH

There will be four subtasks in Task 10, with 17 activities. The total range of deliverables has been designed comprehensively to include and meet the various needs of the stakeholders who have been identified as having value systems which contribute to urban-scale PV. The deliverables are designed to optimise usefulness to the stakeholders and have multiple communication and promotion scenarios. Although each of the deliverables is a separate product which can be developed independently from all the other deliverables, the relationship between deliverables will be cross-referenced or data based as appropriate. Through developing and producing these deliverables, Task 10 will contribute to achieving the vision of mainstreaming urban-scale PV. The comprehensive list of targeted stakeholders is:

- Building Sector: builders and developers, urban planners, architects, engineers, permit and code authorities;
- End-Users: residential and commercial building owners;
- Government: supporting, regulatory and housing agencies;
- Finance and Insurance Sector: Banks, insurance companies, loan for houses
- PV Industry: system manufacturers, PV system supply chain, retail sector;
- Electricity Sector: network and retail utilities; and
- Education Sector.

SUBTASKS AND ACTIVITIES

SUBTASK 1: Economics and Institutional Factors

This subtask seeks to provide opportunities for stakeholders to look beyond a single-ownership scenario to the larger multiple stakeholder value. In this way, utility tariffs, community policy, and industry deployment strategy can be used to create scenarios which combine all stakeholder values to the PV system investor through sustained policy-related market drivers. Austria is the subtask leader and is also the corresponding work package leader for the PV-UP-Scale project. Activities will include:

Activity 1.1: Value Analysis

This activity will develop a value matrix of stakeholders by the extended value stream beyond the economic market drivers (the market drivers will be included), allowing individual stakeholders to realise a full set of values. Austria leads this activity.

Progress includes a stakeholder value survey developed and implemented with the participating technical experts as well as other interested countries. The results of the survey were presented in a paper at the 20th EU PVSEC conference in Barcelona, Spain in June 2005. The US has developed analysis on government stakeholder economic values such as emissions, health care cost and water consumption reductions, jobs, gross regional product, and household incomes.

Activity 1.2: Barriers Resolution

Recommendations to stakeholders will be developed for removing barriers to mass market uptake of PV. Austria leads this activity.

Progress includes the development of a barriers survey.

Activity 1.3: Market Drivers

Building upon existing lessons learned with financing, policy, environmental and rate structure issues this activity will analyse the economic contribution of these market drivers and developing best practice scenarios. Austria leads this activity.

Progress includes the collection of individual country's analysis. The surveys in activities 1.1 and 1.2 will be used to determine priorities for the global analysis.

Activity 1.4: Market Roadmaps

Using participating country industry roadmaps, either a global market roadmap or a roadmap of global markets will be developed. Either product will serve as a guide for roadmap development.

Progress on this activity includes analysis of the European Industries Association Roadmap, the US Industry Roadmap and the Australian Industry Roadmap.

SUBTASK 2: Urban Planning, Design and Development

This subtask focuses on infrastructure planning and design issues needed to achieve the vision of a significantly increased uptake of PV in the urban environment. The subtask will integrate PV with standard community building practices.

Activity 2.1: Integrating PV Development and Design Practices

This activity will develop guidance for integrating PV into standard whole building design models, rating tools, and building development practices. Emphasis will be placed on the building integration properties of PV for efficiency gains.

Activity 2.2: Urban Planning

A guide will be developed for integrating PV and the whole community energy infrastructure element into urban planning practices through a guide providing processes and approach for setting quantifiable urban-PV goals and objectives in the planning process. Architectural considerations such as building aesthetics, land use, shading, and urban renewal opportunities for BIPV will be included as planning elements. Additionally, community energy use forecast and planning impacts related to the whole building approach and coordinated utility or community system load control to increase demand reduction and increase PV capacity value. The US leads this activity.

Progress on this activity includes a workshop in France on Solar Cities prior to the lyon Task meeting. Using results from the workshop a compendium of solar cities has been developed and is under review. Additionally, Norway is developing a tool for urban planning integration of solar technologies. The UK, through PV-UP-SCALE will make specific contributions to this activity and the Swiss contribution is largely towards this activity.

SUBTASK 3: Technical Factors

This subtask concentrates on technical development factors for mainstream urban-scale PV. Large-scaled urban integration of BIPV systems faces technical challenges related to synergetic use as building material and for energy supply purposes. Other challenges involve the potentially negative impact on the grid and obstacles posed by the regulatory framework. The aim of this subtask is to demonstrate best practices and to advocate overcoming those barriers associated with extensive penetration of BIPV systems on urban scale. The deliverables focus on the broad set of stakeholders required to achieve the vision such as the building product industry, builders, utilities and PV industry.

Activity 3.1: Building Industry/BIPV Products and Projects

By identifying the building material and energy use synergies of PV and of BOS as well as updating the existing Task 7 database of products and projects for BIPV, guidance will be developed for mainstreaming these products in the building industry . A major aspect of the building integration will be building energy management integration and coordinating energy use with lighting and HVAC systems to assure demand reduction and capacity value. Canada is the lead for this activity.

Progress includes the development of a detailed workplan entitled "Residential Urban BIPV in the Mainstream Building Industry" a first step to this is to get the PV industry to participate in updating the database. Malaysia's MBIPV development program plan, may potentially serve as a guide for other countries as well as communities program development.

Activity 3.2: Codes and Standards

Existing codes and standards applicable to urban scale PV and the needs for developing new codes and standards will be evaluated. Both electrical and structural codes will be evaluated as related to buildings. Network codes and standards will be evaluated in a separate activity. This work will build upon work initiated in Tasks 5 & 7. Denmark is the lead for this activity.

Progress on this activity is includes an information matrix for investors or installers of PV systems which points to legal demands, guidelines and good advice for PV system components, issues and systems as part of buildings

TABLE 1 - LIST OF PARTICIPANTS AND THEIR ORGANISATIONS

COUNTRY	PARTICIPANT	ORGANISATION
Australia	Mr. Mark Snow	University of New South Wales
Austria	Mr. Reinhard Haas Mrs. Assun Lopez-Polo Mrs. Demet Suna	Institute of Power Systems and Energy Economics Energy Economics Group Vienna University of Technology
Canada	Mr. David Elzinga Mr. Masa Noguchi	Arise Technologies Corporation NRCan/CANMET Energy Technology Centre - Varennes
Denmark	Mr. Kenn Frederiksen	Energimidt Erhverv A/S
European Union	Mr. Henk Kaan	Energy Research Centre of the Netherlands Through EU, PV-UP-SCALE
France	Mr. Marc Jedliczka Mr. Bruno Gaiddon	HESPUL
Italy	Arch. Niccolo' Aste Mr. Michele Pellegrino Mr. Carlo Zuccaro	Politecnico di Milano CER ENEA CEPI SpA
Japan	Mr. Keiichi Komoto Mr. Tomoki Ehara	Environment, Natural Ressources and Energy Mizuho Information & Research Institute Inc.
Korea	Mr. Kyung Shick Yoom	Korea Photovoltaics Development Organization Korea University
Malaysia	Mr. Ahmad Hadri Harris	Malaysia Energy Center, PTM
Norway	Mrs Inger Andresen Mrs. Käthe Hermstad Mrs. Anne Grete Hestnes	SINTEF Civil and Environmental Engineering
Portugal	Mrs. Maria Joâo Rodrigues	Center for Innovation Technology and Policy Research Instituto Superior Têcnico (Technical University of Lisbon)
Spain	Mrs. Estefanía Caamaño Martín	INSTITUTO DE ENERGÍA SOLAR E.T.S.I. Telecomunicación, Ciudad Universitaria s/n
Sweden	Mr. Mats Andersson	Energibanken AB
Switzerland	Mr. Pierre Renaud	Planair SA
USA	Ms. Christy Herig	Segue Energy Consulting/Subcontractor to National Renewable Energy Laboratory

Activity 3.3: Electricity Networks

This activity will analyse electricity network effects, benefits, impacts, and issues. Interconnection, operational effects, and market issues will be included.

Progress includes the collection of analysis of PV's contribution to peak load reduction in both Australia and the US. Japan has developed a proposal for the activity and Germany is the PV-UP-Scale lead for the corresponding work package.

Activity 3.4: Market Driven Approach

The US developed systems driven approach to research and development will be expanded to the global market by i) establishing a benchmark of current system component cost and market penetration relationships; ii) testing benchmark relationships with existing and potential future system designs, applications, building integration and operational economics; and iii) documenting relationship between research investment in system component development and market penetration.

Progress is the initiation of work on a Canadian contribution focusing on the Mass Customising Photovoltaic Solar Homes in Subdivision Development.

Activity 3.5: Certification Practices

Certification practices will be reviewed and standard test procedures harmonized and transferred to the relevant stakeholders and standard committees. The US leads this activity.

Progress includes a set of documents developed by the US installer certification program in accordance with ISO/IEC 17024 Working Draft, "General Requirements for Bodies Operating Certification Systems of Persons". These documents, will be reviewed by Task 10 participants to be made into templates for countries to use.

SUBTASK 4: Targeted Information Development and Dissemination

This subtask will carry out the information dissemination of all deliverables produced in Task 10. As activities develop in other subtasks, subtask 4 will review to assure the results are useful to the targeted stakeholders. Participating countries will be encouraged to translate documents and workshop materials. This task will also organise countries to host technical development and education workshops. The subtask will also prepare mass/multi-market promotional material about urban-scale PV and will update existing PV education tools. An innovative deliverable will involve holding a competition for urban-scale PV with the winner of the competition announced at a forum on PV for the venture capital sector. Market research for the purpose of understanding and targeting stakeholder perceptions will also be part of this subtask. Finally, this task will be responsible for continuous outreach to stakeholders for input and participation in the task.

France is the Subtask leader, and is also the Work Package leader for the corresponding Work Package in the PV- Upscale project, thus guaranteeing a broad dissemination.

Activity 4.1: Educational Tools

This activity will include a best practices web site which will include templates for tender documents, sales contracts, consumer guides, as well as best practices, detailed real project development information. Sweden leads this activity.

Activity 4.2: Competition

Progress is that Portugal launched the Lisbon Ideas Challenge - Designing with Photovoltaics: New Energy Concepts for the Built Environment.

Activity 4.5: Continuous Communication

France leads this activity.

Progress includes three 2005 workshop in Chambery, France on Solar Cities, a task 10 brochure, a Task 10 presentation which was used at the Shanghai PVPS workshop and a fully active website. At the 26th ExCo meeting it was decided to move the website to the PVPS website.

INDUSTRY INVOLVEMENT

At the 20th EU-PVSEC, Task 10 was invited to participate in an industry meeting looking at values, several points emerged as important to industry from this meeting. The network peak match

TABLE 2 – MEETING SCHEDULE (2004, 2005 AND 2006 PLANNED)

TASK 10 MEETING	DATE	PLACE
1st Task 10 Technical Experts	Feb. 4-5, 2004	Vienna, Austria
2nd Task 10 Technical Experts	Oct. 4-5, 2004	Florence, Italy
3rd Task 10 Technical Experts	March 17-18, 2005	Lisbon Portugal
Combined 26th Task 1 and 4th Task 10	June 1-3, 2005	Lyon, France
5th Task 10 Technical Experts	October 6-7, 2005	Washington, DC, USA
6th Task 10, combined with Tasks 1,2&9	March 27-28, 2006	Vancouver, BC, Canada
7th Task 10 Technical Experts	Sept 11-13, 2006	Malmö, Sweden

Fig. 2 - Task 10 Technical Experts, Washington, DC, October 2005.

value of PV, which has been started in Task 10 and is a work product to be completed by the end of 2006 in PV-UP-SCALE Standardising value analysis so that different countries are not presenting differing answers to non-country specific values, which Task 10 is starting to address by participating in the analysis publication database, expected to lead to analysis guidelines following the values-by-stakeholder matrix developed in Task 10. Additionally, as Task 10 moves forward, the two main reasons for commitment delays which are market oriented will be considered as deliverables are developed. These reasons:

1. As the PV market grows at phenomenal rates, countries question their analysis/resource investment in deployment type work such as Task 10 and consider R&D expenditures to be more important. Task 10 will participate in the development of a publication database, which should help with both analysis and R&D coordination.
2. Three countries, Japan, Germany, and USA (mainly California) installed 94 % of the 2004 market. The market sectors that have emerged, though both grid connected, are mainly customer sited for the purpose of offsetting customer energy use (Japan and California) and large free field systems for the purpose of selling into the grid (Germany and most of EU). The later market sector of free field systems puts to question the need for urban-scale deployment type work such as Task 10. Both markets are policy driven and Task 10 will work towards understanding the market transformation related to the policies.

KEY DELIVERABLES

(2004)

- 2nd International Symposium, Photovoltaic-Electricity From the Sun, February 11, 2004, Vienna - Austria
- Oral Paper Mainstreaming PV in the Urban Landscape - Activities of the New Task 10 IEA PVPS Implementing Agreement, 19th PVSEC, Paris, France, June 2004.
- Architects and Builders workshop for French stakeholders during the 19th PVSEC, Paris, France, June 2004
- Brochure/flyer for outreach to stakeholders.
- Task 10 website with front end for stakeholder outreach and Task 10 participants' password accessible working platform.
- Italian Stakeholders Workshop, PV integration in urban areas, October 6, 2004, Florence, Italy

(2005)

- Workshop targeted at all building sectors, Photovoltaics in Buildings: Opportunities for Building Product Differentiation, Lisbon, Portugal March 16th, 2005
- Workshop on Solar Cities in Chambery France, June 1st, 2005
- Paper Value Analysis: International Comparison Of PV Values For Multiple Stakeholders, at 20th PVSEC, Barcelona Spain, June 2005
- Task 10 Presentation at ISES/ASES World Conference in Orlando, August 2005
- Task 10 presentation at PVPS Workshop Shanghai Oct, 2005
- Best practises website

(PLANNED 2006)

- Swedish stakeholder meeting, September 11, Malmo, Sweden
- Environmental Benefits of PV Systems in OECD Cities
- The Value of Policies in OECD Countries (proposed)

AUSTRALIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
DR MURIEL WATT, SCHOOL OF PHOTOVOLTAIC AND RENEWABLE ENERGY ENGINEERING, UNIVERSITY OF NSW

GENERAL FRAMEWORK

The use of photovoltaic power systems (PV) in Australia continues to grow at a steady 15 % with total installed capacity reaching 52 MWp by the start of 2005. Off-grid industrial and agricultural applications continue to dominate Australia's cumulative installed capacity (57 %), although the percentage of installed capacity for this sector has fallen from 76 % over the past decade. Around 3,6 MWp was installed in off-grid non-domestic installations during 2004, representing 54 % of annual installations. Off-grid residential applications continue to grow strongly, accounting for 35 % of 2004 installations and 30 % of installed capacity. This is up from 24 % a decade ago and reflects continued efforts by State and Commonwealth governments to assist remote households in reducing their reliance on diesel fuel. Total off-grid cumulative installed capacity accounts for 87 % of PV installed in Australia. The off-grid market is expected to remain strong due to a booming minerals sector, which utilises PV for telecommunications and signalling. However, this market is also impacted by the strength of the agricultural sector, which is just emerging from severe drought, and by infrastructure developments undertaken by the telecommunications sector.

Grid connected PV has grown from zero to 13 % of installed capacity over the past decade, with most of this (10 %) being PV on residential and community buildings. The national PV Rebate Programme, Greenpower programmes and, to a lesser extent, the Mandatory Renewable Energy Target, account for a major portion of grid connected PV installations. These programmes are expected to remain the major market drivers in the short term, with the Solar Cities programme, described below, beginning to provide a new focus.

A number of utilities maintain a watching brief on PV developments with a view to increased use for peak load supply and grid support. Utilities with diesel grids continue to support the addition of PV to their systems, although recent decisions to remove fuel excise for off-grid diesel use will make PV less cost effective. For main electricity grids, PV remains a high cost option for utilities and the most immediate areas of interest are in safety and grid reliability issues associated with the interconnection of privately financed distributed PV systems.

PV is increasingly being accepted at the local government level, for street lighting, traffic management, parking meters and other applications in urban areas. Building developers have also been encouraged to consider PV through a special component of the PV Rebate Programme while most States have instigated Solar Schools programmes. These initiatives will gradually increase public awareness and confidence in PV.

Fig. 1 - PV system for a remote railway bore pump (photo BCSE).

NATIONAL PROGRAMMES

Existing Programmes

The Australian Government has initiated a number of measures over recent years to support renewable energy in general and, in some cases, PV in particular. These include:

Mandatory Renewable Energy Target (MRET) - which seeks to increase the contribution of renewable energy sources in Australia's electricity mix by 9 500 GWh per year by 2010, with that target continuing until 2020. Since 2001, electricity retailers and large energy users must purchase increasing amounts of electricity from renewable sources. A trade in Renewable Energy Certificates (RECs) and financial penalties for non-compliance are features of this scheme. Twenty nine PV systems have so far registered for REC creation. Small generating sources, such as rooftop PV systems, are allocated RECs on the basis of deemed generation over their lifetimes, rather than claiming RECs annually. For PV, RECs have been available on installation for up to 5 years of operation. This time period has now been extended to 15 years, which is expected to boost the number of PV systems registering for RECs. In addition, the size of systems eligible for deemed RECs has been increased from 10 to 100 kW.

Renewable Remote Power Generation Programme (RRPGP) - commenced in 2000 and is expected to make available around 200 MAUD over nine years for the conversion of remote area power supplies (including public generators and mini-grids) from diesel to renewable energy sources, and for new renewable installations that would otherwise have used fossil fuels. The RRPGP provides up to 50 % of the capital value of the replacement or new renewable generation for off-grid users of diesel-based power systems. From 2005 eligibility was extended to fringe-of-grid installations, displacements of other fossil-fuels (not just diesel), energy efficiency measures and solar water heaters. The programme is administered by and is slightly different in each State and Territory, in line with local priorities. Some States have also provided supplementary funding. From 2006, only Western Australia and the Northern Territory have significant funding remaining. Important national sub-programmes also funded include Bushlight (an indigenous renewable energy services project) which aims to install suitable renewable energy power systems in small remote aboriginal

Fig. 2 - 42 kW grid connected PV array at University of NSW (photo BP Solar Australia).

Fig. 3 - PV powered remote beach house (photo BP Solar Australia).

communities, as well as to increase industry capacity to service indigenous communities and to build greater understanding of renewable energy issues within communities, and RESLab, a renewable energy systems test centre. 3,8 MWp of PV had been installed under RRPGP by early 2005, of which 0,28 MWp is installed in large utility run diesel grid systems.

PV Rebate Programme (PVRP) - commenced in 2000 and currently runs until 2007. Funding is provided by the Australian Government, with administration by the State Governments. Rebates on PV capital costs are provided to householders or community building owners who install grid-connected or stand-alone photovoltaic power systems. Householders are eligible for a rebate of 4 AUD/W capped at 4 000 AUD per residential system. Rebates will be reduced in stages to 3,50 AUD/Wp over the coming two years. Smaller rebates are also paid for extensions to an existing system. Community buildings attract a 4 AUD/W rebate but have had a higher cap of 8 000 AUD. This cap will be reduced to 4 000 AUD from 2006. As part of the Programme, the Australian Government has made available one million Australian dollars to fund projects by residential housing developers and display home builders. A rebate of 3,50 AUD/Wp, reducing to 3 AUD/Wp by end 2007, is available in 50 000 AUD blocks. Since the start of the programme in 2000, more than 6 600 systems, using 8 MWp of PV, have been installed and rebates of over 30 MAUD have been provided. Slightly more than half the installed capacity has been grid connected.

New Programmes

In line with the 2004 Energy White Paper "Securing Australia's Energy Future", several new support programmes for renewable energy technologies have been introduced. Those relevant to PV include:

Solar Cities Trials - 75 MAUD have been allocated over 5 years to demonstrate high penetration uptake of solar technologies, energy efficiency, smart metering and other options aimed at improving the market for distributed generation and demand side energy solutions. Tenders were called for consortia to install PV and other distributed generation options in four or more urban sites, with detailed monitoring and associated tariffs, marketing and financing also being supported. Eleven consortia from around Australia have been short-listed from 23 applicants. Each short-listed consortium will receive 50 000 AUD to assist them in preparing a detailed business case, which will be assessed by an expert panel, before a final decision is made mid 2006 about the location of Australia's Solar Cities.

Renewable Energy Development Initiative (REDI) - launched in October 2005, this programme will provide 100 MAUD over seven years in the form of competitive grants to Australian industry to support early-stage commercialisation; research and development; technology diffusion and proof-of-concept activities in renewable energy technology. Projects are required to demonstrate strong commercial and emissions-reduction potential. Origin Energy received 5 MAUD in the first grant round to assist with commercialisation of its Sliver™ Cell PV technology.

The Low Emissions Technology and Abatement (LETA) initiative is a 26,9 MAUD measure to reduce greenhouse gas emissions over the longer term by supporting the identification and implementation of cost effective abatement opportunities and the uptake of small scale low emission technologies in business, industry and local communities. Support for renewables is provided via an industry development sub-programme and will be available to State and Territory Government agencies and renewable energy industry associations.

Advanced Electricity Storage Technologies, including batteries, electro-mechanical, thermal and chemical storage, will be supported via a 20,4 MAUD fund, as part of the government's push to overcome barriers to renewables and other intermittent energy sources. Expressions of interest were called in late 2005 and funding will be awarded in 2006. The aim is for Australian industry to demonstrate world-leading electricity storage technologies and develop creative solutions that will benefit both the electricity storage and renewable energy industries.

State and local government policies also increasingly support PV market growth directly or indirectly and are expected to play a more significant role in future.

Fig. 4 - 50W system for a school crossing in Ballarat, Victoria (photo BCSE).

Fig. 5 - PV array for a new remote home (photo Luke Williams).

R, D & D

PV and Remote Area Power Systems have been identified by the Australian Government as technologies of strategic importance for Australia and for which Australia has a clear technological advantage internationally. This is reflected in priorities for Government R&D funding and will also be boosted by some of the new national government programmes described above.

Australian Government annual funding for PV R&D, D (including market incentives) was about 19,4 MAUD during 2004. Funding from the State governments for the same period was around 0,9 MAUD, while funding is also available through various local governments.

University based PV research is undertaken in a number of facilities. The Centre of Excellence in Advanced Silicon Photovoltaics and Photonics, University of NSW, has research streams focussed on short, medium and long term technology needs. Research undertaken includes cost reduction and efficiency improvements for wafer based silicon cells, improved silicon thin film processes and all-silicon tandem cells.

The Centre for Sustainable Energy Systems at the Australian National University undertakes research into solar thermal and photovoltaic technologies including parabolic trough and paraboloidal dish PV concentrator systems, and associated concentrator cells, trackers, controllers and mirrors, as well as a Combined Heat and Power Solar System. It is also undertaking research into thermochemical storage and phase change energy storage materials.

The Solar Energy Applications Research Group at Monash University undertakes research into renewable energy power systems design, analysis and storage. It works with off-grid and grid applications.

The Sustainable Energy Centre, University of South Australia, undertakes research into PV applications, including commuter cars.

Other university PV programs include:

- University of NSW - GaAs solar cells
- Murdoch University - low cost silicon production
- Flinders University - improved dye sensitised solar cells
- University of Queensland - semiconductor biopolymers
- Newcastle University - nanoscale polymer devices
- University of Western Australia - Tantalum-Silicon cells.

In industry, some of the most innovative product development is occurring with PV concentrator systems. Solar Systems Ltd. continues development and commercialisation of its PV tracking concentrator dishes for off-grid community power supplies and end of grid applications. Current systems achieve 500 times concentration and use air or water cooling. System efficiencies of 20 per cent have been achieved. The systems are currently based on silicon cells, but work is continuing on development of non-silicon devices.

Green and Gold Energy has developed the smaller SunBall™ concentrator system, aimed at domestic and commercial applications. The company is currently undertaking its final trials before beginning pilot manufacture in Adelaide. The concentrators use a Spectrolab triple junction GaInP2/GaAs/Ge cell mounted on a copper heat spreader. The cells are placed at the focal point of a Fresnel lens and mounted in an aluminium hemisphere. The sphere is double axis tracked. The company claims to maintain operating temperatures at less than 18 degrees C above ambient and efficiencies higher than 30%. The first product will be a 1m^2 diameter system, rated at 330 W and is expected to retail at 1 100 AUD, excluding taxes. The company is anticipating electricity prices of 0,1 to 0,2 AUD, depending on location.

BP Solar is the largest commercial PV manufacturer in Australia and continues its development of automated production equipment, improved cell and module manufacture and systems development.

Origin Energy is commercialising the "Sliver cell" PV technology developed by the Australian National University. The technology promises crystalline Si cell performance with significantly lower wafer requirements. A 5 MW Pilot Plant was installed in Adelaide in 2004 and trial 10 W modules produced. More extensive manufacture is anticipated in 2006. The pilot plant will be expandable to approximately 25 MW p.a. capacity if pilot production is successful.

Fig. 6 - Outback solar home, Hay NSW (photo BCSE).

CSG Solar (formerly Pacific Solar) undertakes R&D on Crystalline Silicon on Glass (CSG), a thin film PV technology based on initial research at the UNSW. CSG cell and module manufacture is scheduled for 2006 in Germany.

Dyesol Limited, formerly Sustainable Technologies International, has broken into the global solar energy market with a 3,15 MAUD contract to supply dye sensitised solar cell (DSC) technology and materials developed in Australia for Europe's first manufacturing plant for dye solar cells, which is to be built in Greece by Solar Technologies AE over the coming two years. Dyesol continues Australian manufacture from its pilot facility in Queanbeyan.

PV Solar Energy Pty Ltd continues development of its PV roof tile which uses a low cost pluggable PV junction box and monocrystalline solar cell laminates. Installation options include active air flow in the roof space below the modules to keep them cool and allow for warm air circulation into the building during winter months.

IMPLEMENTATION

Total PV installed in Australia reached 52 MW in 2004, with 6,7 MW installed in 2004. The market growth rate remains steady, as does the proportion of installations in each end use category. Off-grid installations represent 87 % of installed capacity and grid installations, including diesel grids, 13 %. Direct government support was provided for approximately 30 % of off-grid installations, and almost 100 % of grid installations.

Module costs have risen, in current dollar terms, to around 10 AUD per Wp, reflecting international market prices. Prices for some inverters and for grid systems have also risen. Installation costs have been impacted by increasingly stringent occupational, health and safety regulations associated with insurance.

PV cell production capacity in Australia increased to 40 MW in 2004 and to 50 MW in 2005. Cell production increased to 35 MW and module production remained at 8 MW. 77 % of cells and 50 % of modules manufactured in Australia were exported in 2004 while around 40 % of modules installed were imported. A 5 MW pilot line was installed for the new Origin Energy Sliver™ technology and production is expected to commence in 2006.

INDUSTRY STATUS

BP Solar remains the major PV manufacturer in Australia, carrying out cell fabrication from imported wafers, through to module fabrication as well as total system production. BP Solar's module ratings continued to increase, with modules now rated up to 180 W. Solar Systems continues to install its CS500 solar concentrator PV dishes in remote communities. These parabolic solar tracking dishes consist of 112 mirrors concentrating to the equivalent of 500 suns onto 24 kW water-cooled upgradeable receiving modules. Four systems with a combined rating of more than 1 MW are currently being installed in central Australia. The first 220 kW system is already operational.

Dyesol Limited manufactures Titania based Dye Solar Cell (DSC) products in its pilot facility in Queanbeyan with in-house manufacturing of all the key materials for DSC technology: titania paste, dye, electrolytes, catalytic paste, interconnecting material and internal sealants. The product is aimed primarily at façade integration.

CSG Solar continues research on its thin-film CSG product in Australia, but will begin manufacture in Germany in 2006 in partnership with Q Cells.

Origin Energy continued to establish its pilot line in Adelaide during 2005, and expects to begin pilot production of its Sliver™ modules in 2006.

PV Solar Energy Pty Ltd continues development and installation of its PV roof tile, based upon a versatile extruded aluminium frame. The tile uses a new low cost pluggable PV junction box and monocrystalline solar cell laminates.

There are several Australian manufacturers of inverters, controllers, batteries and other components, as well as of specialized end use products, such as water pumps, electric fences, lights and hybrid power supplies. Manufacturers are consolidating their product ranges and specializing. Some are concentrating on export markets, others on diesel systems, grid systems or small scale off-grid systems.

MARKET DEVELOPMENT AND FUTURE OUTLOOK

Growth in the local Australian market saw annual sales expanding by 15 % during 2004, with imported cells, modules and BOS components increasing their market share. Government support was provided for around 30 % of off-grid installations and for the majority of on-grid installations. The two key support programmes, the PV Rebate Programme and the Renewable Remote Power Generation Programme will continue through 2006, although grants will be lower for the former and some States have already filled their quota for the latter programme.

New programmes at national and State level are likely to maintain interest in PV development, but seem unlikely to impact significantly on the market in the short term. Programmes such as Solar Cities and State Government building regulations are, however, expected to create an increasing PV market over the longer term.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

HUBERT FECHNER AND ANDREAS LUGMAIER, ARSENAL RESEARCH

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

Austria's PV society is still lacking of federal support since the feed-in-tariff, which was effective for only some weeks in early 2003 has run out when the cap, with a total of 15 MW, was reached. Although some provinces have re-introduced support mechanisms for PV installations, the general situation of the public support schemes in Austria for electricity producers using renewable energy sources is further mainly characterised by discontinuity. Today, in six regions (Burgenland, Lower Austria, Upper Austria, Styria, Tyrol and Vienna) different conditions for obtaining subsidies are provided (funds in context of the Green Electricity Act and funding by housing subsidy schemes; list is not exhausting).

The National Green Electricity Act (GEA) on 1.1.2003 provided basically a fundamental change. From this date the legislative authority changed from the provincial to the federal level and thus most of the regional incentives by the federal states were disbanded at that time, but soon reintroduced after the shortfall of the federal incentive. The GEA governs not only the support for green electricity but also for electricity from combined heat and power generation. The GEA supplements the Austrian Electricity Law (ELWOG, 2000) which defines the basic framework for the liberalised electricity market.

The overall aim of the GEA is to increase the share of electricity from Renewables to more than 78 % in 2010, based on the obligations of the Renewable Electricity directive of the EU. For this purpose the GEA sets a target to meet 4 % (about 2,3 TWh/a) of the public national electricity demand with electricity generated from 'new' renewable energy sources (RES) (not including hydropower) as well as 9 % (about 5,2 TWh/a) by small hydropower until 2008, respectively. Those RES are supported mainly via long-term guaranteed feed-in tariffs to achieve the above mentioned political target quotas. The feed in tariffs are stated by the federal Ministry for Economics and financed by a supplementary charge on the net-price and a fixed price purchase obligation for electricity dealers (so far 4,5 Eurocent/kWh).

A revision of the GEA had been foreseen for 2005. Negotiations had been started in 2005, but a consensus between the two main parties in the national council (related to necessary changes with 2/3 majority) was hard to find (lasted until end of 2005). Final negotiations about acceptance of the revision with the EC and legal accuracy are going on and if agreed upon positively, the new GEA finally shall come into force within the first half of 2006.

The current draft for the revised GEA for the first time defines a total maximum amount of additional support for new RES power plants for the years 2006 to 2011. The time frame for the feed-in-tariff is planned to be reduced. The tariffs are planned to be reduced in total (100 % of the source/size specific tariff (which are not announced yet) in year 1 to 10, 75 % in year 11,50 % in year 12), as well.

Fig. 1 - Solar Settlement in Weiz/Styria (photo KW-Solar).

A decrement factor shall also be implemented (to reduce the source/size specific maximum tariffs each year about a few %). In addition, a definition of specific shares for energy sources is planned. In the actual draft about 30 % of the support shall be dedicated to solid biomass and waste with a high share of biomass; an additional 30 % shall be dedicated to biogas. Wind, shall be supported with 30 %, as well. The remaining 10 % are reserved for all other sources, as PV, liquid biomass, co-firing power plants or others. Although PV still plays a minor role in the revised draft, a small support seems to be possible, but will depend on the exploitation of the maximum amount by other competing sources (mainly co-firing or liquid biomass power plants). Calculating with the actual draft,
a maximum support for PV amounting to about 3-4 MW would be possible to install per year. A significant market stimulation aiming at establishing competitive Austrian PV industry will not be achievable. Furthermore, no definitions for supporting special PV applications (as e.g. Building Integrated PV) niche markets, where Austrian companies could maybe reach a leading position, has been made.

RESEARCH AND DEVELOPMENT

Austrian PV research activities are mostly focused on national and international project bases. The involved research organisations and companies are participating in various national and European projects as well as in different tasks of the IEA-PVPS Programme. The RTD development and approach is widespread located and decentralised orientated.

The national programme, "Energy Systems of tomorrow," successfully initiated by the Ministry of Transport, Innovation and Technology is a quite broad research programme on energy technologies. Although research is not directly related to PV, PV systems as well as distributed generation with many aspects relevant for PV are of high priority within this programme.

On a European level, the ongoing initiatives to increase the coherence of European PV RTD programming (PV-ERA-NET) are actively supported by the Austrian Ministry of Transport, Innovation and Technology.

Some principal descriptions of these projects highlight the general RTD trend of photovoltaics in Austria:

- Organic Solar Cells based on thin plastic films have been intensively investigated during the last 10 years, at the Kepler University of Linz, lead to the foundation of a local branch of an U.S. PV company in Linz.
- Other areas of institutional and academic research include the improvement of photovoltaic solar cells made from lower purity or multi-crystalline silicon.
- At the University of Salzburg, a new initiative was started in late 2005 to develop thin film solar cells, based on sulfosalt solarcells.
- Socio-economic research concerning the integration of PV is internationally well positioned at the Technical University of Vienna.
- Grid-interconnection, not exclusively related to PV but more to Distributed Generation from RES in general, is the main focus of several EU financed projects, which are jointly carried out by research institutions, industry and utilities.
- Cost reduction and optimization of new solutions for building integrated PV are addressed within several EU projects.
- A large Austrian glass industry has started activities in PV, mainly for addressing architectural building design.
- In the area of system technology, the activities for quality assurance, certification and testing of PV modules were initiated. For about two years, arsenal research an Austrian research and testing institution has been officially accredited to qualify crystalline silicon PV modules according to the EN/IEC 61215 standard.
- A Master of Building Science at the Danube University in Krems is dedicated to Solar-Architecture where the lectures and the scientific work are focusing more and more on PV Building integration.

Fig. 2 - Special PV Construction at the AVL-List Company, Graz, Austria (photo ertex Solar GmbH, Amstetten, Austria).

IMPLEMENTATION & MARKET DEVELOPMENT

Due to the ceasing of PV support, a serious decline in newly installed capacity to a level below 3 MW has been reported. As mentioned in the sections General Framework and National Programme, it is only in few regions that local incentives have alleviated the unfavourable situation and provide limited support in form of investment subsidies or grants.

Approximately 19,2 MW of PV power had been installed in Austria by the end of 2004, numbers for 2005 can not be assured, but are expected to reach a total installation of about 22 MW. While until 2003 capacity grew continuously about 37 % each year, the growth dropped down to only 12 % in 2004 similar to the data to be expected for the 2005 survey.

The main applications for PV in Austria are grid connected distributed systems, representing more than 90 % of the total capacity. Grid-connected centralised systems in form of PV-Power plants play a minor role with about 1,2 MW installed.

Building integration is an important issue and several remarkable installations were realised. Besides on-grid applications, off-grid systems are widely used to provide electricity to technical systems or for domestic use in Alpine households or mountain huts lying far away from the grid. But not exclusively in remote areas, also on urban sites PV is an increasing option to supply infrastructure systems. PV is also becoming more and more visible on Austrians highways supplying the increasing numbers of screens which are informing the drivers with actual information about the traffic situation.
Some provincial governments have built PV-demonstration plants on municipal buildings in order to create public awareness for PV.

In Table 1 the amount of Austrian RES electricity, supported through the national feed in tariff system for 2004 and 2005 can be found (2005 values are preliminary). First real numbers for the whole year 2005 show a total amount of about 5.750 GWh for 2005, and thereof ca. 13 GWh for PV.

TABLE 1 – FEED IN TARIFF SUBSIDISED RENEWABLE ELECTRICITY [IN GWH]

SUBSIDISED GREEN ELECTRICITY 2005 AND COMPARAISON WITH 2004			
Energy Source	Amount of fed in electricity [GWh 2005]	Percentage of amount of fed in electricity [%]	Amount of fed in electricity [GWh 2004]
Small Hydro	**3 554**	**61,76**	**3 995**
Other supported Green Power	**2 200**	**38,24**	**1 444**
Wind	1 316	22,87	924
Biomass solid-including garbage with parts of solid Biomass	554	9,62	313
Biogas	219	3,80	102
Biomass liquid	33	0,57	18
Photovoltaic	13	0,22	12
Gas from landfill or purification plants	64	1,11	74
Geothermal	2	0,04	3
Total smal Hydro and other supported Green Power	**5 754**	**100,00**	**5 439**

E-Control, Austria; Preliminary Data (status Jan. 2006)

INDUSTRY STATUS

Despite the unclear and unsatisfactory situation with almost no national market for PV, the Austrian PV industry could still expand their activities during 2005 focussing on the export of their products to the booming German market and other International markets.

Ertex Solar: A new subsidiary company of the traditional company Ertl Glass (known for e.g. safety glass or insulation glass production, etc.), specialises in production and distribution of building integrated PV modules. The company uses a new and innovative laminated glass production technology.

RKG Photovoltaik, since 2004 produces PV modules. The company is closely linked to GREENoneTEC, European's market leader in solar thermal collectors.

SED manufactures modules specially designed for integration into PV-roof tiles. The custom laminates produced are directly stuck into standard format tiles made of recycled plastic and can easily replace conventional roofing materials.

PVT Austria, the first manufacturer of PV modules in Austria produces standard and tailored modules from imported crystalline silicon cells. The company successfully increased their output taking profit of the German PV boom.
Besides PV-Module production, various other companies are manufacturing components for modules and BOS-components like batteries, inverters, or mounting systems:

SIEMENS AUSTRIA started large-scale manufacturing and development of string-inverters in the range of 1,5 kW to 4,6 kW for grid connected applications in 2004.

FRONIUS INTERNATIONAL has been engaged in solar-electronics and is Europe's second largest manufacturer of inverters for grid connected PV systems.

ISOVOLTA AG is the world market leader for flexible composite materials used for encapsulation of solar cells. The ICOSOLAR back sheet laminates are available in various colours and are used by many module manufacturers in the world.

MARKET DEVELOPMENT

The National Photovoltaic Association has further expanded their activities by creating a national network for dissemination of information on PV and initiating awareness raising activities. By fostering the political contacts and intensive political lobbying work for PV, the association is aiming at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives preferably based on feed in tariffs.

About 30 companies involved in the PV business are currently members of the Association.
The annual National Photovoltaic Conference 2005 was organised by arsenal research, the City of Vienna and the Austrian Photovoltaic Association with support of the Ministry of Transport, Innovation and Technology and was a big success, with about 150 participants.

Fig. 3 - Schiestl-Haus: First Alpine Passive House, 2 156 meters high 7,5 kW PV (photo Fa. ATB Becker).

For the first time, an "industry forum" was a part of the Conference where all relevant national market players (module producing companies, BOS producing companies, research experts etc.) informed the audience about the latest developments.

The PV installers and module producers together with Architects had been preparing tools for the Architects and the building industry to integrate PV more and more as part of the building. It has been recognized that it is not only the costs, but often very practical reasons, which prevent architects from integrating PV into their building concepts, or the lack of arguments to convince the building owner to implement PV.

FUTURE OUTLOOK

- While waiting for the introduction and perhaps further negotiations concerning the GEA, the situation of PV is currently unclear and unsatisfactory. If no significant and stable support mechanisms, (which can provide long and promising perspective for a national PV industry development) are introduced, the market will remain limited relying on regional incentives which will only partly support the market. And even if the suggested small amount of subsidies per year, as suggested in the GEA, is not triggering potential PV niche markets, where Austrian could take a lead position, a further deviation to the strong development in other markets (especially Germany) has to be expected.
- PV research and development will be more and more concentrated on international projects and networks, following the dynamic know-how and learning process of the worldwide PV development progress. Specifically, the direct links to the new members of the European Union in Central and Eastern Europe in energy related items are to be mentioned (EU-Interreg Initiatives), where PV plays more and more an important role.
- The level of the public know-how about the potential and perspectives of PV is still insignificant but continuously growing. Several renewable energy education courses are already implemented, some new course offerings are currently under development. All of them include PV as an essential part of the future energy strategy. The importance of proper education for installers and planners of PV systems will increase depending on the market situation. However, the Austrian research center "arsenal research" in coordination with the national PV association is just about to initiate a national "Certified PV Training" for installers and planners in order to keep the quality of the installed systems at a high level.
- It can be expected that the National PV Association will significantly promote the topic in Austria. The small PV industry, currently taking advantage of the strong German market is very much interested in creating a home market for PV, and is further waiting for an improvement in the economic frame conditions.

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
CANADIAN ANNUAL REPORT 2005

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Fig. 1 - Government of Canada's 33,5 kW BIPV Greenstone Building, Yellowknife, Northwest Territories (photo Visionwall).

GENERAL FRAMEWORK

The federal Department of Natural Resources Canada (NRCan) is responsible for energy policies and energy R&D in Canada. The CANMET Energy Technology Centre-Varennes (CETC-Varennes) is one of three energy research and innovation centers of NRCan[1]. Established in 1992, CETC-Varennes' mission is to encourage targeted sectors of the Canadian economy to reduce their greenhouse gas (GHG) emissions, facilitate the sustainable use of energy, and improve their innovation capabilities. CETC-Varennes also designs and implements technological solutions, and gathers and disseminates knowledge in order to produce and use energy in ways that are more efficient and sustainable, and in order to stimulate the health of the Canadian economy. CETC-Varennes is responsible for the management of the federal photovoltaic energy R&D and technology transfer programme.

The Government of Canada is signatory to the Kyoto Protocol to the United Nations Framework Convention on Climate Change. An on-going Technology and Innovation Initiative is contributing to advancing promising GHG technologies through R&D, demonstration and early adoption initiatives to achieve long-term GHG reductions and strengthen Canada's technology capacity in five key areas: decentralized energy production; advance energy end use in buildings and communities, industry and in transportation; cleaner fossil fuels; biotechnology; and, the hydrogen economy. Photovoltaic and related activities have been included in the implementation plans of the Technology and Innovation initiative.

In 2005 the Government of Canada released a new national climate change plan entitled, "Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment." The plan combines regulatory, negotiated, and incentive-based approaches. It anticipates mandatory emission intensity caps for major GHG-producing sectors but also relies heavily on government-funded purchases of emission reductions, both domestically and through the Kyoto Protocol's market-based mechanisms. The Plan is the first phase of Project Green - a national project to create a healthier environment and a stronger economy by combining the efforts of governments, non-governmental organizations, businesses and all Canadians to build a more sustainable future[2]. It is estimated that the approaches outlined in the Plan, with an associated federal investment in the range of 10 billion CAD, could reduce GHG emissions by about 270 megatonnes annually in the 2008-2012 period.

Also in 2005, the Government of Canada, through Canada Mortgage and Housing Corporation, launched the first phase of a Canadian net zero healthy housing initiative, a government/industry partnership to build a vision for a sustainable living environment. The initiative, part of Project Green, will initially see the construction of 14 demonstration homes across Canada, and hopefully lead to a broad based deployment of Net-Zero Energy Homes in Canada. Industry participation in this initiative is coordinated by the Net-Zero Energy Home (NZEH) Coalition[3] - of which Spheral Solar Power division is founding member. The initiative is intended to significantly increase consumer interest in and awareness of the important role

TABLE 1: CUMULATIVE PV POWER CAPACITY INSTALLED IN CANADA

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
PV power (MW)	1,24	1,51	1,86	2,56	3,338	4,47	5,83	7,15	8,83	10	11,83	13,88	16,77*

**NRCan estimate is based on expected 20 % growth in 2005.*

that solar and other renewable energy technologies can play in meeting Canada's commitment for a clean energy future and healthy communities.

The PV market and industry in Canada is continuing with a modest growth, despite the low price for conventional energy. A sustainable market for remote and off-grid applications has developed over the last 12 years in Canada and continues to accounts for about 95 % of total PV installed. This is an unsubsidized market that is growing because PV technology is meeting the remote power needs of Canadian customers particularly for transport route signaling, navigational aids, remote homes, telecommunication, and remote sensing and monitoring. The installed power capacity has reached approximately 16,77 MW in 2005 compared to 13,88 MW in 2004 (see Table 1).

NATIONAL PROGRAMME

NRCan's Renewable Energy Strategy is a blueprint for cooperative action with stakeholders to accelerate the development and the commercialization of renewable energy technologies in Canada. Within its framework, CETC-Varennes is responsible for the photovoltaic science and technology activities[4]. The photovoltaic energy research group's primary mandate is to help develop and deploy photovoltaic energy technologies in Canada. To this end, two strategic approaches are being taken. The first is to accelerate the deployment of this technology in Canada, while the second aims at exploiting the technology's potential, both nationally and internationally. Specific activities of the federal Photovoltaic Programme centre on:

1. Performing R&D addressing cross-cutting issues on off-grid and grid connected PV systems through collaboration with Canadian and international partners;
2. Providing leadership and technical assistance to committees and task forces that develop policies, codes and standards related to photovoltaic energy and interconnection guidelines;
3. Encouraging investment in manufacturing and provide business development support to globally competitive photovoltaic manufacturers that significantly contribute to Canada's climate change objectives; and,
4. Providing information to stakeholders and to Canadians to increase their awareness of the potential and value of photovoltaic energy.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Federal Photovoltaic Programme R&D

The Canadian PV R&D Programme contributes to research projects in remote regions, undertakes technology development and demonstration projects, participates in the formulation of standards and codes, and supports, the evaluation of the performance of PV systems in new applications and their adaptation for use in cold climate conditions. R&D activities are mainly funded by the Office of Energy Research and Development (OERD), the Government of Canada's co-ordinator of energy research and development activities. OERD is responsible for the Programme of Energy Research and Development and the Technology and Innovation Research and Development initiative which support the energy-related R&D activities of federal departments, including the federal PV Programme. OERD also coordinates Canada's involvement in international energy R&D activities through linkages with the International Energy Agency (IEA), the U.S. Department of Energy, the European Union and the Asia-Pacific Economic Co-operation.

On-going R&D projects undertaken by the PV Programme include:

- R&D for the integration of PV-thermal systems in buildings;
- Optimization strategies for Low Energy Solar Homes;
- Evaluation on the use of small PV-hybrid systems in off-grid applications;
- Integration of renewable energy technologies in off-grid residences in Canadian climatic condition;
- Assessing the performance of PV products designed for building applications;
- Collaboration with Measurement Canada on net-metering to address the regulatory issues;
- Simulation studies on the impact of inverter-based systems and utility interconnected PV systems; and,
- Supporting the development and adoption of performance and safety standards for use in Canada, including participation in the International Electrotechnical Commission working groups that aim to develop international standards.

Solar Cell Research

There has been growing interest in fundamental solar cell R&D at Canadian universities over the past several years. In 2005, a federally-funded study[5] provided an overview of fundamental solar cell R&D capability in Canada as a first step in identifying relevant solar cell research undertaken in the private sector and universities, and the potential of this work in strengthening the global competitiveness of Canadian companies involved in the production of PV technologies in Canada.

Solar Buildings R&D Network

The Government of Canada, through the National Science and Engineering Research Council (NSERC) is investing 5 million CAD over a 5-year period to create a Solar Buildings Network - a research consortium with the aim of advancing multi-disciplinary collaboration to innovate solar energy production and efficiency of its use in commercial, institutional and residential buildings in Canada. The federal research centres at NRCan and CMHC, industry and ten Canadian universities are participating in the Network to facilitate collaborative research in four subject theme areas: the

Fig. 2 - Hybrid Remote Area Power Systems at Seymour Arm, British Columbia - a complete turn-key solution for off-grid power supply by Xantrex Technology Inc. (photo by Xantrex).

integration of solar energy systems into buildings; solar thermal systems for heating and cooling; solar electricity generation in buildings; and simulation tools for solar building design. The Network is expected to produce about 80 Masters and PhD students knowledgeable in solar buildings research. This collaborative R&D effort will provide in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions. It will help to support innovation in the residential construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

Highlights of Canadian Demonstration Projects

The most advanced building-integrated photovoltaic installation 'North of 60'

In partnership with industry, the Government of Canada in 2005 unveiled a new federal building in Yellowknife, Northwest Territories, as an environmental showpiece for the North. The new 7,200 m^2 four-storey building - *the Greenstone Building*[6] - will house about 200 public service employees from approximately 15 different federal departments, and is scheduled to become the first 'North of 60' Leadership in Energy and Environmental Design (LEED®) Silver-certified project (Figure 1). The LEED® standard, originally developed in the United States and recently adopted in Canada, provides an effective and consistent framework for gauging sustainable building design. The building not only incorporates innovative energy conservation measures but actually generates some of its own power - enough electricity to meet five percent of the buildings electrical needs. In this installation 33,5 kilowatts PV cells are incorporated into a high performance south-facing curtain wall developed by Canadian-based Visionwall Corporation[7]. Visionwall® PV curtain wall technology integrates PV laminated glass and an interior circuit wiring system into modular frames of energy-efficient glazing systems. This technology has overcome challenges, including high temperatures of the PV modules and access to wiring for maintenance. The electricity produced by the 33,5- kW PV curtain wall will be sold to the local electric utility, Northland Utilities, resulting in notable GHG reductions in an area heavily reliant on fossil fuels (diesel).

Low emissions multi-energy source PV/GENSET hybrid platform for remote area power supply

The Government of Canada through a TEAM-funded technology demonstration project is assisting Canadian industry to develop and grow the Canadian market for emerging innovative photovoltaic energy technology. The project led to the development of an advanced control system and platform that can enable photovoltaic, wind, fuel cells and alternative power systems to be optimally integrated into conventional fossil fuel-based power generating systems ("hybrid systems") for remote and off-grid power applications. The project is undertaken by Xantrex Technologies Inc.[8], a world leading manufacturer of innovative power electronic product interfaces and is based in Burnaby, British Columbia. Six field trials of the hybrid system (which combines a PV array, an engine generator, battery energy storage and power electronic controls) rated at 5kW are presently underway and are being monitored for performance and refinement (Figure 2).

Canada's "Northern Light" solar powered house shines at the Solar Decathlon competition

The Government of Canada in collaboration with private sector partners in the building and solar industry sponsored a Canadian entry into the second Solar Decathlon competition. The Canadian team, composed of engineering students from Concordia University and architectural design students from l'Université de Montréal, entered the competition with their Northern Light solar house, and were handsomely rewarded for their 2-years of hard work on this project (Figure 3). Their house was judged by an expert panel from the National Association of Home Builders of America as the most energy-efficient house of all the entries. Also, BP Solar awarded the Northern Light house with the BP Solar Award for best roof integration of photovoltaic technology. The house is now located on the Loyola Campus of Concordia University, to be used by the engineering school to further R&D advancements into solar optimized homes. Through research and education projects such as the Decathlon Solar House the Government of Canada is partnering with other levels of government, industry and academia, to demonstrate its commitment to building energy-efficient, healthy and sustainable communities.

IMPLEMENTATION

Project Green: Canada's 2005 Climate Change Plan

- The Government of Canada is committed to the transformative, long-term change required to make deep reductions in greenhouse gas emissions while ensuring continued economic growth. In achieving that transformation, Canada believes it will meet its Kyoto target while maintaining a productive and growing economy. In 2005, Canada a passed the Climate Change Plan, "Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment". The Plan is built on six key elements:

competitive and sustainable industries for the 21st century; harnessing market forces; a partnership among governments; engaged citizens; sustainable agricultural; and forest sectors, and, sustainable cities and communities.

Federal Investments in Technology-To-Market Support

Federal investment in technology transfer is through continued support to three key delivery programmes:

- *Technology Early Action Measures (TEAM)*[9], now in its third phase of funding (2003-2008), the federal government is continuing to provide financing for the late stage development and first demonstration of new technology with support between R&D and market implementation. TEAM supports projects that are designed to develop technologies that mitigate GHG emissions nationally and internationally, and that sustain economic and social development. Since 1998, TEAM has invested 113 million CAD in 101 projects, leveraging more than 800 million CAD in technology development investments. Of this, 10,35 million CAD were invested in six photovoltaic technology early market-entry demonstration projects;

- *Technology Partnerships Canada (TPC)*[10] is a programme that was established in 1996 through which the Government of Canada provides strategic support to firms engaged in private-sector R&D projects on a risk/reward sharing basis. Working in collaboration with innovative companies across Canada, TPC supports private sector R&D and prototyping for pre-competitive projects across a wide spectrum of technological development. Overall, TPC generates important benefits in terms of company competitiveness in areas that bring economic, environmental and social benefits to Canada. Since 1996, TPC has invested 2.75 billion CAD in 275 projects, leveraging more than 11 billion CAD in R&D investment (figures as of June 30, 2005). The large majority of TPC's projects are undertaken by small and medium-sized enterprises. While 37 % of the overall funding goes to these enterprises, they represent 89 percent of TPC's projects. TPC and TEAM are funding the development and commercialisation of *Solar Spheral™ technology*[11]. The existing Programme is being phased out and in its place the Government of Canada will introduce the Transformative Technologies Programme, a new initiative to support innovation and technology adoption in Canada.

- *Sustainable Development Technology Canada (SDTC)*[12] is a not-for-profit foundation established by the Government of Canada in 2001 to act as the primary catalyst in building a sustainable development technology infrastructure in Canada. SDTC finances and supports the development and demonstration of clean technologies which provide solutions to issues of climate change, clean air, water quality and soil, and which deliver economic, environmental and health benefits to Canadians. To do so, the Foundation draws from an investment fund of $550 million. SDTC works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian clean-technology entrepreneurs, helping them form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada.

Net Metering Initiative

A working group composed of stakeholders from the electricity industry (manufacturers and utility) and federal regulatory branches in collaboration with the federal government is continuing work on the Net-Metering Project to identify and eliminate barriers to the introduction of net metering in the electricity sector[13]. Deregulation of the Canadian electric utility industry is creating opportunities for distributed power generation to occupy a significant share of the electricity markets of the future. PV has an important role to play in this market, and appropriate policies to promote investments in PV are being pursued.

INDUSTRY STATUS

There are over 150 solar energy organizations (sales companies, wholesalers, product manufacturers, private consultants, systems installers and industry associations) driving the PV market in Canada. A majority of them are active in the Canadian Industry Association and Energie Solaire Quebec[14]. The Canadian PV manufacturing sector has grown significantly in the last three years to serve both the domestic and export market.

In 2005, Carmanah Technologies Corporation[15] , a leading integrator of renewable and energy-efficient technology solutions completed the acquisition of Soltek Powersource Ltd. - a Canadian PV wholesaler - thereby enabling it to grow its portfolio of proprietary technologies, as well as partnerships with many of the world's leading component suppliers. Carmanah's headquarters and primary manufacturing facilities are in Victoria, British Columbia, Canada. The Company also operates an additional manufacturing facility in the Canadian Province of Alberta, as well as regional sales and customer support offices in many major city centres in Canada, the United States and in England. The Company is currently focused on three technology groups; solar-powered LED lighting, solar power systems (off grid and grid tie), and LED illuminated signage. Carmanah currently has more than 250,000 installations in 110 countries.

ICP Solar, a leading manufacturer and supplier of consumer products based on advanced solar technology, in 2005 introduced a new PV brand - the Sunsei™ line of solar products - embodying ICP's continuous product R&D and its innovative proprietary manufacturing process. The company's headquarters and manufacturing facility, inaugurated about five years ago, are located in Montreal, Quebec, where ICP continues to expand its operations to manufacture new lines of PV products to meet consumer demand for innovative solutions. In 2005, ICP was recognized by a leading Canadian business magazine as one of the Canada's 200 fastest-growing companies.

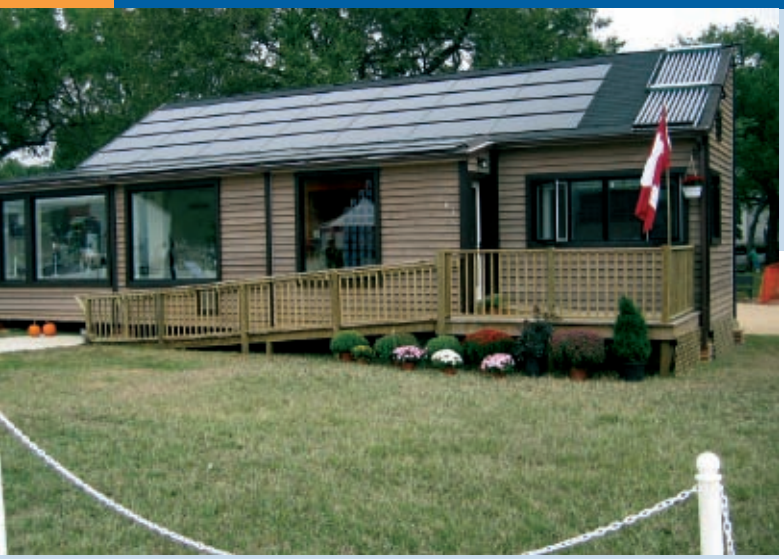

Fig. 3 - Canada's 'Northern Light' solar house at the 2005 U.S. Solar Decathlon competition.

Xantrex Technology Inc. is a world leader in the development, manufacturing and marketing of advanced power electronic products and systems for the distributed, mobile and programmable power markets. The company's products convert raw electrical power from any central, distributed, or backup power source into high-quality power required by electronic and electrical equipment. Headquartered in Vancouver, British Columbia, the company has facilities in Arlington, Washington; Livermore, California; Elkhart, Indiana; and Barcelona, Spain.

The Spheral Solar Power[16] plant in Canada, a division of ATS Automation Tooling Systems Inc., has a capacity to produce 20 Megawatts per year, capable of providing annual electricity for 6,000 homes. A state-of-the-art 190,000 sq ft fully automated manufacturing plant is located in Cambridge Ontario.

MARKET

The Canadian total PV installed capacity in 2005 was 16,77 MW with a sustained domestic market growth that has averaged 21 % annually since 1992. In 2005, the PV module market was 2,89 MW compared to 2,12 MW in 2004. Module prices have gradually declined from CAD 11,09 per Watt in 1999 to CAD 4,31 per Watt in 2005. This represents an average annual price reduction of 14 % over the seven year period (Table 2). Twelve manufacturers in Canada reported revenues from manufacturing operations related to modules and BOS sales of 105 million CAD and the addition of 77 new jobs in 2005. It is estimated that the PV business in Canada is valued at 150 million CAD and employs 975 people.

TABLE 2: MODULE PRICES (CAD/WATT) IN CANADA FOR 1999-2005

Year	1999	2000	2001	2002	2003	2004	2005
Average price (CAD)	11,09	10,70	9,41	7,14	6,18	5,53	4,31

FUTURE OUTLOOK

Private sector investments in the development and marketing of solar PV power systems in Canada will continue to drive the domestic PV market for the foreseeable future. This is reflected by steady growth in the installed base, as well as the significant private-sector investment in manufacturing. The Canadian Solar Industries Association and Énergie Solaire Québec have continued their promotional and marketing activities. CanSIA in particular has been very active in 2005 in developing the foundation for significant changes in polices and programs that will support the solar industry in the coming years. The Solar Buildings Network, which will begin its R&D mandate in 2006, will generate opportunities for demonstrations of innovative PV projects and will expand the knowledge base of Canadians to the benefits and add value of PV technology in the buildings of the future. Over the last five year, the photovoltaic manufacturing industry has benefited from increased "technology-to-market" project support for climate change mitigation that has encouraged a growing number of demonstration projects and collaborative joint ventures.

Footnotes with relevant web sites:

1 *CANMET Energy Technology CentreVarennes: http://cetcvarennes.nrcan.gc.ca/eng/accueil.html*
2 *http://www.climatechange.gc.ca/english/newsroom/2005/plan05.asp*
3 *Zero Energy Home Coalition: http://www.associations.cc/nzeh/aboutthecoalition.htm*
4 *Program CETC-Varennes: http://cetc-varennes.rncan.gc.ca/en/er_re.html*
5 *Report on Canadian Solar cell R&D: web: http://ctec-varennes.nrcan.gc.ca/fichier.php/38862/2005-077e.pdf*
6 *http://www.climatechange.gc.ca/english/team_2004/dbProjects/viewProject.asp?id=5371&typ=ind*
7 *Visionwall: http://www.visionwall.com/*
8 *Xantrex: http://www.xantrex.com/*
9 *Technology Early Action Measure: http://www.climatechange.gc.ca/english/team_2004/*
10 *Technology Partnership Canada: http://tpc-ptc.ic.gc.ca/epic/internet/intpc-ptc.nsf/en/Home*
11 *Spheral Solar Power: http://www.spheralsolar.com/*
12 *http://www.sdtc.ca/en/index.htm*
13 *Netmetering initiative: http://www.micropowerconnect.org/NetMeteringProject/index.htm*
14 *Canadian Solar Industries Association: http://www.cansia.ca; and Énergie Solaire Québec: http://www.esq.qc.ca/*
15 *Carmanah: http://www.carmanah.com/*
16 *Manufacturing: http://www.spheralsolar.com/*

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS

FLEMMING KRISTENSEN, ENERGIMIDT A/S, DENMARK, PETER AHM, PA ENERGY A/S, DENMARK

Fig. 1 - Transparent solar modules as roof on patio.

GENERAL FRAMEWORK

The Danish government launched a new energy plan in March 2005. The energy plan focuses on a fully liberalised energy market supported by a framework, which underpins high consumer and environment protection, energy efficiency, subdued development in energy prices and high security of supply both in the short and long term. The energy plan further focuses on the ongoing development of efficient energy technologies both nationally and in the EU, and the government wish to strengthen the research community and the development of new and promising energy solutions. With regard to renewable energy (RE) the plan sets quantifiable targets for the overall contribution from RE, but no technology specific targets. The market forces are supposed to promote the most suitable and competitive RE technologies.

The Kyoto protocol and the consequent EU agreement on GHG reduction targets has lead to a Danish commitment to reduce GHG emissions by 21 % in the period 2008-2012 compared to the base year 1990. The market for CO2 certificates is seen as the most cost-effective way to reach this target.

Renewable energy is not only a future option, but very much a present and considerable element in the energy supply: by the end of 2005, more than 25 % of the national electricity consumption is expected to be generated by renewable energy sources. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the energy plan, the two main objectives being the development of a future environmental benign energy system and a high degree of security in the energy supply many years ahead.

Photovoltaic technology (PV) is not specifically mentioned in the government's energy plan, but in early 2004 the Danish Energy Authority (EA), in collaboration with the electricity sector, the industry and other key stakeholders finalized a national strategy on PV after a public hearing. This PV strategy includes the fields of research, development and demonstration. Deployment activities in support of the PV strategy are expected to be developed in the coming years and an overall framework for the coordination of PV development and deployment in Denmark is thus expected to be in place inside a few years.

Key actors have been identified as: utilities - carrying out small and large R&D and in particular demonstration projects; network operators - identifying potentials and unresolved issues related to PV in a large network; universities and institutions - carrying out R&D activities on PV technology and its application & integration; professional consultants - catalysing a broad range of PV projects; industry - developing and manufacturing PV components and systems; NGO's - disseminating information and the general public - exhibiting steadily increasing interest in and willingness to buy PVs.

NATIONAL PROGRAM

Denmark has no unified national PV programme, but does have a number of projects supported mainly by the Danish Energy Authority and via the Public Service Obligation (PSO) of Danish network operator, Energinet.dk.

PVs have been included in the action plan of the Danish Energy Authority (EA) since 1992 and have received increasing attention in the consecutive three-year Solar Energy Action Plans. Since 1992, the Renewable Energy Development Programme of the EA has supported about 125 PV projects, and by the end of 2004 about 2,3 MW have been installed in the context of projects and demonstrations plants. A 300 roof-top's project including 750 kWp was launched early 1998 and was completed by the end of 2001. A 1 000 roof-top programme was launched in late 2001 as a follow up; this programme targets a mix of general cost reductions, increase in end-user payment and promotion of small roof-tops. Only a few weeks after the announcement of the programme, the SOL 1 000, more than 3 000 house owners had registered their interest. However, uncertainty about the programme due to change of government and increased demand for end-user payment have introduced a delay of almost a year in the programme implementation. By the end of 2002, the programme reported a portfolio of some 1 300 house owners expressing firm interest in the programme and by end 2005 about 560 kW have been implemented stimulated by an investment subsidy of 40 % of the turnkey system cost, average turnkey system cost being 4,40 EUR/W. The SOL 1 000 programme has been extended until end of 2006. The average system size in the project for private households is 1,8 kWp.

A special support programme for PV applications in the commercial sector, funded by the CO2 tax on electricity, was set up early 1998. The support includes a subsidy of up to 40 % for the turn key system costs. The calculation of the actual subsidy will be in favour of high yield installations. This programme has so far not been very successful, as the commercial sector seems to regard an incentive of 40 % as inadequate, and during the last few years no projects have been implemented using this support mechanism.

Net-metering for privately owned PV systems was established in mid 1998, for a pilot-period of four years. In late 2002, the net-metering scheme was extended another four years up to end of 2006. Net-metering has proved to be a cheap, easy to administrate and effective way of stimulating the deployment of PV in Denmark; however the relative short time window of the arrangement has so far prevented it from reaching its full potential. During the political negotiations in the fall of 2005 the net-metering for privately owned PV systems was made permanent.

RESEARCH & DEVELOPMENT, DEMONSTRATION

During 2003, the government announced additional financial support to the new R&D programme, started in 2002. Over a 3-5 year period more than 150 MDKK will be allocated to renewables; however it is still too early to say to which extend PVs can benefit from the programme. In 2004, the government increased the PSO allocation for R&D into environmentally benign generating technologies from 100 MDKK per year to 130 MDKK 130 per year. However, due to an ongoing merging of the two network operators into one new state-owned venture, Energinet.dk, this extra funding was only effective for the call for proposals with a deadline of 01.10.05. The extent to which PV's will benefit from this call will only be clear in the first quarter of 2006.

In 2004, the EA became part of the new EU supported PV RTD network PV-ERA-NET focussing on EU level and national level coordination and optimization of PV RTD programmes.

R&D activities into PEC cells (Grätzel type cells) are ongoing at the Danish Institute of Technology. This activity has in 2002-04 been supported by the PSO of the Danish network operators. This R&D activity has now attracted commercial finance and a new company has been formed. Ongoing PSO support is expected from 2006 and onwards for continued R&D activities at the Institute of Technology. At the Risoe National Laboratory basic research into polymer based PV cells is ongoing with progress reported in both efficiency and in particular in stability and life time.

In mid-1995, the Photovoltaic System Laboratory (PVSyslab) was established in collaboration between Risoe National Laboratory and the Danish Institute of Technology. The main function of PVSyslab is to certify the quality of PV systems and their installation and to help industry develop better products. The PVSyslab is also engaged in PV system monitoring and in the upkeep of a national knowledge base on applied PV technology. The PVSyslab has ongoing activities in the field of technology cooperation with developing countries; particularly in the setting up of local quality assurance schemes and test laboratories.

The first Danish book on PV and architecture focussing exclusively on Danish buildings, design, architecture and products was published in the fall of 2005 by the publishing branch of the Danish Architects Federation.

Fig. 2 - Solar cells integrated in the roof and transparent solar shutters.

Fig. 3 - Solar shutters seen from the inside of the house.

IMPLEMENTATION

The potential for large scale deployment of PVs in Denmark has been identified as building integrated systems.

The SOL 1000 programme run by the utility EnergiMidt, which as mentioned above, intends to demonstrate low cost and architecturally acceptable integration of PV technology primarily on existing single family houses, had implemented about 560 kW in total, by the end of 2005. The same project focuses on the gradual increase of end-user payment, this way paving the way to a commercial market with no investment subsidy. A third objective is to disseminate information and experience on PV roof-top deployment to the Danish distribution utilities. Several projects for building integrated PV systems including commercial buildings, apartment buildings and schools have been implemented, typically in the range of 2-15 kWp. The small "do it yourself" PV plants were also introduced with a size of 250Wp, and in 2005, 120 of these systems were sold and installed.

A new utility initiative has been launched in 2003 by Copenhagen Electric: the sale of certified PV produced electricity without any subsidies or other external support. The utility contracts to buy all electricity from new PV systems for the next 20 years at commercial terms, and tries to sell the same electricity to the consumers in small standard packages including a certificate. Even though the end-user cost of the certified PV electricity is 3-4 times that of standard electricity - ironically, partly because of the present tax and duty structure - the scheme reports a small but growing success.

INDUSTRY STATUS

R&D efforts are beginning to exhibit commercial results in terms of export. The company Topsil, which uses a float-zone technique produces high purity Silicon (Si) ingots for the semiconductor industry, announced in 2002, their intention of developing a low-cost float-zone manufacturing technology, that would enable the company to offer high purity Si to the PV industry. In 2004, Topsil saw the first commercial results of its R&D into low-cost float-zone processing and is expected to continue to supply SunPower in the US with float-zone Si for high efficiency PV cells.
Inverter technologies have been R&D'd for some years, for both fuel cell and PV applications. For the latter, a commercial breakthrough was also announced in 2003, by the Danfoss related company Powerlynx; which reports in 2005 to have underpinned and significantly strengthened the commercial breakthrough announced in 2003.

PV Si cell production stopped in Denmark in 1996. A single Danish module manufacturer (Gaia Solar) with an annual capacity of about 1 MWp per shift has existed since 1996. A few other companies producing tailor-made modules such as window-integrated PV cells can also be found.

Some medium to large scale industrial corporations long established in the building industry, such as Velux Industries and Dansk Eternit, continue their R&D into how to integrate PVs in their main stream products. The products are currently under field tests in the context of demonstration projects. New companies are also exhibiting interest in this field.

A project on the integration of PVs in industrialized residential buildings was completed in 2005 with good results. In particular, the collaboration with the Aarhus School of Architecture proved to be successful with PVs entering the curriculum. The objective of integrating PVs in industrialized building processes is expected to be continued in 2006 via new projects.

There is no PV relevant battery manufacturing in Denmark at present.

A few companies develop and produce power electronics for PVs, mainly for stand-alone systems for the remote-professional market sector such as telecoms, navigational aids, vaccine refrigeration and telemetry.

A number of companies are acting as PV system integrators, designing and supplying PV systems to the already competitive international market sector of remote stand-alone applications.

Consultant engineering companies specializing in PV application in developing countries report a slowly growing business area.

MARKET DEVELOPMENT

Market development incentives already in place are mentioned above under, "National Program."

Total PV business volume in 2005 is very difficult to estimate with any degree of accuracy primo 2006, due to the commercial secrecy surrounding the above mentioned new business developments in the fields of Si feed stock and inverters. However, a significant increase from 25 MEUR in 2004, to 35 MEUR, in 2005 is a "best guess."

The cumulative installed PV capacity in Denmark (including Greenland) is by end of 2005 estimated to be about 2,65 MWp; an increase of about 15 % compared to 2004.

FUTURE OUTLOOK

The increasing government funds allocated to R&D into renewables are expected to give a boost also to the PV sector, but - if left alone - may lead to an imbalance between R&D efforts and demonstration, as the eventual R&D results need support to be demonstrated and reach the market. However, it is the hope, that the earlier mentioned effort to establish a national PV strategy and consequent deployment schemes may succeed in creating a more coordinated and unified approach to PV in Denmark.

The SOL 1 000 project targeting building integrated PVs mainly on single family houses but also addressing apartment houses and institutions is also expected to lead to ongoing availability of government funds for PV demonstration and deployment, e.g. a SOL 5 000 initiative is under development. However, funding for large scale demonstrations has proven to be difficult to find in the existing support structure of the Danish Energy Authority and the PSO system.

It is regarded as obvious that without funding and a clear public support towards the deployment of PVs for yet some years to come, the sector risk will quickly diminish because of an insufficient home market.

However, the trend towards commercial sustainability for PVs is seen as ongoing and with the objective realistically within reach. Projections and scenarios now under study seem to indicate, that with the continued global technical and economic development of the PV technology, with a more permanent net-metering scheme in Denmark and with unchanged development of the Danish end-users increasing willingness to invest in PVs, a market for PV roof-tops in Denmark without any investment subsidy will emerge around 2011-12.

EUROPEAN COMMISSION

RESEARCH, DEVELOPMENT AND DEMONSTRATION ACTIVITIES ON PHOTOVOLTAICS SUPPORTED BY THE EUROPEAN COMMISSION

ROLF ÖSTRÖM, SCIENTIFIC OFFICER, EUROPEAN COMMISSION, DG RESEARCH
PIETRO MENNA, RESPONSIBLE FOR SOLAR SECTOR, EUROPEAN COMMISSION, DG ENERGY AND TRANSPORT

European policies on renewable energy - which are of direct relevance to the solar photovoltaic sector - were described in the White Paper on renewable energy adopted in November 1997. Further clarifications on EU policies for the renewable energy sector are contained in the Green Paper on the Security of Energy Supplies, which was launched in November 2000, and in the recent EC Communications on the Share of Renewables and on Renewable Electricity Support Schemes. Since 2001, the EU has put in place a new regulatory framework, with a view to accelerating the growth of EU markets for renewable electricity. In this context, the most important instrument is the Directive on electricity production from renewable energy sources and its monitoring process, which is underpinned by a number of data gathering activities, notably also for the new Member States and Candidate States[1]. In view of these policy commitments, the future development of photovoltaics is supported through the *EU Framework Programme*, for both research and demonstration activities and through the *Intelligent Energy - Europe Programme* for non-technological actions aiming at overcoming market barriers.

The policy objectives of the programme of research[2] into sustainable energy systems include reducing greenhouse gases and pollutant emissions, increasing the security of energy supplies, improving energy efficiency and increasing the use of renewable energy. In addressing these objectives, a distinction is made between activities having the potential for exploitation in the short to medium term and those which are expected to have an impact in the medium to longer term.

Through a series of RTD framework programmes (FP), preceded by two Energy R&D Programmes, the European Commission has been supporting research and development in the Photovoltaic sector in Europe for about 30 years. The support has included the development of a full range of PV devices, including crystalline and thin film solar cells, PV modules and balance of systems.

THE SIXTH FRAMEWORK PROGRAMME - START OF A NEW ERA

The transition from the fifth to the sixth Framework Programme was marked by an increased awareness of the need to reduce fragmentation in European research. To reduce fragmentation and improve the exploitation of results, the EU launched initiatives aiming at the creation of the European Research Area - which can be thought of as a single market for research. New types of projects, or instruments, were introduced in the sixth Framework Programme for this purpose, namely Integrated Projects (IP), Networks of Excellence (NOE) and the lesser known Article 169. Instruments from the previous programme were maintained in the sixth Framework Programme i.e. Specific Targeted REsearch Projects (STREP), Specific Support Actions (SSA) and Coordination Actions (CA).

From the proposals received under the first three calls in FP6, the following eleven new PV projects have been launched with an expected impact in the medium to long term. The projects have a total budget of nearly 110 M and a maximum EC contribution of about 62 M , as indicated after each project description. See also the pie-chart in Fig 1.

CRYSTAL-CLEAR (IP)
Development of crystalline silicon PV technologies for low-cost high-efficiency and reliable modules (16 M)

FULLSPECTRUM (IP)
Development of new concepts for third-generation PV materials and techniques aiming at very high efficiency solar cells (8,4 M)

HICONPV (STREP)
High concentration PV system (2,7)
BIPV-CIS (STREP) Improved integrated PV using thin-film CIS modules for building retrofit (2,3M)

MOLYCELL (STREP)
Molecular materials and hybrid nano-crystalline/organic solar cells (2,5 M)

PV-CATAPULT (CA)
Long-term research, technology, market and socio- economic aspects for the PV sector & PV-thermal forum and European photovoltaic performance initiative collaboration (1,7 M)

PERFORMANCE (IP)
Pre-normative actions focusing on performance assessment, including BIPV codes (7 M)

ATHLET (IP, NB still under negotiation at the moment of writing)
Advanced techniques for low-cost thin-film cells and modules (11 M)

LARCIS (STREP)
Large area CIS module for MW-scale production (4,2 M)

FOXY (STREP)
Development of solar-grade silicon feedstock for crystalline wafers and cells, by purification and crystallisation (2,7 M)

FLEXCELLENCE (STREP)
Roll-to-roll technology for the production of high-efficiency low cost thin film silicon photovoltaic modules (3,1 M)

The short to medium term activities focus mostly on demonstration aimed at accelerating the market penetration of more cost-effective PV technologies. More specifically, the priority has been given to innovative production concepts for high efficiency cells/modules to be integrated into larger scale photovoltaic production facilities to lower the cost; and including low-cost integrated components or devices for PV generators; large area, low cost photovoltaic modules for building integrated PV and autonomous solar electricity generation systems; integration of photovoltaic installations in generation

Footnotes:
[1] *The relevant mentioned documents are available at the following internet address: http://europa.eu.int/comm/energy/index_en.html*
[2] *The word "research" used in the general sense refers to research, technological development and demonstration activities.*

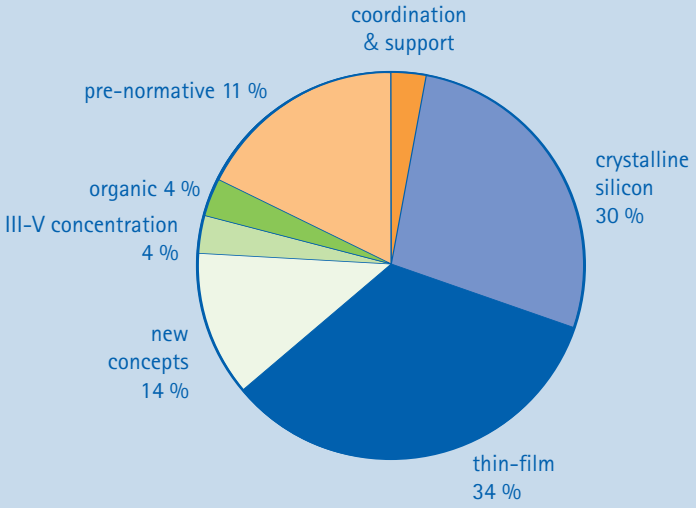

Fig. 1 – Distribution of EC contribution for the medium to long term in FP6.

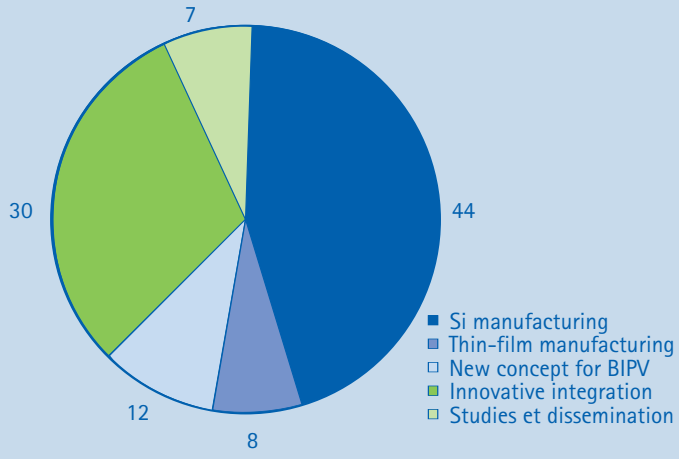

Fig. 2 – EC contribution to short-medium term activities on PV in FP6 (%).

schemes to feed local distribution grids and development of new devices and systems to manage these installations. Six new projects, selected among the proposals submitted in the first three calls launched under FP6, have been already launched. Their total cost is 35 M and the EC contribution is 11 M. Furthermore, it is worth noting that photovoltaic installations received indirectly an additional 14 M of EC through the Concerto initiative. The preliminary results of the 4th (and last) TREN call launched under FP6 are not yet finalised. However, it is expected to fund new projects for a total cost of about 19 M and an EC contribution of about 5,5 M. In summary, it ispossible to estimate a total EC contribution (for the whole short/medium term activities in FP6) of about 30 M for a total cost of the projects of about 90 M.

The distribution of the EC contribution to short medium term activities on photovoltaics under FP6 is considered in the figure. It is worth noting that projects aimed at demonstrating innovations in manufacturing plant for mass-producing solar PV technologies received 52 % of the total EC contribution (44 % to silicon manufacturing process and 8 % to thin film). Projects demonstrating new concepts for integrating PV electricity supply in buildings received 12 % of the contribution and 30 % was allocated to activities aimed at innovative integrated solutions of the components of a PV system. Studies and dissemination account for 7 % of the whole contribution.

PHOTOVOLTAIC TECHNOLOGY PLATFORM

In December 2003, a Photovoltaic Technology Research Advisory Council (PV-TRAC) was formed under the auspices of Loyola de Palacio and Philippe Busquin (the former European Commissioners for Energy & Transport and Research). PV-TRAC was established as a high-level advisory council, consisting of a broad range of members who represent a balance of the major European PV stakeholders. The Council was charged with the task of defining a common European vision and strategy, contributing to the rapid expansion of a world class, cost-competitive, European PV industry. The PV-TRAC presented its report - A Vision for Photovoltaic Technology - in Brussels on 28 September 2004. The report examines the current state of photovoltaics and looks ahead towards the year 2030. It predicts that photovoltaic electricity will become competitive with conventional utility peak power in southern Europe by 2010, and in most of Europe by 2030. By then, photovoltaics could provide around 4 % of electricity production worldwide.

One of the main recommendations of the PV-TRAC was to set up a Photovoltaic Technology Platform to mobilise stakeholders sharing a long-term European vision for PV. In domains where RTD has a vital role to play in addressing major economic, technological or societal challenges, technology platforms provide a means to foster effective public-private partnerships between industry, the research community, and policy makers towards achieving a common goal. Following a call for expressions of interest, the members of the Steering Committee were selected by the European Commission and met for the first time in May 2005. The Platform is now in full operation and consists of the Steering Committee, four Working Groups (Policy and instruments; Information, promotion, education, market deployment; Science, Technology and Applications; Developing countries) and the Mirror Group (representing the Member States including Associated States and Candidates Countries).

EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION (EPIA)
MISSION AND ACTIVITIES
MICHEL VIAUD, SECRETARY GENERAL

With over 80 Members drawn from across the entire solar electricity sector, the European Photovoltaic Industry Association (EPIA) represents over 95 % of the European photovoltaic industry. EPIA represents the whole value-chain of the photovoltaic industry; from silicon producers, cells and module manufacturers to system providers.

A MARKET-ORIENTED STRATEGY

A 3-year strategy was unanimously established in June 2003 by all EPIA members.

The Association's mission is to deliver to its members a distinct and valuable service driven from the strength of a single European photovoltaic (PV) voice.

EPIA has three objectives:

1. To become the most credible reference point for the European PV industry stakeholders. EPIA will provide accurate information, statistics and feedback to both its members and the wider audience.
2. To help shape the development of new PV markets both in Europe and in the export community.
3. To take the lead in positioning the photovoltaic industry within the European political environment and supporting the member state association in their local objectives.

To reach these three objectives, the EPIA strategic plan focuses on three action fields:

1. Market Growth Strategy
2. Products and Services
3. Lobbying

A SUCCESSFUL STRATEGY

As a result of its strategy, EPIA:

- launched a strong dialogue between industry and the research community in order to define common priorities.
- cooperates with national associations to further influence governments on the adoption of favorable political frameworks for PV.
- supports the definition and the creation of financial instruments in order to collaborate on the development of new projects in the sector.
- started The Alliance for Rural Electrification (ARE), a forum which aims at promoting sustainable development by facilitating the access to clean energy sources.
- supports the creation of the Global Photovoltaic Solar Electricity Council (GPSC), which will serve as the dialogue platform on a global level, among industrials.

AT THE CROSSROADS BETWEEN STAKEHOLDERS

EPIA's headquarters are located in Brussels, in the heart of Europe, within the Renewable Energy House; a monument-protected building integrating renewable energy sources. EPIA, as the coordinator of the European Photovoltaic Technology Platform, plays a key role at the crossroads between all the stakeholders of its sector.

Fig. 1 - Asia Solarhaus (photo courtesy of SCHOTT Solar GmbH).

Fig. 2 - PV Power Plant 2 - Conenergy (photo courtesy of Conenergy AG).

Fig. 3 - Solargebäude SMA Frontansicht (photo courtesy of SMA Technologie AG).

FRANCE

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS IN FRANCE

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FRENCH AGENCY FOR ENVIRONMENT AND ENERGY MANAGEMENT (ADEME), RENEWABLE ENERGIES DIVISION, SOPHIA ANTIPOLIS CENTRE

Fig.1 - Grid-connected PV system, 32 kW - Réunion Island (photo -courtesy Apex BP Solar).

GENERAL FRAMEWORK

The year 2005 was marked by a few important events which were conducive to the exploitation of renewable energy sources. The French Parliament has passed the Finance Act setting the guidelines for the energy policy while the government was implementing fresh fiscal and financial measures:

- The Energy Framework Policy Law passed last 13 July 2005 emphasizes energy management coupled with the development of renewable energies; while priority was given to the use of bio-resources and the recourse to solar thermal energy. Solar photovoltaic energy (PV) comes under the same research package of the law on par with hydrogen and carbon dioxide sequestration;
- Fiscal measures are aiming at favouring the use by private individuals of materials for heat and electricity generation based on renewable energy sources. The tax credit on income previously set at 40 % for the year 2005 will rise to 50 % in 2006;
- The announcement of a 50 % increase in the buy back rate for PV-generated electricity for the private individuals and a 100 % rise for enterprises and local communities, a measure that will come into force as of 31 March 2006.

In parallel with these measures, the government has overhauled its policy for research funding and created two new means agencies.

The Ministry in charge of research has created the National Research Agency (ANR) (www.agence-national-recherche.fr) while the Ministry for Industry has set up the Industrial Innovation Agency (AII, www.aii.fr). Both agencies have put photovoltaics high on their agendas as priority action themes. And that's how in 2005, the ANR has funded a new photovoltaic research programme. This initiative was developed in conjunction with ADEME and supported by its experts committee. ADEME had been until to date, the sole national agency for photovoltaic R&D funding. Concerning the Industrial Innovation Agency future photovoltaic projects will have an industrial aspect while the ANR will be backing basic and applied research projects. In France, the main players acting in the photovoltaic industry are developing, manufacturing, assembling and installing the systems. These players act in conjunction with public research teams for research and technological development projects (RTD) funded either by ADEME, or by the ANR, or OSEO anvar Agency for the innovating SMEs or by AII in future.

Activities deployed by the main industrial players are described under Section "Industrial context" and those relating to public laboratories developed under Section "RTD" below.

Public research organizations such as CNRS (National Research Organization) and the CEA (Atomic Energy Commissariat) are also involved in research and study works, usually, in cooperation with

the industry. CEA and CNRS have decided to join forces for the implementation of the new National Institute for Solar Energy (INES). There are ongoing prefiguration initiatives. And INES will have personnel from both CEA and CNRS.
The electricity utility (EDF) also has a programme aimed at development and promotion of photovoltaic systems and has been granted subsidies from ANR and ADEME for research on materials and developing International Standards.

In order to implement its policy of market incentives, ADEME is sharing with the regional councils the subsidies designed for investment, and for some operations the Agency is acting in cooperation with the European Commission structural funds. ADEME and the regional councils have reviewed their funding policy and tried to adjust to the Finance Act that came into force in 2005. As some regional councils are very active, this allows some French regions to be better equipped with photovoltaic systems (Rhône-Alpes, Languedoc-Roussillon, etc.) than others.

NATIONAL PROGRAMME

ADEME, the French Agency for Environment and Energy Management (www.ademe.fr) is the public establishment that the French government has put in charge of implementing the national policy for sustainable development in the following four intervention fields: energy management, waste management, soils conservation and air quality. The energy management aspects include energy efficiency as well as the use of renewable energy sources, among which solar photovoltaics.

The national photovoltaic programme is structured around three actions axes:

- Research and technological development funded since February 2005 by two agencies: ADEME (the historic backer) and the new ANR;
- Incentives for opening the market provided by ADEME in conjunction with the regional councils and the EC;
- Training activities, information dissemination and cooperation aspects run by ADEME.

The first two R&D activities and markets axes are described in the sections below. The third axis covers several activities. For instance, at the Sophia Antipolis centre, ADEME is running three to four annual training sessions meant for installers and those managing PV systems projects. ADEME is also contributing to the training of young engineers through PhD grants. Novice engineers participate in applied research projects in the public or industrial research laboratories during their three-year PhD thesis.

In parallel, ADEME is involved in several types of cooperation projects together with European and international partners. ADEME is a partner in several projects backed by the European Commission: PV-ERA-NET (www.pv-era.net) and PV-Policy-Group (www.pvpolicy.org). The Agency also participates in the works carried out by the European Photovoltaic Technology Platform (www.eupvplatform.org). ADEME is also active in the Photovoltaic Power Systems Programme of the International Energy Agency (IEA), (www.iea-pvps.org) with a direct participation or via subcontracted participation through working groups (tasks) n° 1, 2, 9, 10 and, in preparation during 2005, it will join the future working group n° 11. Concerning International Standards, ADEME is contributing with its partners to the works carried out by the International Electrotechnical Commission (IEC/CEI, Technical committee 82, www.iec.ch). ADEME is also involved in several other international projects with photovoltaics as just one aspect (CRESMED, SYNERGY+, RESTMAC projects, etc.)

ADEME intervenes under bilateral partnerships and provides support to some French-speaking African countries for some off-grid electrification projects.

ADEME is also a sponsor of events of national or international impact. For example, the building industry Bâtimat exhibition held in Paris in November 2005. Renewable energies and more particularly photovoltaics were subject of much attention and information requests. ADEME is funding a network of energy information centres allowing putting across its messages to private individuals. At the national level, ADEME has launched an awareness campaign on energy saving and other related topics with the slogan "Let's act fast, it's heating up."

RESEARCH AND DEVELOPMENT

In 2005, the creation of the National Research Agency (ANR) and the launch of a PV R&D programme went down well with the French photovoltaics teams. The latter observed that since about two years, ADEME budgets could not meet their ambitions, namely for basic and applied research.

ANR has selected ten projects with a duration ranging from two to three years among which, from the crystalline silicon sector (PHARE and TWIN projects); the thin film sector (CISEL and ATOS projects); the organic materials and the new concepts (NANORGYSOL and PRE-THECES projects). Additional R&D projects relate to the studies on the photovoltaic systems and components (QUALIVAL-ENR, PVPERFORMANCE, MICROSCOPE and MULTISOL projects). ADEME itself has namely supported two industrial development projects: the PHOTOSIL project which is targeting the construction of one pilot for manufacturing photovoltaic grade feedstock silicon through the metallurgic route (three-year project) and, the RÉDUCOP project (lasting four years) that is aiming at reducing manufacturing costs of photovoltaic cells and modules. Both projects were launched by manufacturers in cooperation with the public laboratories. Development of PV construction materials comes under a fresh programme called PREBAT and run jointly by the ANR and ADEME. Under the European EUREKA cooperation programme, one pilot project for manufacturing PV silicon ribbons received the backing of OSEO anvar, the agency in charge of innovation funding in the

Fig.2 - Grid-connected PV system, 22 kW roof of waste treatment centre - Martinique Island (photo - courtesy Apex BP Solar).

SMEs. The photovoltaic research and technological development public budget thus grew from 4 MEUR in 2004 (ADEME budget) to 12 MEUR in 2005 (ADEME and ANR budgets).
The scientific community meets once a year in Sophia Antipolis. On the 14, 15 and 16 November 2005, 130 participants gained first hand knowledge of the PV RTD works on the occasion of the seminar hosted by ADEME, in partnership with the CNRS and the CEA. Summaries of the communications can be accessed on following website www.pv.ademe.cea.cnrs.free.fr. The printed proceedings of the previous 2004 seminar (273 pages) are available upon request (CD-ROMs are no longer available).

IMPLEMENTATION

The Finance Act that came into force in 2005 has implemented a new financial aid system designed for private individuals installing a photovoltaic system on the roof of their houses. This system replaces the subsidies granted by ADEME. Conversely, in the case of projects launched by public and private operators, ADEME and the regional councils have continued granting subsidies that cover part of the total investment costs (materials and work force).

And thus, for the private individuals subjected to income taxation, the fiscal measure consists of reimbursement covering up to 40 % of the cost of equipment (installation costs are not taken into consideration). Financially speaking, this measure is less profitable than the subsidies granted in 2004 for this type of users. And some regional councils have therefore adopted financial measures to partly compensate for the difference (subsidized feed-in tariff or direct subsidy). It should be noted that in 2006, the tax credit rate on the income will be increased from 40 % to 50 %.

For the industry and public operators that are not subjected to taxation, the subsidy amount is granted on a case-by-case basis as part of calls for projects. In this case, ADEME is insisting on the quality of the architectural integration of the PV modules over the buildings when it is a new building and, requires that a strong energy management policy be implemented. In 2005, the overall power of the systems installed in France was estimated at 6 MW of which 5 MW connected to the grid, a 15 % increase as compared to the previous year.

The projects developed with the European Commission backing, and co-funded by ADEME, were completed in 2005. The PV-STARLET project, in partnership with the Hespul association and the Imerys-Toiture firm, has allowed the installation of 420 kW of photovoltaic systems based on solar tiles on approximately 200 houses. The UNIVERSOL project, coordinated in France by Hespul, ended with the installation of 290 kW on 12 educational buildings.
Feed-in tariffs applied for electricity from solar source for the year 2005 were set at 0,14 EUR per kWh in mainland France and 0,28 EUR per kWh in Corsica and the French overseas departments (DOM). On 14 November 2005, and this is important news, the Prime Minister announced that the feed-in tariffs will be raised to 0,225 EUR per kWh for the PV systems installed on private premises (also benefiting from the tax credit) and 0,30 EUR per kWh for the PV systems installed on industrial or public buildings. The measure should be effective as of 31 March 2006. The rate applied for the French overseas departments remains unchanged for the time being.

INDUSTRY STATUS

The French photovoltaic industry relies on a few motivated players acting since the early 1980s. Photowatt (materials, multicrystalline silicon cells/modules and systems), Apex BPSolar (PV components and systems), Tenesol (previously called Total Energie, PV components and systems) and Free Energy Europe (amorphous silicon modules). Some new firms have recently become involved in this industry: Emix (multicrystalline silicon ingots), Invensil/Ferroatlantica (feedstock Si material), Apollon Solar (c-Si process), Solar Force (silicon ribbon) alongside industrialists manufacturing equipment ECM, Vésuvius, Semco, etc., storage batteries of which SAFT or construction components manufacturers: Imerys-Toiture, Lafarge Couverture, Sunland21, Kawneer, etc.

Production of photovoltaic cells and modules by the Photowatt International firm was 33 MW in 2005 and has reached full production capacity. In order to meet demand, the firm is manufacturing, in addition to the multicrystalline silicon cells, monocrystalline silicon cells by purchasing monocrystalline ingots from outside sources. Photowatt is contemplating an increase in production capacity to reach 100 MW per year. The pilot company for the RTD project called RÉDUCOP dedicated to the reduction of production costs in cooperation with research teams from CEA and CNRS (with ADEME backing).

The Emix Company has launched the production of multicrystalline silicon ingots using the cold crucible continuous electromagnetic casting process. Products from this new production tool have passed the validation tests among the firm's customers. Emix is running the new RTD project called TWIN (supported by ANR).

The Tenesol firm (a joint-venture between the Total Group and EDF), specialised in photovoltaic systems, has launched manufacturing of photovoltaic modules based on crystalline silicon (15 MW capacity per year) in April 2005, in Toulouse.

Invensil/Ferroatlantica and Apollon Solar firms have launched the

construction of one pilot for manufacturing photovoltaic grade silicon feedstock material (200 tonnes capacity per year). This project, called PHOTOSIL, in which CEA/LITEN Laboratory cooperates, receives funding from ADEME and the local communities. The pilot should be operational in 2006. The project is located in Bourget-du-Lac, as part of the future INES (National Institute for Solar Energy). Regarding the technology sector based on thin film hydrogenated amorphous silicon on glass substrate, the industrial players Free Energy Europe and Solems (small power applications) are continuing their production. However, they have not announced new developments in 2005.

MARKET DEVELOPMENT

Operational photovoltaic capacity in France[1] at the end of 2005, was estimated at 30 MW. This accounts for the annual production of 30 GWh in electrical energy. Approximately 6 MW were installed in 2005. Acquisitions of PV systems connected to the grid by private individuals were down in continental France. This is attributable to the financial terms that have become less attractive than they were in 2004, when there were still direct subsidies from ADEME in place; as the latter were replaced in 2005 by a tax credit at the rate of 40 %. This decrease has been compensated by the growth of the number of installations in the French overseas departments (DOM), which has allowed an overall volume of grid-connected installations equal to the one achieved in 2004, i.e. approximately 5 MW. The installed power of the stand-alone systems still remains stable, with approximately 1 MW. And it is now more a matter of replacing the end-of-life installations and reinforcing the existing installations than the installation of new equipment.

CONCLUSION AND OUTLOOK

2005 was marked by important initiatives from the government that strengthened photovoltaic electricity within a legal and regulatory framework. Here it is worth mentioning the Energy Framework Policy which strengthens energy management and the applications of renewable energy sources, the new PV R&D programme of the National Research Agency (ANR) that gives a new impetus to photovoltaic research and finally, the announcement in late 2005, of the increase in the PV electricity feed-in tariffs as well as a rise in the tax credit rate.

The research teams were the first beneficiaries of the new measures. The public intervention budget for PV RTD grew three-fold in 2005. ADEME and the ANR, which are now the two national agencies for research funding, will continue to support selected PV RTD projects launched as part of consortia of industrial and public partnerships. The installation volume of photovoltaic roofs at the private individuals', however, has not really benefited from the tax credit scheme (40 % rate) implemented in 2005. The overall power of the PV systems installed in 2005 is 15 % higher than the one of 2004, approximately 6 MW.

In late 2005, the French government announced the increase in the feed-in tariffs for electricity generated by PV up to 0,225 EUR per kWh in the case of the PV systems installed at private individuals'. This measure supplements the decision to raise the tax credit up to the 50 % level. In the case of the PV systems installed over industrial or communities buildings, the feed-in tariff has been set at 0,30 EUR per kWh. This measure will be effective as of 31 March 2006. This is an important step in the right direction taken by the government by recognising the potential of this industrial business sector.

In exchange, ADEME will end the grants in continental France while the regional councils may maintain their subsidies. Industrialists are expecting the implementation of these new measures to reactivate the commercial activity in France.

[1] *France means mainland France and Corsica and the four French overseas departments (DOM) i.e.: Guadeloupe, Guyane, Martinique and Réunion that are large users of photovoltaic energy.*

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY - STATUS AND PROSPECTS

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GENERAL FRAMEWORK

The reduction of greenhouse gas emissions is an ongoing task which is considered by all environmental policies in Germany. An enhanced utilisation of renewable energies is the key to a sustainable energy system. The new Federal Government constituted at the end of 2005 explicitly confirmed the national targets for renewable energies: Their share of the production of electricity will be increased from today's 10 % to 12.5 % by 2010 and 20 % by 2020. Renewable energies will contribute to the gross energy consumption with a share of 4.2 % by 2010 and 10 % by 2010.

Photovoltaic (PV) adds to this development. Currently, only 1 % of the renewable power generated in Germany comes from PV. But PV shows by far the highest growth rate of all renewable energies: The first half of 2005 showed a doubling of the electricity generated by PV compared to 2004. Therefore, one can expected an increasing importance of PV in the near future. Additionally, PV has become a real business with noticeable employment and turnover.

NATIONAL PROGRAMMES

Today, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has the responsibility for the renewable energies within the German Federal Government. In 2005 Research and Development (R&D) was conducted under the 4th Programme on Energy Research and Energy Technology. From 2006 on, this programme will be substituted by the new 5th programme edition called "Innovation and New Energy Technologies," which was published in July 2005 [1]. Main parts of this programme will be administrated by the Project Management Organisation PtJ in Jülich. In addition to this programme, there are other sources for the support of PV R&D: The Federal Ministry of Education and Research (BMBF) conducts a programme aiming for the support of renewable energies related networks. Moreover, the funding of renewable energies at national institutes is partly covered by their institutional funding provided by the Federal Government and the Federal States. Finally, some of the Federal States carry out their own R&D programmes.

From January 1999 until end of 2003, the "100 000 Rooftops Solar Electricity Programme" provided soft loans for approximately 65 700 grid connected PV systems with a capacity of 345.5 MW in total. It is now substituted by a soft loan programme called "Solarstrom Erzeugen - Solar Power Generation" [2].

In addition to the soft loan programmes the Renewable Energy Sources Act (EEG) is guaranteeing favourable feed in tariffs for renewable energies. The EEG is the main driving force for the PV market in Germany.

Fig. 1 - Sun shines bright over German PV installations. This system was built on a rooftop at the Centre of Berlin, nearby the Federal Chancellors office (photo UVS/Langrock).

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Overview

The new 5th Energy Research Programme is designed to be valid for the period from 2006 to 2008. It is understood that the PV R&D concept "Photovoltaic Research 2004-2008" developed under the 4th Programme and published in June 2004 continues. The R&D concept puts emphasis on

- the consequent implementation of R&D results into production,
- a further reduction of costs for PV-cells, modules and systems by decreasing production costs and by improving the overall system efficiency and
- the consideration of environmental issues related to the produc tion and operation of PV systems.

In order to provide these targets with concrete goals, a R&D roadmap was developed during the 9th BMU R&D strategy meeting in November 2005 (Table 1 - PV R&D Roadmap). This roadmap developed by representatives from industry and research institutes puts emphasis on a stable decrease of the costs of electricity from PV. It demands the need for an efficient consumption of raw materials, especially of silicon, as well as higher efficiencies in general, long-term stability of all system components and innovative production technologies.

The PV R&D concept and roadmap are designed to support the German PV industry to reach, maintain and extend their leadership in all relevant disciplines. To achieve this goal, key projects in the areas silicon wafer technology, thin-film concepts and system technologies are funded. In 2005, federal support for R&D projects on PV amounted to about 42 MEUR, shared by 120 projects in total. The

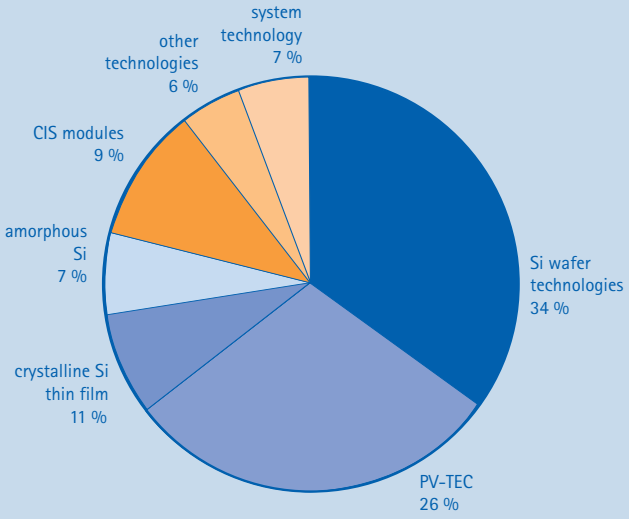

Fig. 2 - BMU funding of R&D in 2005.

distribution of the budget shows that the focal point is on wafer based silicon technologies (60 % of the budget). But innovative concepts like thin-film technologies (33 %) and the development of system technology (7 %) are funded, as well (See Fig. 2).

RESEARCH AND DEVELOPMENT

In accordance with the PV R&D concept and roadmap, 21 new R&D projects were funded in 2005. The grants for these projects amount to 32,3 MEUR in total (2004: 29,5 MEUR and 22 projects).

Crystalline silicon is still the most important material for manufacturing solar cells. In 2005 extra funds were available for the realisation of the PV Technology Evaluation Centre (PV-TEC). PV-TEC deals with the development of new silicon solar cell concepts and is designed to facilitate the transition from laboratory to production. While the BMU supports the initial set up of PV-TEC, the operation of the centre will be financed by cooperative R&D projects of industry and research groups. Other research projects deal with efficient silicon ingot production and innovative rear contact cells.

While thin-film technologies have the potential for a cost-effective large area production, their market share is still low. Now, the R&D efforts on CIS technology bear their first fruit as Würth Solar announced the setup of a 15 MW pilot production line in 2006. The basis of this development was laid out in the 1980s which proves that reliable long-term support is of great importance. Beside CIS technology, the development of crystalline Silicon thin-films and amorphous Silicon is supported.

PV System Technology: With an increasing number of grid-connected PV systems their integration into the electricity networks is of growing interest. The latest developments address high quality three phase inverters as well as inverters which provide added value by improving the local grid quality.

Demonstration

As the EEG is a powerful driving force for the development of the German PV market, no demonstration projects were granted within the current R&D-programme.

IMPLEMENTATION

In 2004, for the first time, Germany became the country with the highest annual PV installation worldwide. This remarkable result is based on the following measures in the area of market introduction:

The "Electricity Feed Law" introduced in 1991 was replaced by the "Renewable Energy Sources Act (EEG)" in April 2000. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. In 2004 the EEG was amended and the feed in tariffs were adjusted mainly according to changes in supporting market introduction programmes. For systems built in 2005 a basic tariff of 0.513 EUR per kWh applies (2004: 0.54 EUR/kWh and 2003: 0.46 EUR/kWh). On top of this, there are bonuses for small systems and building integration. The rates are guaranteed for an operation period of 20 years. For the coming years, there will be further decreases in tariffs by 5 % annually for new installed systems.

At the end of 2003, the "100 000 Rooftops Solar Electricity Programme" terminated. With a total granted capacity of 345.5 MW and 65 700 systems built, this soft loan programme was a real success. Meanwhile, the support of PV systems by soft loans is maintained by other programmes of the KfW Promotional Bank; from 2005 on for example, by the new programme "Solar Power Generation" [2]. Under this programme, 16 000 loans for a total volume of 500 MEUR were granted until now.

Other programmes like the "Sun at School" as part of a federal marked introduction programme, programmes of the Federal States (Länder) and the Federal German Environmental Foundation (DBU) are designed for a local or an application specific support of PV. Moreover, a number of utilities have launched initiatives to build PV-demonstration and pilot systems or to provide advice and information.

INDUSTRY STATUS

Based on the EEG, the German PV-Industry and the German market experienced a period of strong growth over the last years. Working in the globally most dynamic market the range of companies dealing with PV is expanding along the whole value chain. During the last years, equipment and production companies became the most experienced ones worldwide and are heading for new markets.

But it is also clear that currently the growth is limited by a global silicon supply shortage. It is estimated that this shortage will continue until 2008. The production figures [3] given below are based on an analysis of the PV magazine "Photon"[3].

Feedstock Silicon: Wacker, one of the world's largest suppliers of silicon for the semiconductor and PV industry almost doubled its silicon production from 2 800 t in 2004 to 5 200 t in 2005. This is equal to a PV production of 430 MW. In 2006, a delivery of 6 500 t is expected and an extension up to 9 000 t until 2008, has already been decided.

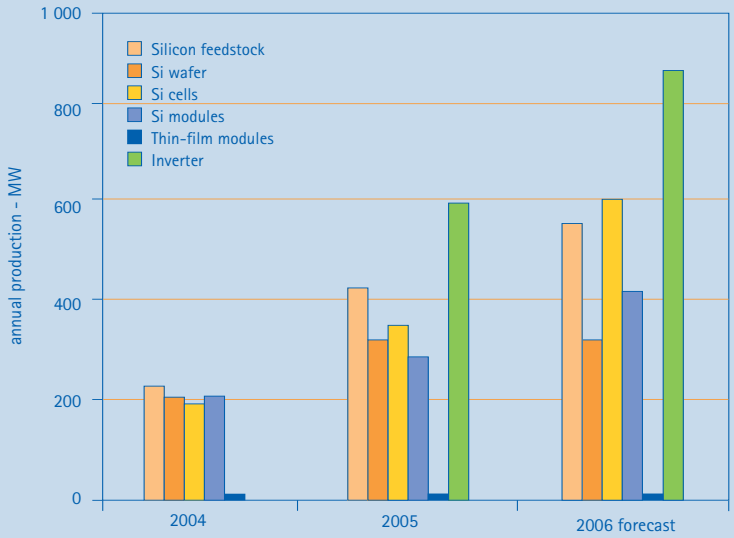

Fig. 3 – Production of German PV companies in 2004, 2005 and forecast for 2006 (based on [5]).

Joint Solar Silicon, a joint-venture between Degussa and SolarWorld, is currently developing a new process for solar Silicon production via the Silane route. Operating a pilot reactor gave its first promising results. An investment is expected in 2006.

Wafer Production: In 2004 the total wafer production in Germany amounted to 202 MW - more than 20 % of the worldwide market. For 2005 the production rose to approximately 300 MW.

The largest stake in the worldwide production is still held by Deutsche Solar AG in Freiberg. The company itself produced and sold 165 MW on mono- and multicrystalline wafers to customers around the world and is the largest company with a global market share of about 13 %.

Besides Deutsche Solar there are two further Germany based wafer manufacturers: PV Silicon at Erfurt and ASI at Arnstadt. It is estimated that both companies together sold up to 115 MW in 2005.

As part of its Smart Solar Fab, Schott Solar produced 17 MW of EFG-Si-ribbon. From 2006 on another ribbon manufacturer named EverQ a joint venture of Evergreen (Marlboro, MA) and Q-Cells (Thalheim) will start production in Germany.

Solar Cell Production: Cell production in Germany shows a steady growth. Rising from 58 MW in 2002, 100 MW in 2003 to 190 MW in 2004, the production reached 332 MW in 2005. Currently, mainly six companies are engaged. These are:

- Deutsche Cell: Founded in 2001 the production started in 2002 at Freiberg. In the year 2005 the production amounted to 40 MW heading for a capacity of 90 MW in 2006.
- ErSol Solar Energy: In 2005 ErSol produced 20 MW in Erfurt. For 2006 a production capacity of 60 MW annually is foreseen.
- Q-Cells is one of the companies with the largest growth rate. The production reached around 160 MW in 2005. An expansion of capacities to 350 MW has been announced for 2006.
- Schott Solar: The facility at Alzenau was expanded in 2004 and produced 79 MW solar cells in 2005. With additional investments Schott Solar is prepared to follow the growth of the German market towards a production capacity well above 100 MW.
- Shell Solar: The production of solar cells in Gelsenkirchen reached 17 MW in 2005.
- Sunways production reached 16 MW in 2005, at their headquarters in Konstanz. The new cell plant at Arnstadt went into operation in September 2005. Consequently, the production for 2006 may double to 32 MW.

With EverQ in Thalheim and Solarwatt Cells (Heilbronn) ready to start production in 2006, and ongoing measures to expand existing plants, an increase in production to more than 600 MW in 2006 seems likely.

The production of solar modules grew again but was significantly limited by the shortage of silicon. After assembling 40 MW in 2002, 80 MW in 2003 and 205 MW in 2004 the output of modules from numerous companies in 2005 reached 276 MW, which is now a little less than the domestic cell production.

Because of the ongoing strong demand for modules and hoping for a better supply of silicon solar cells, many manufacturers are aiming for further production extension. Therefore, in 2006 a production of 420 MW seems to be possible.

Thin-film Technologies: In addition to the crystalline activities, thin-film technologies from Antec (CdTe), Schott Solar (amorphous silicon) and Würth Solar (CIS) reached a total volume of another 12 MW. These activities were on the same level as in the previous years. But for the coming years this may change:

- From 2007 on, CIS production capacity at Würth's new factory will reach 15 MW.
- With CSG (crystalline silicon thin-film) in Thalheim and Sulfurcell (CIS) in Berlin, two new players will start production in 2006.

Besides the manufacturing of wafers, cells and modules, the production of inverter technology shows impressive growth rates. In 2005, this industry produced 593 MW and for 2006, 911 MW are foreseen.

In Conclusion, the German PV industry is not only a fast growing industry but is also offering innovative products along the whole value chain. More and more companies are entering into the business; thus, making PV a real opportunity for employment and business in general.

MARKET DEVELOPMENT

The programmes described above have accelerated the installation of PV-systems in Germany significantly. The capacity installed during 2004 is still under discussion. In a recent communication from BSW

TABLE 1 – PV R&D ROADMAP

	status today	target 2010	target 2020
ECONOMY			
Production in Germany (MWp/a)	350	1 000	12 000
Employment in Germany	20 000	50 000	200 000
System prices (grid-connected, €/W)	4.5 - 5.5	3.6	1.5
PV electricity costs in Germany (¢/kWh)	45 ± 5	30	10
Module lifetime (years)	20-25	35	
Costs for inverter (€/Wp)	0.4	0.2	0.15
WAFER – TECHNOLOGY			
Silicon demand (t/MW) (ribbon)	8	6	5
(ingot)	12	10	
Wafer thickness (µm)	250 - 300	150 - 180	100
CELL EFFICIENCY IN PRODUCTION (%)			
Wafer – Technology (single crystalline)	16.5	20	20
(multi crystalline)	14 -14.5	17 - 18	
Thin-film – Silicon	9	12	15
CIS-Technology	10	14	17

Extract from the R&D Roadmap, developed during the 9th BMU strategy meeting of representatives from German industry and research institutes (November 2005).

(Bundesverband Solarwirtschaft), the association of solar companies in Germany, indicated that 500 MW in 2004 could be on the lower boundary of estimates. A first estimate for 2005 results in an additional installed capacity of around 600 MW (Fig. 4). Thus, in mid 2005, the first Gigawatt of grid-connected PV was reached in Germany and today around 1.5 GW PV feed electricity into the public grid.

In addition to the market of grid connected systems, there is a stable request for stand alone systems. First estimates indicate that in 2005 slightly less than 3 MW were installed.

However, it is not only the installed capacity which counts. The association of solar companies in Germany (BSW) estimates that meanwhile around 3 500 companies with 20 000 employees are active in the PV business. The turnover in 2004 amounted to 1.76 billion EUR and is still growing.

FUTURE OUTLOOK

Today, the PV market in Germany expands and offers excellent business opportunities. But the current technical and economical status does not allow standstill. By enhancing production efficiency and at the same time lowering costs until 2020, not only a noticeable share of PV electricity should be accomplished but also electricity costs should be lowered by a factor of four to five, when compared to today. To reach this target, high-level R&D together with strong and sustainable supporting mechanisms like the EEG are needed. The current situation in Germany supports the conviction that PV will successfully continue on its way.

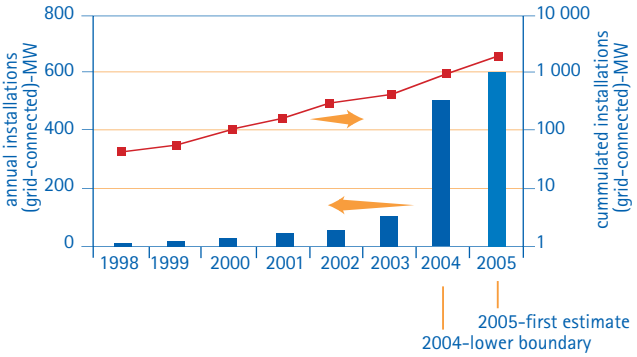

Fig. 4 – Development of grid-connected PV capacity in Germany.

REFERENCES

1 An English version of the 5th Energy Research Programme of the Federal Government is available at http://www.bmu.de/english/renewable_energy/downloads/doc/36411.php
2 For information on the soft loan programmes of KfW see http://www.kfwfoerderbank.de/EN_Home/KfW_Foerderbank/index.jsp
3 Photon Magazine, January 2006.

FURTHER READING ABOUT GERMANY

- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), see www.bmu.de
- BSW - German Solar Industry Association, see www.bsi-solar.de and www.solarwirtschaft.de

The author would like to thank Mr. Peter Woditsch (Deutsche Solar AG) for his support; especially concerning the section on "Industry Status."

ISRAEL

PV TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE

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GENERAL

Photovoltaic activity in Israel is concentrated mainly in academic research, with limited industrial involvement. The ubiquity of the electricity grid makes most applications non-cost-effective, except in unique situations.

886 kW of peak power have been installed so far; 353 kW were installed in 2004. Nearly all the applications are off-grid remote electrification systems. Most installations were made on an economic basis, the PV system being the most economically viable alternative (because of its distance from the electric grid). At the present time, there are no promotion initiatives or subsidies for PV systems.

A resolution adopted by the Government in November 2002, mandates that at least 2 % of total electric energy be generated from renewable sources by 2007, rising to 5 % by 2016. The Israel Electric Corporation (IEC) is required to purchase electricity from private producers, according to rules set by the Ministry of National Infrastructures. The Ministry is in the process of preparing regulations regarding the purchase by the utility of electricity generated from renewable energy sources. It is expected that these regulations will also positively influence the local PV market. The IEC has general guidelines relating to the quality of the electricity it purchases.

INDUSTRY INVOLVEMENT

A few firms are active in the PV field, and they deal mainly with system integration. Most companies are small, and are not exclusively dedicated to PV. Some of the local production of systems is exported.

Presently there is no local production of either PV cells or inverters. The technological infrastructure required to produce all the components needed for integration in PV systems is available; however, due to economical considerations, components such as modules are imported. In spite of this, some unique Israeli PV systems have high added value related to the balance of system (in particular, control systems), and therefore, they have international market potential.

RESEARCH AND DEVELOPMENT

A relatively large number of research teams is involved in photovoltaic R&D, most of them from academe, spread over most research areas. Many of these teams cooperate with leading teams worldwide (both in academe and in industry).

Among the current R&D projects, a number are highly innovative and worth noting:

- The optimal design of a solar field of stationary collectors is the objective of intensive research work at Tel Aviv University. This design may be based on several criteria: maximum energy output from a given field, minimum field area for required energy production, minimum cost per unit energy, minimum plant cost, maximum energy per unit area or other objectives. The use of many rows densely deployed, in a limited field size, increases the field incident energy but also increases the shading. Therefore there is an optimal deployment of the collectors in the solar field. These design problems may be formulated as optimization problems with objective functions and sets of constraints (equality and inequality) for which mathematical optimization techniques may be applied. Field and collector parameters include field length L, field width W, number of collector rows K, distance between rows D, collector height H and collector inclination angle (Figure 1).

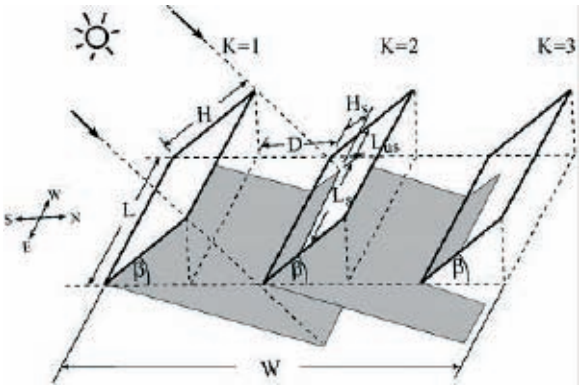

Fig. 1 – Shading by collectors in a solar field.

- DiSP Ltd. is developing a Miniature Concentrating PV (MCPV) system for distributed power applications, in cooperation with Tel Aviv University. The system is designed to provide both electricity and high-grade heat, making it a true Combined Heat and Power (CHP) system. It includes a small (about 1 m diameter) concentrating dish and a high-efficiency CPV module. Preliminary calculations indicate that the power generated by the MCPV may be less expensive than grid power. The heat can be provided at temperatures suitable for steam generation, cooling, space and water heating, and process heat. A demonstration unit is currently under construction.
- R&D activity at the Solar Energy Laboratory of the Jerusalem College of Technology is directed toward increasing the efficiency of silicon solar cells and photovoltaic modules without significant additional fabrication expenses. It consists of:
  1. Development of improved solar cell fabrication technologies suitable for industrial application. The activity is focused mainly on back surface field (BSF) optimization and extends in two different directions:
     - BSF formation in multi-crystalline Si cells by simultaneous B and Al diffusion;

- Research and improvement of ion implantation process as a doping method for BSF formation of the high-efficiency single-crystal solar cells (in cooperation with Italy and Russia).

2. Development and improvement of a cheap glass antireflective coating for the PV and thermal modules, allowing efficiency to increase by more than 0,5 % absolute in the PV case.

- Long-term performance of various photovoltaic modules under desert conditions is being monitored at the National Solar Energy Center in Sde Boker.

DEMONSTRATION AND APPLICATION

The higher fuel prices have caused increased installation of off-grid systems, replacing diesel generators (Figure 2). In addition, there is growing interest in grid-connected applications (Figure 3).

A large PV project, aimed at electrifying a Bedouin village, was started in 2005. The village of Drijat, in the Negev desert, in which about a hundred families live, is about 6 km from the nearest grid. Electricity was supplied by old and inefficient diesel generators, which only worked a few hours a day. In the first phase of the project, stand-alone PV systems were provided to 20 homes, 6 lighting poles, a school and a mosque. The home systems (Figure 4) provide about 1 000 W of peak power each, with batteries storing 14 kWh (enough for two to three days of consumption). The total cost of the first phase was 300 000 USD.

The Municipality of Tel Aviv has decided in principle that every public building undergoing restoration will incorporate a photovoltaic system. It remains to be seen how the decision will be implemented.

EDUCATIONAL ACTIVITIES

In the Nitzana village in the Negev desert, an educational project is underway, called "Science Following the Sun." The project brings the message of solar energy, including photovoltaics to hundreds of school children.

GOVERNMENT ACTIONS

As mentioned above, it is expected that the recent Government resolution establishing a minimum quota for electricity from renewables will favorably influence the PV market. In addition, a number of actions are being taken to encourage the PV activity. Among them:

- Support of R&D excellence centers through selective funding of projects. The R&D expenditures in photovoltaics of the Ministry of National Infrastructures were only about 110 000 USD in 2005; however, additional funding is available in this area from other research foundations.
- Partial funding of innovative demonstration projects.

Fig. 2 - 1 200 W off-grid system, providing electricity to a Bedouin family (photo SolarPower).

Fig. 3 - 400 W grid-connected system, at a transportation museum in the Jordan Valley (photo SolarPower).

Fig. 4 - Home system at the Bedouin village of Drijat; the mosque is in the background (photo Dr. Ibrahim Yihia).

ITALY

PV TECHNOLOGY STATUS AND PERSPECTIVES
S. CASTELLO, ENEA
S. GUASTELLA, CESI

Fig. 1 - PhoCUS Project: the first 5 kW prototype (photo ENEA Research Centre).

GENERAL FRAMEWORK

In Italy, a very high public demand for PV installations was registered during the year 2005, as a result of public financial support for these plants. In spite of this enthusiasm, the bureaucratic issues related to the incentive mechanism (based on a contribution on the installed plant cost) still resulted in frustrating these expectations and limiting the increase in the annual installed capacity, even if an adequate budget was available for dissemination programmes implementation.

In this framework, the cumulative installed PV power increased similarly to the previously year (about 5 MWp) reaching a total of about 36 MW. Most of this capacity has been due to the expansion of the small grid-connected market, which now amounts to 17 MW, accounting for 47 % of photovoltaic power installed in Italy, with respect to 40 % at the end of 2004. However, even in this situation of constrained national installations, the production of photovoltaic modules has recorded an increase in 2004; essentially due to the request from the German market.

The budget for market stimulation, funded by both the Ministry of Environment and Land Protection (MATT) and the Italian Regions in the framework of the Regional Roof-Top Programmes, utilised during this year amounts to about 25 MEUR. Meanwhile, in the field of research and demonstration, the expenditure has been about 5 MEUR, remaining essentially flat with respect to the previous years, and was mainly supported by ENEA (the Italian Agency for New Technology, Energy and Environment) and CESI (the Institute for Research and Certification of electric components and system). This stagnating situation seems to have been overcome with the decree of the Ministry for Productive Activities (MAP), issued on August 2005, which defines the criteria for the promotion of photovoltaics through a feed-in tariff that provide a fair remuneration of the investment and operating costs. In fact, in less than one month, nearly 3 600 applications have been submitted to GRTN (Gestore del Sistema Elettrico), a company (owned by the Ministry of Economy and Finance) which plays a key role in the scheme of promoting electricity generation from renewable and assimilated sources and in managing the market system based on green certificates.

NATIONAL PROGRAMME

During this year, dissemination initiatives included both some still ongoing Regional Roof-Top Programmes and the Feed-In Tariff Programme launched last September.

The Regional Roof-Top Programmes, completely managed by the 19 Italian Regions and the 2 Autonomous Provinces, constitute the follow-up of a National Programme (concluded in the year 2003 with the installation of about 1,8 MW) and are mainly aimed at enforcing the diffusion of PV technology among the Italian citizens. A contribution percentage, ranging from 50 % to 70 % of the investment cost, has been requested by the applicant and constitutes the main parameter for financing grants. On the whole, from 2003 to 2005 public contributions amounted to approximately 105 MEUR, thus allowing, a total capacity of 21 MW. Nevertheless, in this framework, the regional Programmes are experiencing rather slow growth principally due to bureaucratic delays in the application and permitting procedures. As a consequence, at the end of 2005, only over 14 MW out of the anticipated 21 MW had been installed.
As far as the Feed-in Programme, the development of a decree by Ministry for Productive Activities, which defines the criteria for promoting the production of electricity from photovoltaics, has provided a strong expectation in the Italian PV market. The support scheme foreseen by the decree is composed of a feed-in tariff for the whole electric energy produced by the PV plant and by the value of the electricity, which can be partially or totally sold to the local electric utility. These incentives are addressed to individuals, registered companies, condominia and public bodies. PV plants are eligible for the incentive scheme if: 1) they are connected to low or medium voltage grid, 2) their components satisfy technical standards, 3) their capacity ranges from 1 to 1 000 kW and 4) they were operational after 30 September 2005. The tariff of produced electric energy varies with the nominal power of the plant and ranges from 0,445 EUR/kWh to 0,490 EUR/kWh. The duration of the support is 20 years and the tariffs are updated on a yearly basis, taking into account the official inflation rate. A tariff reduction of 2 %/year is applied to PV plants for which the support request is delivered after 2006. Moreover, the electricity produced by the PV plant can be used for its own consumption or sold to the local utility and this benefit is maintained also after 20 years. For plants larger than 50 kW, the tariff is subject to a tender mechanism, which favours the tariff with a lower value. For these plants, a bank guarantee of 1 500 EUR/kWp is requested as a penalty, in the case the PV plant is not installed within the deadline fixed by the decree. Finally, the decree states that promotion tariffs: 1) are reduced by 30 % if combined with fiscal incentives, 2) are not applicable to PV plants which have obtained incentives from public bodies exceeding 20 % of investment cost and 3) are not compatible with green certificates.

The overall power, which is expected to be supported by this decree, is 100 MWp, of which 60 MWp assigned to plants up to 50 kWp and 40 MWp for the larger ones. A final target of 300 MW is expected by 2015.

Nevertheless, within 11 days from the launch of the initiative (September 19th) more than 3 600 applications have been submitted and 78 % of them, corresponding to 2 872 projects, have been

Fig. 2 - Regional Roof-top Programme: 20 kW PV plant (photo FIAT Research Centre).

admitted to the feed-in tariffs: 47 projects concern plants over 50 kW (corresponding to about 28 MW) and 2 825 are referred to plants up to 50 kW (resultant in approximately 59 MW). As a consequence, the residual power still available at the end of September 2005 was 12 MW for plants over 50 kW and 1 MW for plants up to 50 kW. In this phase, the most involved Regions were Apulia, Sicily and Campania, where the solar radiation availability is higher with respect to other Italian Regions.

More amazing has been the subsidies demand in the period October - December 2005; with about 7 500 applications submitted, corresponding to a total power of about 190 MW, well beyond the limit of the decree.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In Italy, RD&D activities on photovoltaics are conducted by ENEA and CESI, with the support, in some cases, of universities, industries and some CNR (the National Council for Scientific Research) institutes. As far as ENEA activities, the most significant ones concern the technical and economical assessment on concentrators' technologies (PhoCUS Project), the optimisation of high efficiency crystalline silicon cells (EU Project) and the development of thin film cells for BIPV as well as Cu2O solar cells research.

In the field of photovoltaics, CESI is carrying out activities in the development and industrial manufacturing of high efficiency solar cells for space and terrestrial applications, based on III-V compounds. Besides, triple junction solar cells (InGaP/InGaAs/Ge) are under development and qualification. They will be commercially available from next year. GaAs single junction and multi-junction concentrator solar cells are also manufactured for terrestrial application.

Furthermore, both ENEA and CESI are involved in components' characterization and performance evaluation of PV systems.

IMPLEMENTATION OF SYSTEMS

The cumulative installed power in Italy, is at present about 36 MWp; 5 MWp was installed during the last year. This capacity begins to be dominated by on-grid distributed PV systems that amounting to over 17 MW, accounting for 47 % of PV installed power. The other primary applications for photovoltaic power systems concern:

- off-grid domestic systems (5,3 MW), mainly promoted in the eighties;
- off-grid economic industrial applications amounting to 6,7 MW;
- on-grid centralized systems (6,7 MW), mainly installed at the beginning of 1990's but now expected to be increased due to the feed-in tariffs.

INDUSTRY STATUS

Two major manufacturers of PV modules, some assembling companies and several operators in the field of systems can be identified in Italy.

A major PV module manufacturer is Enitecnologie. Its manufacturing facilities have a production capability of about 10 MWp/year. Both single-crystal and multi-crystalline silicon cells are currently produced from wafers bought on the international market. Another important Italian module manufacturer is Helios Technology: its manufacturing facilities have an overall production capability of 8 MWp/year. The Helios Technology module manufacturing process includes the fabrication of cells and modules from mono-crystalline silicon wafers.

Further companies can be found in Italy: they are assembling and encapsulating standard and/or especially designed modules (such as windows integrated cells, tiles or using coloured cells). The total production capacity of such companies amounts to about 10 MW. Typical module prices range from 3 to 3,6 EUR/W, depending on order size.

Altogether, an estimation of the number of companies, that install PV systems in Italy, reaches 100 units. These are specialist PV companies offering consultancy, installation services and component delivery, which include ENEL (the biggest Italian electricity utility) Group, CESI and some electric municipalities.

The most important operators in this field are associated in the Italian PV firms Group (GIFI).

FUTURE OUTLOOK

A new edition of the feed-in decree issued in August 2005 is under discussion by the State-Regions forum. The new decree should increase the target of the Italian feed-in tariff from 100 MW to 500 MW (by the same year 2015), of which 360 MW for installations up to 50 kWp and 140 MW for installations between 50 kWp and 1000 kWp.

Moreover, this decree should foresee an annual limit of 85 MW to applications admitted to receive feed-in tariff: 60 MWp for installations up to 50kWp and 25 MWp for installations over 50 kWp. Thin-films, excluded from the previous decree, are now allowed in the new draft decree, but exclusively for building integrated systems, submitted by juridical persons.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

YUKAO TANAKA, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)
OSAMU IKKI, RTS CORPORATION

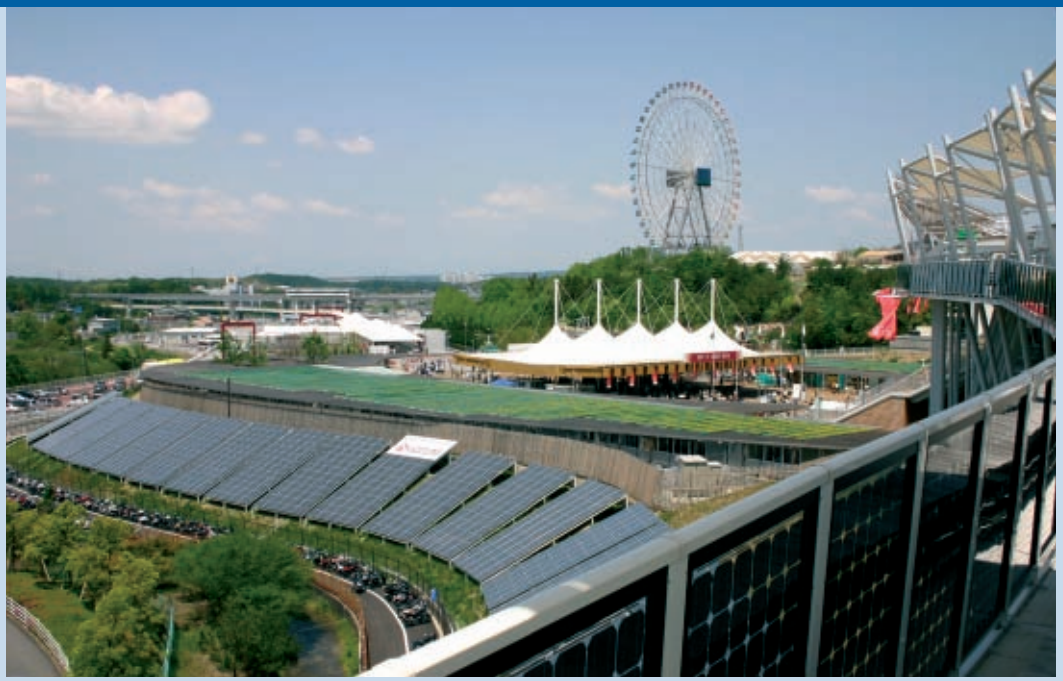

Fig. 1 - 30-kW Bifacial type PV system (front), 200-kW PV System installed on the slope (back), Aichi EXPO.

GENERAL FRAMEWORK

The promotion and deployment of photovoltaic (PV) systems are defined in the perspective for new energy in the "Long-Term Energy Supply and Demand Outlook," prepared by the Advisory Committee for Natural Resources and Energy under the Ministry of Economy, Trade and Industry (METI). Japan's target cumulative volume for PV system introduction by FY2010 was set to 4 820 MW. METI has been actively driving forward measures for PV deployment and programs for research and development for PV systems to achieve the target. "The New Energy Law" established in 1997 defines the responsibility of each sector: the national and local governments, energy consumers, energy suppliers and energy system manufacturers, to introduce and expand new and renewable energy. "The Renewables Portfolio Standard (RPS) Law" newly established in 2002, which obliges energy suppliers the use of a certain percentage of renewable energy, was thoroughly enforced in 2003. In addition, the Government of Japan established "the Basic Energy Plan" in 2003, in order to materialize the basic policies based on "the Basic Law on Energy Policy" enforced in 2002.

In 2004, three visions foreseeing the year 2030 were released: "Energy Supply and Demand Outlook for 2030", "Vision for New Energy Business" and "PV Roadmap toward 2030 (PV2030)", a roadmap for the technological development of PV systems. The efforts for larger scale dissemination of PV systems from a long-term view point were started. In addition, the Cabinet endorsed the "Kyoto Protocol Target Achievement Plan" in 2005, and the Plan positioned the utilization and large-scale deployment of new and renewable energy as one of the countermeasures to reduce greenhouse gas emission toward 2010.

Beside these, the "Law Concerning the Promotion of Measures to Cope with Global Warming" and the "Law on Promotion of Green Purchasing" were enacted to promote introduction of new and renewable energy.

NATIONAL PROGRAM

The Japanese Government has implemented research and development (R&D), demonstrative projects, dissemination measures, and introduced legislation toward the achievement of targeted introduction capacity of 4 820 MW of PV systems by FY2010 and further deployment of PV systems thereafter. In the field of R&D, technological development for cost reduction of PV systems, technological development for PV deployment and research for innovative next generation technologies have been conducted. Regarding demonstrative research, the Field Test Project on New Photovoltaic Power Generation Technology has been conducted to demonstrate the effectiveness of PV systems employing new PV modules, new components, advanced system technology and newly developed installation methods, etc. and enlarge the application area of PV systems. The Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems, in which a large number of PV systems are intensively installed in a community, also has been conducted. Moreover, the Demonstrative Project of Regional Power Grids with Various New Energies has been underway as a demonstrative research of energy supply system, that intensively

Fig. 2 - PV system using flexible type PV modules, 10 kW, Aichi EXPO.

employ various types of new and renewable energy sources such as PV system, wind power generation, fuel cells, etc. The major dissemination measures, the Residential PV System Dissemination Program was terminated in FY2005 as the Government evaluated that with the "creation of the initial market," the goal of the Program had been achieved. In addition, the Government has continuously implemented supporting programs for local governments and private entrepreneurs in order to introduce new and renewable energy.

The budgets for major national PV programs implemented in FY2005 are as follows;

1. Research and Development on Photovoltaic Power Generation: 4 100 MJPY
2. Residential PV System Dissemination Program: 2 600 MJPY
3. Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications: 110 MJPY
4. Field Test Project on New Photovoltaic Power Generation Technology: 9 230 MJPY
5. Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems: 1 248 MJPY
6. Project for Supporting New Energy Operators: 34 500 MJPY
7. Project for Promoting the Local Introduction of New Energy: 7 600 MJPY
8. Project for Establishing New Energy Visions at the Local Level: 1 180 MJPY
9. Project for Promotion of Non-profit Activities on New Energy and Energy Conservation: 170 MJPY
10. Demonstrative Project of Regional Power Grids with Various New Energies: 6 000 MJPY

The budgets for items 6, 7, 8, 9 and 10 include ones for PV and other new and renewable energies.

R&D, D

The New Sunshine Project established in FY1993, aiming at comprehensive and long-term R&D, finished in FY2000, and a new technological program, the "5-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY2001 - FY2005)", which covers the following 4 research areas, has been underway by the New Energy and Industrial Technology Development Organization (NEDO), based on the results achieved so far. In addition, the framework for the new technological development plan from FY2006 is in preparation, based on a roadmap for technological development of the PV system, "PV Roadmap toward 2030 (PV2030)", compiled in FY2004.

1. Development of Advanced Solar Cells and Modules

The short- to medium- term goal of this program is to establish elemental technologies that can achieve PV power generation cost on par with typical residential electricity rates and transfer developed technologies into practical applications at an earlier stage. The program is focusing on development of thin-film crystalline Si solar cells, thin-film CIS solar cells and super high-efficiency polycrystalline compound solar cells (InGaP/InGaAs/Ge). All the development goals, initially set, were achieved. In 2005, commercial production plans of thin-film Si hybrid solar cell and thin-film CIS solar cell employing developed technologies were announced.

2. Development of Technology to Accelerate the Dissemination of Photovoltaic Power Generation Systems

This program aims at developing industrial technologies in order to accelerate practical application of results of technological development so far. Technological development has been advanced in the following area: silicon feedstock for solar cell, mc-Si sheet silicon wafers for solar cells, mass-production process of a-Si solar cell on plastic films and mass production film fabrication equipment for low-cost, thin-film polycrystalline silicon. All the projects are to be finished by the end of FY2005, and planned to transfer to the phase of commercial application. From FY2005, a new 3-year successive program, PV Systems Advanced Practical Technology was started. The development of a high-performance inverter is underway.

3. Development of PV System Technology for Mass Deployment

This program was designed to develop common infrastructural technologies to support the environment for large-scale PV deployment from technological aspects. Development of technologies for performance evaluation of solar cells, PV modules and PV systems and recycling and reuse technologies of PV systems has been carried out under the program. Fundamental technologies such as evaluation technology of solar cell performance will be continued in FY2006 and later.

Fig. 3 - PV system installed on the slope, 100 kW, Aichi EXPO.

4. Development of Photovoltaic Power Generation Technology (Investigation for Innovative Photovoltaic Power Generation Technology)

The program has a long-term goal for exploring seed technologies for further improvement of performance and economical efficiency of PV power generation in and beyond the year 2010. R&D has been carried out for new materials, novel concepts and structures: nano-structure silicon solar cells, dye-sensitized solar cells (DSC), carbon-based thin-film solar cells, organic thin-film solar cells, etc. In FY2004, NEDO has transferred these programs into the preliminary R&D program with an eye to the year 2030 and designated 5 R&D areas, based on the PV2030 Roadmap: 1) thin-film silicon solar cell, 2) crystalline silicon solar cell, 3) CIS solar cell, 4) dye-sensitized solar cell (DSC) and 5) PV system technology, in order to efficiently promote technological development of innovative next generation technologies for PV systems. In FY2006, new technological development program will be started based on the results of these R&D issues.

DEMONSTRATION

4 major demonstration programs were implemented in FY2005: The "Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications," the "Field Test Project on New Photovoltaic Power Generation Technology," the "Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems" and the "Demonstrative Project of Regional Power Grids with Various New Energies."

1. Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications

This program started in FY1998 and installations were completed with great success. 740 PV systems with 18 100 kW in total were installed to schools, medical facilities, welfare facilities, factories, office buildings and private-sector facilities by the end of FY2002. Data collection and analysis have been continued since FY2003.

2. Field Test Project on New Photovoltaic Power Generation Technology

This field test program aims at leading dissemination of middle-scale PV systems by installation of PV systems employing advanced technologies on trial basis and promoting improvement of performance and cost reduction of those PV systems. This program is regarded as a succeeding program of the Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications. Under this program, the following 4 model technologies are defined: 1) the PV system with new modules, 2) the PV system with building material integrated modules, 3) the PV system with new control systems and 4) the PV system aiming at higher efficiency. The introduction of PV systems for public facilities and industrial uses are promoted under this program. 263 projects were selected and PV systems totaling 7 191 kW were installed in FY2004.

In FY2005, METI enhanced this application area as a prioritized area for PV power dissemination, the number of the selected projects significantly increased to 574, totaling 23 960 kW.

3. Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems

This program started in FY2002 for a 5-year scheme, to install grid-connected PV systems equipped storage batteries into 600 households to conduct demonstrative research on a large-scale and to intensively introduce on-grid PV systems. The program aims at establishing grid connection technologies for grid-connected PV systems intensively installed to one area. The specific research objectives are 1) development of technology to avoid restriction of PV system output by using storage batteries, 2) analysis and evaluation of higher harmonics, 3) analysis and evaluation of devices for mis-actuation function to prevent islanding operation, 4) development of applied simulations and 5) evaluation of characteristics of power generation and economical efficiency. Residential PV systems with storage batteries were installed about 480 residences by the end of FY2005 and the demonstrative researches have been advanced.

4. Demonstrative Project of Regional Power Grids with Various New Energies

This program was launched in FY2003 to intensively install various types of distributed power sources such as PV systems, fuel cells and wind power generators, etc. in one area, aiming at demonstrating various issues: ensuring quality of electricity, balance between supply and demand of electricity, stability, and studying economical performance of distributed power sources. In FY2003, 3 demonstrative sites were selected across the country: Aichi Prefecture (total 2 400 kW of distributed power generation systems including 3 PV systems totaling 330 kW), Aomori Prefecture (total 710 kW of distributed power generation systems including an 80-kW PV system) and Kyoto Prefecture (total 850 kW of distributed power generation systems including a 50-kW PV system). Installation of power generation systems was started in FY2004. The demonstration site of Aichi Prefecture was located in the premises of the 2005 World Exposition (EXPO 2005), Aichi, Japan, and the micro-grid formed by the PV systems and other new energy power generation systems supplied electricity for Government Exhibition, etc. (see also photographs).

Fig. 4 - PV system at AEON Kitatoda Shopping Center, 10 kW, Toda City, Saitama Prefecture.

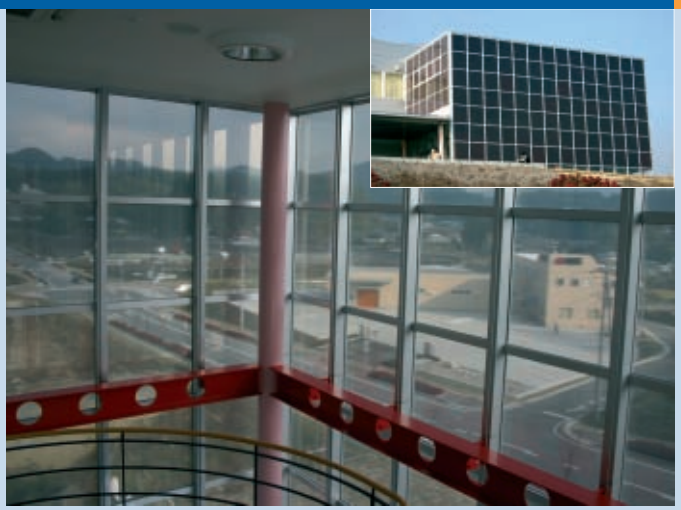

Fig. 5 - PV system at MSK Fukuoka Factory, 6 kW, Omuta-City, Fukuoka Prefecture.

IMPLEMENTATION

The Ministry of Economy, Trade and Industry (METI)

The main implementation programs carried out in FY2005 were the "Residential PV System Dissemination Program," the "Project for Promoting the Local Introduction of New Energy" and the "Project for Supporting New Energy Operators."

1. Residential PV System Dissemination Program

The "Residential PV System Monitor Program" initiated in FY1994 was renamed the "Residential PV System Dissemination Program" in FY1997 to develop the initial residential PV system market. The program was terminated in FY2005. The total number of PV systems installed under these programs expanded to the scale of 250 000, and the initial market of residential PV system was successfully created.

This program aims at reducing the cost burden to buyers of residential PV systems and creating the initial PV market through subsidizing the installation cost for residential PV systems. The subsidy is given through three categories; i) an individual to install a PV system to one's own house, ii) a ready-built house supplier of housing development and iii) a local public organization to introduce PV systems to public housings. PV systems with 9,99 kW of the maximum output capacity, connected to low voltage grid and allowing reverse power flow are qualified for the subsidy. Although the amount of the subsidy in FY2004 was 45 000 JPY/kW, it was further reduced to 20 000 JPY/kW in FY2005.

Under this program, residential PV systems were installed to 162 525 houses, total 595,1 MW, from FY1994 to FY2003. In FY2004, 54 475 houses equipped with PV systems totaling 200,1 MW. In FY2005, 39 643 applications for the program were received as of October 2005, and the Program was terminated since the applications reached the budget.

2. Project for Promoting the Local Introduction of New Energy

This program aims at accelerating new energy introduction by supporting the regional projects developed by local governments for promoting introduction of new and renewable energy. Another object is raising awareness of the local residents for new and renewable energy. Subsidy is provided for local public organizations who are going to introduce and promote power generation using new and renewable energy such as PV power generation, wind power generation, use of solar thermal energy, differential temperature energy, natural gas co-generation, fuel cells, wastes generation, use of waste thermal energy, production of wastes fuel, clean energy vehicles and energy conservation measures. PV systems with 10 kW of output capacity and over are qualified under the program. Recipients can receive the subsidy, lower amount of half of installation cost or 400 000 JPY/kW. 285 systems in total were subsidized from FY1998 to FY2003. 148 systems out of them were PV systems. Total capacity installed was 18 295 kW. In FY2004, 71 systems in total were qualified and 45 systems out of them were PV systems. Total capacity installed was 3 433 kW. In FY2005, 103 systems in total were qualified and 33 systems out of them were PV systems. Total capacity installed was 870 kW. The program allows local governments to understand the benefit of the introduction of new and renewable energy and introduces PV systems intensively to school buildings and public facilities, etc. over several fiscal years.

3. Project for Supporting New Energy Operators

This program aims at accelerating new energy introduction by supporting the industrial entrepreneurs who set about introducing new energy, such as PV power generation, wind power generation, solar thermal energy, differential temperature energy, natural gas co-generation, fuel cells, wastes power generation, use of waste thermal energy, production of wastes fuel, etc. Private entrepreneurs who start new energy businesses are eligible for guaranteed debt or subsidization. A third of the installation cost is subsidized, and 90 % of the debt is guaranteed. The capacity of an eligible PV system is 50 kW and over (10 kW and over is also eligible in case of installation of multiple new energy sources). 174 systems in total were qualified from FY1998 to FY2003, and 6 systems out of them were PV systems, 598 kW in total. In FY2004, 37 systems were qualified and 3 systems, 147 kW in total, out of them were installed. In FY2005, 66 systems were selected and 2 systems were PV systems, and the total installed capacity was 27,2 kW.

Besides these programs, supports have been offered to local governments for their projects to develop their own visions for the introduction of new energy and to nonprofit organizations (NPOs) for their supporting activities in introducing new energy at the local level.

Fig. 6 - PV system at Chiba Toyota headquarters building, 10 kW, Chiba City, Chiba Prefecture.

The Ministry of Land, Infrastructure and Transport (MLIT)

Under the "Guideline for Planning Environmentally-Friendly Government Building (Green Building),"construction of green government buildings equipped with PV systems has been promoted. Introduction of PV systems with 455 kW in total was completed in 13 central government office buildings as of June 2003. In addition, MLIT introduces PV systems to local facilities for the central government such as the national government buildings of local branches every fiscal year.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT)

MEXT continues the "Eco-school Promotion Pilot Model Project" initiated in partnership with Ministry of International Trade and Industry (current METI) in FY1997 and has been promoting the introduction of PV systems to elementary schools, junior high schools and kindergartens. 440 schools all over Japan were designated as the pilot model schools by the end of FY2004, and 282 schools among them installed PV systems with output capacity of 10 kW and over each. In FY2005, 95 schools were newly selected as the pilot model schools and PV systems are to be installed at 55 schools among them. From FY 2005, the Ministry of the Environment (MOE) also joined to the Project.

The Ministry of Environment (MOE)

The Ministry of Environment (MOE) is promoting projects of CO_2 emission reduction by use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming" enforced in FY1998. In addition, it implemented the "Law on Promotion of Green Purchasing" in April 2001, and commodities procured by the national and local governments have to be replaced with environmental-friendly products. Since the PV system is specified as one of the special procurement products, introduction of PV systems to governmental facilities has been in progress. Besides this, the Ministry has been implementing several measures: 1) the development of practical application of technology to introduce renewable energy as a measure for technological development projects to cope with global warming, 2) a project to improve and maintain the local environment as a model town project for virtuous cycle of environment and economy, 3) a project for the introduction of CO_2 low-emission houses using PV system as the project to construction and maintenance of model houses to reduce CO_2 emission and 4) the environment-friendly renovation of schools and environmental education projects, such as the project of environment-friendly renovation of schools and the project of a model school for environmental education.

The Local Governments and Municipalities

The movement to actively work on environmental issues has been spreading among the local governments and municipalities year by year. Prefectures began to set their own target for introduction volume of new energy following the national target for PV system introduction (4 820 MW) one after another. More and more local authorities began to develop their own new energy introduction visions and plan introduction of PV systems into public facilities and public housings. Some local governments and municipalities also additionally provide their own subsidies to the national subsidy for residential PV systems and offer preferential loans for introduction of PV system, and the number of such local governments has been increasing over the years. Promotional supports to PV systems are enhanced at local governments and municipalities. The number of local governments that provide additional subsidy for residential PV systems increased from 282 in 2004 to 339 in 2005.

Utilities

Electric power companies in Japan continue the introduction of PV systems at their own facilities and net billing to buy-back surplus PV electricity at the same rate as selling.

Electric power companies established the "Green Power Fund" in October 2000, aiming at introducing and promoting PV systems and wind power generators. The utilities bill an additional charge as a contribution at 500 JPY/share/month to the supporters among their customers, and contribute the same endowment as the amount of their supporters' contribution for installation of PV systems and wind power generators. From FY2001 to FY2004, 445 public facilities including schools across Japan were subsidized through the Fund and the total capacity installed was 8 439 kW. In 2005, 147 sites were selected, and installation of PV systems totaling 4 372,8 kW are underway.

Electric utilities achieved to purchase required amounts of new energy for FY2004 designated under the Renewables Portfolio Standard (RPS) Law that was enforced from FY2003. Usage volume of electricity generated by new energy by utilities for FY2004 was 4 908 TWh in total, including 346 TWh from PV power generation. The accredited facilities for power generation using new energy under the RPS Law was 199 027 systems totaling 6 858 MW. Among them, PV systems are 198 159, accounting for 741 MW of generation capacity.

Financial Institutes

Some banks and other financing institutes provide preferential financing at low interest rates for the introduction of residential PV systems for private use and houses equipped with PV systems. The number of such financial institutions has been increasing year by year.

INDUSTRY STATUS

2005 marked a major turning point for the PV industry in Japan with 1) completion of the Residential PV System Dissemination Program, which had been leading the expansion of Japan's PV market for the past 12 years (October 2005), 2) enhancement of a global strategy by domestic PV manufactures to meet the increasing global demand for solar cells, and 3) promotion of new energy by the national and local governments following the decision of the Kyoto Protocol Target Achievement Plan. The annual production volume of PV cell/module in Japan grew to over 800 MW. The PV industry in Japan achieved progress in terms of the following aspects: 1) technological development of production of solar-grade polysilicon (SOG-Si), 2) enhancement of production capacity of solar cells, expansion of PV module production sites overseas and the introduction of PV modules with higher conversion efficiency into the market by PV manufacturers, 3) new entries into thin-film PV module manufacturing, 4) enhancement of market development of PV systems for public and industrial facilities in addition to the residential PV system market, 5) commercialization of large-sized inverters for PV systems installed in industrial and public facilities by power source manufacturers, 6) start of new market development such as the one for MW-scale PV systems, and 7) expansion of manufacturers' production capacity of raw materials for PV cells/modules; for example, raw materials for PV modules such as EVA and PET.

Highlights of PV cell/module manufacturers in 2005 are as follows. Sharp raised the solar cell production capacity from 400 MW/year to 500 MW/year. It also newly constructed a 15 MW/year manufacturing line for thin-film crystalline silicon tandem solar cells. Kyocera increased its solar cell manufacturing capacity from 150 MW/year to 240 MW/year. It also completed a PV module production line in the Czech Republic in 2005, and established the "quadripartite global production framework" for PV modules in Japan, Mexico, China and the Czech Republic. Sanyo Electric completed a PV module factory with a capacity of 50 MW/year in Hungary and began operations for the European PV market. Mitsubishi Electric commercialized a 170-W lead-free PV module with higher efficiency and larger output and an inverter for residential PV systems with 95,9 % of power conversion efficiency. Kaneka and Mitsubishi Heavy Industry (MHI) are both preparing for an enhancement of amorphous silicon PV modules' production capacity towards 2006. Hitachi increased production capacity of bifacial single crystalline silicon bifacial solar cells from 6 MW/year to 10 MW/year.

New entrants announced the construction of new plants; Fuji Electric Systems announced the construction of a flexible amorphous silicon PV module plant with a capacity of 15 MW/year, Showa Shell Sekiyu also announced the establishment of a CIS PV module plant with a capacity of 20 MW/year, Honda Motor disclosed plans to construct a CIGS PV module plant with a capacity of 27,5 MW/year. Clean Venture 21 and Fujipream jointly announced the construction of a light-concentrating spherical silicon solar cell and module plant with a capacity of 12 MW/year.

In the area of the silicon feedstock and wafer production, Tokuyama completed the construction of a solar-grade polysilicon (SOG-Si) plant with a capacity of 200 t/year, using the Vapor to Liquid Deposition (VLD) process and has begun demonstrative research. Chisso planned a demonstrative research for mass production of solar-grade polysilicon (SOG-Si) with a SiCl4 zinc reduction process. M.Setek started to build an integrated manufacturing plant, covering from polysilicon to silicon wafer for solar cells.
Besides these activities, with the growth of the PV system market, manufacturers of inverters and raw material providers for PV cells/modules have been actively increasing their capacity investment.

In the distribution of PV systems, Misawa Homes started to adopt the PV system as standardized equipment for residential houses. This movement has penetrated other housing companies such as PanaHome, Sekisui House, Daiwa House Industry, as well as major prefabricated housing companies, after Sekisui Chemical followed Misawa Homes with successful results. Providing PV system equipment in newly-built housing is now becoming a regular practice.

As stated above, PV installations in Japan have been steadily and ceaselessly expanding in 2005, based on the strong industrial structure around the PV system, which realized 1 GW of cumulative PV capacity. However, due to the phenomenally rapid growth of worldwide demand for PV systems over the past three years, a shortage in the supply capacity of raw materials and component materials for PV cells/modules started to become an obstacle for the growth of PV market. While PV cell/module production capacities are being expanded, expansion of component and raw materials supply capacity for PV cells/modules arens't able to meet the demand.

MARKET DEVELOPMENT

Through the measures for introducing PV systems, mainly implemented by METI, the market development of residential PV systems and PV systems for industrial and public facilities are underway. The size of the residential PV market grew to 50 000 systems/year through the government support programs for introducing residential PV systems, which have been conducted for the past 12 years. PV manufacturers have been working on expansion of the market for residential PV systems for both newly built and existing houses by cost reduction of the PV system and

Fig. 7 - PV system using Dye-sensitized Solar Cell (DSC) at Toyota Dream House "PAPI", Nagakute Town, Aichi Prefecture.

commercialization of PV modules with higher efficiency, as well as small-sized PV modules which can enlarge the installed area, fitting to the shape of the roof. In the newly built residential house market, housing manufacturers enhance efforts for energy conservation and the reduction of CO_2 emission. Accordingly, some of the housing manufacturers adopted PV systems as standard equipment and the number of such companies has been increasing, and major housing companies also followed this movement. Housing manufacturers strengthen their nationwide sales activities via TV commercials. Especially, for the concept of zero-utility charge house using the PV systems, a new concept for the residential house was created; buyers, who recognize economical efficiency for the running costs of the house, as well as the environmental value, are increasing.
In the PV market for existing houses, PV manufacturers established the sales channels with local builders, electric contractors, electric appliances stores and roofers, etc. and cultivate buyers all over Japan.
Through the long-term field test projects, PV systems for non-residential use, such as for public and industrial facilities have seen significant progress, year by year, in many aspects: economical efficiency, grid-connection technology, design and installation as well as system efficiency. Consequently, opportunities for market expansion have been increasing and diversified in such areas as application, design, installation sites, power generation capacity and introducers of the PV system and the market development of non-residential area is in progress. As for the installation sites, the PV system have been made to a wider variety of places in addition to public facilities (schools, government office buildings, community buildings, water purification plants, welfare and medical facilities) and industrial facilities (factories, warehouses, laboratories, office buildings, commercial buildings). In addition to these sites, recently, PV systems have been installed to agricultural facilities (farm houses), commercial facilities (shopping malls, family restaurants), railway facilities (station buildings and platforms), road facilities (parking lots and expressway toll booths), financial facilities (banks, etc.), transport facilities (logistics centers, etc.) and resort facilities (hot-spring resorts, etc.). Generation capacity of one installation site has been increased to as large as 5 MW. The introducers, who purchase PV systems to install, are very much varied, from large to small-sized local governments, large corporations to sole proprietors, and to public-interest organizations and nonprofit organizations (NPOs). Furthermore, some companies have been introducing the PV system to their factories and offices nationwide; and are installing additional PV systems to existing PV-equipped facilities. Others have been introducing the PV system intensively in specific areas or introducing large-sized PV systems, and the number of such companies has been increasing year by year.

FUTURE OUTLOOK

The Government of Japan drew up the Kyoto Protocol Target Achievement Plan toward 2010 and presented extensive and various action items in the Plan. The Plan stipulates that introduction of new and renewable energy will be promoted because the PV system, wind power generation and biomass, etc. significantly contribute to countermeasures against global warming and improvement of the energy supply's self-sufficiency ratio. In addition, it is mentioned that micro-grid utilizing PV and wind power generation, biomass, fuel cells and other new energy technologies will be introduced to promote implementation, technological development and demonstration of advanced model projects, in order to facilitate a multifaceted introduction of new energy and secure the flexibility of energy. Moreover, as the national direction of countermeasures against global warming, the Plan requires shared responsibility by the national and local governments, businesses and citizens to play a role in achieving the Kyoto Protocol target. The Ministry of Economy, Trade and Industry (METI) held a meeting of the Subcommittee of New Energy of the Advisory Committee on Energy and Natural Resources to achieve the new energy introductory target by 2010. The Subcommittee started to consider appropriate measures for disseminating new energy, including evaluation and reexamination of the Renewable Portfolio Standard (RPS) Law. The direction of new and additional measures on the PV system will be revealed, based on the achievements made, thus far.

As for future measures, the framework for dissemination of the PV system by METI and the Ministry of the Environment (MOE) will start, as MOE recently joined in the work on dissemination measures on a full scale, in line with METI, which has been responsible for the dissemination of the PV systems on its own. METI will enhance introduction of PV systems into public, industrial facilities and complex housings through the Field Test Project on New Photovoltaic Power Generation Technology, and designate these application areas as the future driving force for further deployment of the PV system. MOE, which set up the "creation of 'the nation of the environment' to establish a new era," as the prioritized measure in FY 2006, will start "operation solar," a program to reduce CO_2 emissions and to launch deployment of PV systems.

As for the PV market, finally the residential PV system market has made the first step to be an independent and self-sustainable market since the monitoring program for residential PV system started in 1994. As major manufacturers of residential PV systems have grown to produce products to meet the needs of the residential market in Japan and the number of housing manufacturers sell houses equipped with the PV system as standard equipment has been increasing. Also, the nationwide distribution network has been established lead by major solar cell manufacturers to promote installations of PV system to existing houses. It is expected that the PV manufacturers will promote further cost reduction of the PV system and build up a stronger partnership with housing manufacturers and housing-related industries to expand the market size with annual sales of 100 000 to 200 000 systems (400 - 800 MW/year), taking advantages of such strong infrastructures of the production framework and the distribution channel. Meanwhile, as for the market for non-residential application, it is assumed that creation of the initial market of PV system for public and industrial uses will advanced with the support of the national measures to disseminate the PV system.

The end-users of the PV system; individuals, industries, local governments and ministries and agencies have been gaining better understanding in the significance of introducing PV systems. It is expected that the introduction capacity of PV systems in Japan will steadily increase in the future.

KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK

In 2004 and 2005, the implementation of the new national plan, "The 2nd Basic Plan for New & Renewable Energy Technology Development & Dissemination" with a target to attain 3 % share of New and Renewable Energy by year 2006, 5 % by year 2012 Government, Korea Ministry of Commerce, Industry and Energy (MOCIE), sharply increased the national budget for renewable energy to 196,4 billion KRW in 2004 and 324,4 billion KRW in 2005 compared to 119,3 billion KRW in 2003. MOCIE selected photovoltaics, hydrogen and fuel cell, and wind power as three main areas to develop and promote during the next 10 years in Korea. PV is especially expected to be relatively mature for near-term deployment and to be a promising and economically viable technology in the near future for Korean environmental and geographical conditions. Therefore, the Korean Government expects that PV has a major role in reducing environmental pollution and has been selected as a high priority programme.

Fig. 1 - PV powered Green Village in Kwangju Metropolitan City under the 100 000 Rooftop Programme. Total 96,9 kW grid-connected PV systems are installed on the roof of 46 residential homes.

NATIONAL PROGRAMME

Korea's renewed PV implementation plan is composed of 100 000 residential roof-tops and 70 000 commercial and industrial buildings, for a total capacity of 1,3 GW by the year 2012. The annual budget for the roof-top program increased to 6,3 billion KRW in 2004, 16 billion KRW in 2005 and will be 49 billion KRW in 2006. The new plan for this technological progress is divided into different steps focusing on developing the technology for mass distribution and commercialization of PV. In the short-term, PV cell R&D is focused on crystalline silicon. The target is to increase PV module efficiency from the current 12 % to 15 %, until the year 2006, and to 18 % until the year 2010. The cost target of the module is 5,4 USD/W until the year 2004, 3,3 USD/W until the year 2006 and 1,9 USD/W until the year 2010. Finally, targeted developed technologies will be commercialized by the year 2012.

Since 1993, the MOCIE has been implementing, via the KEMCO (Korea Energy Management Corporation), demonstration and field tests of various renewable energy technologies. In addition, the government has been encouraging and supporting local authorities to implement their own demonstration or field test projects under the framework of the "Local Energy Development Programme." This programme aims in part to raise public awareness on renewable energy technologies and to develop indigenous renewable energy sources for each region. In both of these projects, PV technology remains the top priority.

- The Public Building Obligation Programme: This programme was implemented in 2005 and was applied to newly installed public buildings larger than 3 000 sq. meters with and obligation to invest in renewable energy equipment, such as PV, at more than 5 % of the total building construction cost. As a case of this programme, a building in "Blue House, Presidential House" was modified to install a 15 KW PV System in 2005 and has been shown to the public for PV promotion as a guided tour of Blue House. By 2005, the total investment for renewable equipment was 68,6 billion KRW and PV was composed of 19,7 billion KRW. This programme will contribute to increase the Korean PV and Geothermal market in the coming years and provide a major BIPV opportunity for the "New Administration Complex City Plan" and the "Relocation of Public Enterprise" from 2010.
- The Renewable Energy Field Test Programme: Several PV rooftop systems have been tested at the "Solar Energy Field Test Site" at Chosun University in Gwangju metropolitan city. System performances and reliability are tested and evaluated.
- The Local Energy Development Programme: Under the local energy development project, a wide variety of PV systems including off-grid domestic, non-domestic and grid-connected systems were constructed (Fig. 1 & 2). In 2004, the government allocated more than 36,9 billion KRW for this programme, PV accounted for more than 43 %. Local authorities, in cooperation with the MOCIE, implemented a variety of PV system installation aimed at increasing public awareness on PV and to develop PV as indigenous renewable energy sources for their region. It is worthy to note that several local authorities started the planning of "Green Village" projects. The objective of this project is to construct a small-size solar village by using photovoltaic power systems and other renewable energy as much as possible. In 2004, three local authorities, Gwangju, Daegu metropolitan cities, mainly for PV and Jeju Island, mainly for wind power, were beneficiaries of "Green Village" projects.

As a collaborative project, known as DURE-Gobi Project with Mongolia, KIER has installed a PV (5kWp) - Wind (3kW) hybrid system and Solar Home Systems at an isolated village in the Gobi Desert in October 2003. With the Solar Village Project through the International Joint Project between Korea and Vietnam, KIER has installed 3kW PV system and 50W solar home systems in a remote area of Vietnam in 2003. The new international collaborative project with China (DURE-Tibet) has begun in 2004. The 100kWp grid-connected PV systems have been installed in Yangbijing, Tibet and the system performances will be monitored during a 3 year period.

Fig. 2 - The 479 kW grid-connected PV systems for a sewage treatment plant in Daegu Metropolitan City under the Local Energy Development Program in 2004: The PV provides about 1,1 % of the plant's total electricity consumption.

Fig. 3 - Grid-connected 100 kWp PV systems installed at Yangbijing, Tibet by DURE-Tibet Project between Korea and China.

Based on the results of DURE-Tibet project, Korea is planning to construct very large PV systems with a capacity of 1MW, in cooperation with the Tibetan local government, beginning in 2006.

RESEARCH AND DEVELOPMENT

The PV R&D projects are mainly supported by the MOCIE, and some basic research projects are supported by the MOST (Ministry of Science and Technology). Since 2004, the Korean Photovoltaics Development Organization (KPVDO) in Korea University has been a leading organization in planning and management of R&D projects as well as in demonstration and field test projects under contract with MOCIE and KEMCO. KPVDO, directed by Professor Donghwan Kim, carries out R&D activities more efficiently and promote cooperation among the government organizations, research institutes, universities and industries. The national budget for R&D and demonstration was 8,86 billion KRW in 2004 and 14,82 billion KRW in 2005. 21 projects have been executed with the participation of 24 companies, 7 national institutes and 17 universities.
The projects implemented in 2004 and 2005 included various categories. For the short- term commercialization, 7 projects have been implemented, covering high efficiency and low cost bulk silicon solar cell, Si ingot and wafer, transformer-less PCS, BIPV and roof- integrated module. For long-term and innovative goals, three projects have been implemented in the area of a-Si and CIGS thin-film, Dye-sensitized solar cells.
In addition, in the demonstration and infrastructure area, 11 programs have been carried out. The main topics are the Road Map for Standardization and Certification, a 1MW PV Power Plant Demonstration, Solar Cell Evaluation, PV Demonstration Site Infrastructure and Public Building Demonstration etc.

IMPLEMENTATION

For the first time since 1992, the Korean PV market surpassed the over 1MW historical hurdle and has reached 2,553MW in 2004, according to an official report by KEMCO. The Korean market size will be in the 3-3,5MW range in 2004, according to the non-official industry information. The main change in 2004 was a big increase in electrification application; from 357KW in 2003 to 2,342KW covering 91,7 % of the total installation. Among the various off-grid non-domestic applications, marine application with lighthouses and street lighting were still the largest sectors of application; 161KW in 2004, followed by telecommunications, although relatively small, with less than 10KW installation. However, this application is no longer important in the market share, with 6,3 % in 2004, compared to 18,6 % in 2003.

In 2004, several dozens of grid-connected distributed systems with a capacity in the range of 3 kW to 400 kW were installed. Among them, 10 systems were for public office and university buildings and 310 systems were for rooftop systems on residential houses which increased from about 20 roof-top systems in 2003. In 2005, 870 roof-top systems were expected to be installed and over 3,000 systems in 2006, based on the government subsidy budget allocation. Grid-connected distributed sector has been intensively promoted under the framework of the "Renewable Energy Demonstration Programme" or the "Local Energy Development Programme," and "Public Building Obligation Programme."
The total cumulative installed PV power for each sub-market on the 31 December of each year, from 1992 to 2004 is shown in Figure 4. The total installed power of PV systems in Korea was 8.534 kW at the end of 2004. The total PV power installed during the year 2004 was 2,553 kW, which is nearly 5 times higher than that achieved in the previous year (563 kW).

INDUSTRY STATUS

Until 1999, the High Solar Company (independent from former LG Siltron Co. in May 1999) continued to manufacture PV cells, but this company stopped its operation in 2000. In 2001, there was no PV cell manufacturer in Korea. In 2002, two new companies entered into single crystalline Si cell production. Neskor Solar Co. produced 0,24 MW and Photon Semiconductor & Energy Co. 0,3 MW in 2003. The latter, significantly increased its production capacity from 0,5 MW to 6,0 MW in 2004 and installed a second manufacturing line of 25 MW multicrystalline Si Solar Cell by the end of 2005. These two companies provided a part of their production to domestic module manufacturers and some to foreign companies. These two companies import wafers from foreign companies.
In 2004 and 2005, four new companies, namely, Symphony Solar Co., Hyundai Heavy Industries, Kyung Dong Solar and Unison entered the PV module manufacturing business and started their operations in 2005. Nominal production capacity per company would be more than 10MW per year but they had a cell supply problem and would not release any actual production results during year 2005, until now.

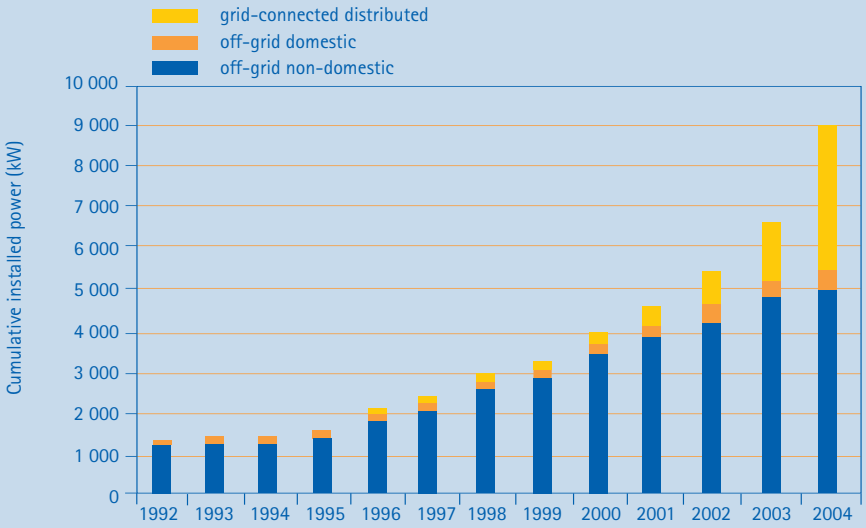

Fig. 4 – The cumulative installed PV power in 3 sub-markets.

S-energy Co., LS Industries and Solartech upgraded and expanded their current production lines. At the end of 2005, total module production capacity was about 75 MW per year. In 2004, Korean manufacturers produced about 2,7 MW of PV modules. This was only an 18 % increase, compared to the previous year's production figure of 2,25 MW. This small expansion of PV module production was due to the bankruptcy of "ATS Solar Co." This company produced about 1,4 MW PV modules with a production capacity of 3,0 MW in 2003. Most of single and multicrystalline silicon PV cells were imported from foreign countries. The average PV module prices decreased about 6 % in 2004, compared to that of the previous year. The prices were 6,500 KRW/W in average.

In 2004, Hex Power Systems Co. was the only company to manufacture inverters for grid-connected systems. This company produced various products with a capacity 1 - 100 kW. The prices ranged between 2 million KRW/kVA for a size smaller than 1 kVA and 1,5 million KRW for larger than 100 kVA, depending on the inverter size. Hyundai Heavy Industries and Hanyang Electrics developed inverters for 3KW grid-connected systems and will enter the inverter market for roof-top systems. In 2005, Hex Power Systems, Hyundai Heavy Industries and Hanyang Electrics received a national certification title for 3KW inverters, which will be on the market in 2006.

Two companies were involved in producing inverters for stand-alone systems. In the case of inverters for stand-alone systems, the average price was about 2.2 Million KRW/kVA for a size larger than 10 kVA. There is one PV battery manufacturer, Global High-tech Co. that produces lead-acid batteries of a tubular plate stationary type. The unit price of the battery with a capacity 2 000Ah/100hr is about 1 000 kKRW. Concerning the supporting structures, PV system installers used their own type of support structures made from anodized aluminum or galvanized steel. That is why the price of the supporting structures is so multifarious.

FUTURE OUTLOOK

Under Korea's new national PV plan, the goal has been increased to 100 000 roofs and 70 000 buildings for a total capacity of 1,3 GW by the year 2012. The total capacity is broken down into different sectors. Three different sizes of systems will be developed such as 3 kWp for residential homes, 10 kWp for public buildings, and 20 kWp for industrial buildings. An explosive growth of the market is expected between 2006 and 2012; once the foundation is set into place by the year 2006. The Korean government recognizes that the PV industry will grow and take up to 10 % of the world market by the year 2012, with exports amounting to 3 billion USD and employing 50,000 people. The strategies for promoting the distribution of PV systems are described below. The whole programme will be managed and monitored by the experts group organized solely for the PV technology distribution.

- Establish the foundation for mass distribution through developing PV systems for distributed electricity system. During 2001-2006, focus on developing the standardized systems for residential homes and for commercial buildings that have large potential demands.
- Set up the test sites and villages for demonstration. Establish "green villages" throughout Korea starting from Daegu and Kwangju. For new buildings, encourage the installation of 10 kW PV systems and, for factory buildings, 20 kW PV systems.
- Complete the regulatory system for promoting PV.
- Maximize the subsidization programme that has a strong short-term effect. Further promotion should be pursued by "green pricing" and other tax incentives.

To fuel the plans and strategies mentioned above, Korea will spend about 2,3 Billion USD during 2004-2012. The fund will be provided by the government. As the PV world market rapidly grows, investment from industry is expected to quickly increase.

MEXICO

PV TECHNOLOGY STATUS AND PROSPECTS IN MEXICO
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Fig. 1 - San Juanico PV-Wind Diesel Hybrid and mini-grid system in operation since 1999.

GENERAL FRAMEWORK

Implementation of PV systems in Mexico during 2005 experienced a slower pace compared with previous years. Rural electrification still remains the main application. However, applications such as water pumping for small irrigation and livestock watering, seem to be leveling off as a result of the GEF-supported program for agricultural applications coming to an end this year. During its 5 year lifetime, this program, better known as the FIRCO program, has supported the installation of more than 1 700 small PV systems for agricultural applications (each under 3 kWp in capacity), On the other hand, new applications in the urban setting are emerging. Such is the case of the 30 kWp grid connected PV system, recently installed in Mexico City.

NATIONAL PROGRAMME

In December 2005 the Lower House of Congress approved a bill to create the law to foster the use of renewable energy resources in Mexico. Although not specifically addressing any renewable energy resource in particular, the bill carries elements that could positively impact the implementation of PV systems. For instance, it obliges the national electric grid operators to take up, at any time, electricity generated from intermittent renewable energy resources; mandates the creation of a Green Fund to provide incentives to feed renewable energy-based electricity to the national grid; and mandates the creation of a Fund to foster Emerging Technologies whose generating costs are not yet competitive with conventional alternatives.

Furthermore, a Rural Electrification Fund will be created to support projects with renewable energy in remote communities. The goal of the bill is to increase the contribution of renewable energy resources, other than large-scale hydroelectric power plants, to 8 % of the total electricity generating capacity of this country by the year 2012. This bill is yet to be ratified by the Senate, which is expected to happen in early 2006.

Recent studies carried out in preparation of a forthcoming rural electrification program with renewable energy, to be co-funded by the GEF, the World Bank and the Mexican Government, show that PV would be the least expensive alternative in more than 51 % of the almost 9 500 targeted communities in four southern states.

RESEARCH AND DEVELOPMENT

The national electric utility, Comision Federal de Electricidad (CFE), has launched several initiatives in preparation for a large-scale effort to deploy grid-connected PV systems. Among them are development of technical guidelines for interconnection with the national grid, studies about the impact of PV neighborhoods on the grid and studies on potential economic benefits for domestic PV users; given the current structure of the electricity tariff scheme. A pilot neighborhood of 100 houses with PV roof tops of 1 kW each is planned for implementation in northwest Mexico during the year 2006.

Fig. 2 - PV pumping system provides drinkable water to rural communities.

IMPLEMENTATION

The first privately owned grid-tied PV system is on line since December 2005 in Mexico City. System performance monitoring and evaluation is being carried out by the Electrical Research Institute (IIE) in collaboration with Luz y Fuerza del Centro, the electric utility serving the metropolitan Mexico City area. The PV array constitutes the roof of a health food store called "The Green Corner." An electronic display has been installed at a visible site in the store, to show customers in real time how the PV system performs.

MARKET DEVELOPMENT

The Mexican PV market during 2005 was a little over 0,5 MWp, which reflects a market contraction of almost 50 % in comparison with the previous year. Market segmentation was as follows. Rural electrification 307 kWp, which includes 242 water pumping systems with a total capacity of 200 kWp; 30 kWp for the grid connected PV system mentioned above; and 175 kWp in professional applications (telecommunications, off shore oil platforms and cathodic protection) Thus, the cumulative PV capacity installed in Mexico by the end of 2005 was 18,65 MWp.

FUTURE OUTLOOK

Grid-connected distributed generation is attracting the attention of the national utility as an alternative to support the electrical grid in some areas, and could become an important market for PV in the near future. Rural electrification is still a top priority for the Federal Government. A forthcoming 4-year rural electrification project co-financed by the GEF, the World Bank and the Mexican Government could help revitalize this market niche.

Fig. 3 - The Green Corner: First privately owned PV grid connected system in Mexico.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK

In 2005, the investments in solar PV in the Netherlands, which had already dropped from 19,8 MW in 2003 to 3,2 MW in 2004, decreased further to 2 MW. This was caused by the gradual ending of the projects, still financed under the previous EPR and MAP schemes, which stopped in 2003. The remaining market is mainly based on local and regional support and the last phase of a running subsidy project.

The new support scheme for Energy RTD, the EOS (energy research subsidy) programme, on the other hand gave a new boost to PV RTD. As a result of a wide consultation amongst energy, research, industry and policy professionals, PV was appointed as one of the priority R&D areas. In the first two calls of the EOS programme, PV RTD came out well in the open competition against the other priority areas, due to the high quality of the proposals.

Though the market for PV was slow in 2005, the PV cell manufacturer Solland Solar started its new activities on the Dutch - German boarder; with a production capacity of 20 MW/year.

NATIONAL PROGRAMME

At the end of 2004, the Ministry of Economic Affairs started the new EOS (Energy Research Subsidy) programme. The new programme consists of five sub-programmes aiming at new ideas, fundamental research, knowledge transfer, demonstration and unique opportunities respectively:

- NEO: New Energy Research, focussing on new, unconventional ideas. This programme is mainly intended for inventors. The programme covers all new energy options.
- EOS LT: Energy Research Subsidy - Long Term, focussing on long term research on a selected range of promising energy saving- or renewable energy technologies, with expected serious impact between 2010 and 2030.
- IS: Innovation Subsidy Collaboration Projects, focussing on technology transfer from research to industry, in order to convert technologies into products.
- EOS Demo: Energy Research Subsidy - Demonstration, focussing on testing and demonstrating new energy saving- or renewable energy applications in a realistic user environment.
- Transition UKR: Transition - Unique Opportunities Scheme, focussing on improvement of material- and energy use and on the application of renewables in general and biomass in particular.

NEO, IS and Transition UKR have a generic character, supporting all activities in the addressed area.

For the EOS - LT sub-programme 5 priority areas were selected:

- Energy efficiency in industrial and agricultural sectors
- Biomass
- New gas / clean fossils
- Built environment
- Energy generation and networks / grids

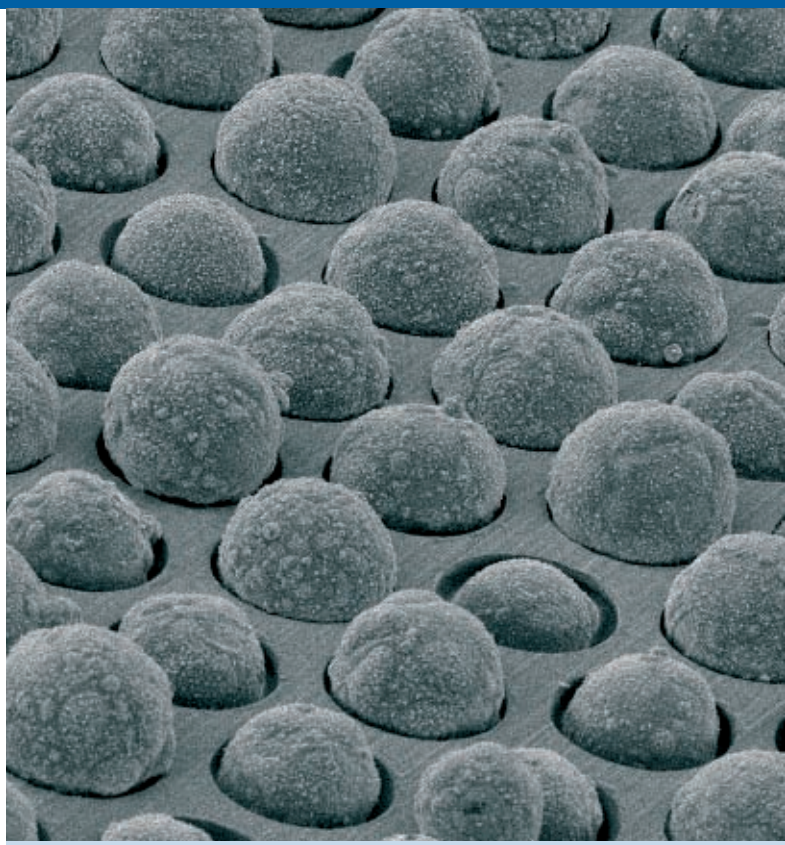

Fig. 1 - Electron microscope picture of CIS coated glass spheres on substrate at Scheuten Solar.

Within each of these areas, 4 to 7 topics related to the Dutch energy research fields were identified. Of the total of 26 topics 2 address PV specifically: 'Solar conversion: multi-crystalline silicon PV technology' and 'Solar conversion: thin-film PV technology.' PV research is furthermore included in a few other topics, such as 'System approach in the built environment and local energy generation,' 'Electricity conversion, power quality customer power converters and EMC' and 'Electricity storage, small-scale storage and system applications.'

EOS - Demo largely follows the EOS - LT topics, aiming at the implementation of the results thereof.

The total budget for the energy focussed programmes is around 36 MEUR/yr. In 2005, approximately 4 MEUR thereof was awarded to PV RTD projects. The contribution to energy research from the more general IS and the Transition UKR programmes depends on the ranking of the projects. The contribution to PV RTD for 2005 is estimated to be negligible.

Implementation of PV is not covered by a national programme. Instead a feed-in tariff and net-metering are available. The feed-in tariff of 0,097 EUR, however, is too low and requires green certification and membership of the management organisation. Net-metering became available in 2005.

Fig. 2 - New technology at Solland Solar: laser edge insulation incorporated in the new 20 MW production line.

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2005 three main lines in PV RTD activities could be recognised:

- Solving the silicon shortage problem by reducing the silicon consumption per Wp and developing production processes for SoG (solar grade silicon). RTD activities include the improvement of the AkzoNobel roll-to-roll process and the ECN work on RGS - wafers. In the field of SoG special attention is given to the relation between impurity levels and cell efficiencies.
- Improving cell production processes, using new cell concepts and new or improved production technologies. Here two projects stand out: 1) development of CIS cells based on 0,2 mm CIS coated glass spheres, homogeneously distributed over a grid-shaped substrate at Scheuten Solar (Fig. 1 and Fig. 2) application of a radio frequency modulated expanding plasma for fast deposition of amorphous silicon at the TU Delft.
- Improving the efficiency of future generation cells through hetero-junctions and up- and down conversion of photons. In this field several projects were running or initiated in 2005. There are interesting projects aiming at integrating several cell improvement techniques, such as thin silicon wafers, back-side contacts, hetero junctions and down-conversion into a new cell concept.

In addition to the EOS - LT programme, FOM and Shell launched a call for fundamental pre-competitive PV RTD projects. The call was opened in 2004 with a total budget of 3,0 MEUR. After a process of pre-selection and selection, seven projects were awarded. The projects started early 2005, and cover subjects such as quantum dots, up- and down conversion and light trapping.

The main players in the fundamental Dutch PV RTD activities are ECN, Scheuten Solar, AKZO, TNO, Solland Solar, the Universities of Utrecht, Eindhoven, Groningen and Delft and FOM-AMOLF.

Very little RTD work was done in the field of BOS. The development of the wire-free mounting system was continued, and some work was started on life cycle assessments and energy payback times of full PV systems.

At the international level, Dutch PV RTD centres and industries collaborate in several networks, amongst which the CrystalClear project, which is co-ordinated by ECN and started early 2004. Other PV RTD or PV RTD related international projects granted in 2004 are PV-ERA-NET and the PV Policy Group.

Bilateral co-operation was initiated between ECN and the French institutes CNRS and CEA. The joint project was submitted to both the EOS LT programme and the French ADEME's Photo-voltaic Programme.

INDUSTRY STATUS

Based on the strong growth of the world PV market, a slight revival of PV industrial activities took place in 2005. Solland Solar opened a crystalline silicon cell factory on the Dutch - German boarder (Fig. 2) and Ubbink Solar and Econcern initiated the construction of a PV module factory in Doesburg. The Solland factory has an initial production capacity of 20 MW, which will be expanded to 500 MW by 2010. Ubbink Solar will have an initial capacity of 5 MW in 2006, but an expansion to 200 MW by 2010 is expected.

Though Shell stepped out of the AkzoNobel/Shell Heliantos project at the end of 2004, AkzoNobel continued, although at a lower pace, the development of a roll-to-roll amorphous silicon thin film cell production process, and delivered the first cells from a pilot production line with an efficiency of 6 %. The work on a second generation cell has also continued, and the first results showed a significant increase in efficiency. The retreat of Shell, however, leaves AkzoNobel with a budgetary problem and in search of a new strategic partner.

DOPT, in 2004 the only serious Dutch PV module manufacturer, had to decrease his production due to the silicon and wafer shortage in the market.

DEMONSTRATION PROJECTS, IMPLEMENTATION AND MARKET DEVELOPMENT

In 2005, the implementation of PV, which had gone back from 19,8 MWp in 2003 to 3,2 MWp in 2004, is expected to have decreased even further to an estimated 2,0 MWp. Projects carried out or finalised in 2005 were still partly supported by former subsidies and partly by local or regional funds. The MEP regulation, offering a feed-in tariff of 0,097, does not appear to stimulate new PV projects. This is partly caused by the low level of the tariff, partly by the fact that application for the feed-in tariff requires a membership of EnerQ, the managing body of the MEP regulation, the purchase of a special meter and the acquisition of green-certificates. For most, especially building integrated PV projects, the costs and efforts of acquiring MEP subsidy are too high, compared to the income.

The EU supported project, City of the Sun Project, again made progress in its goal of installing 5 MW in the to-be-developed HAL districts (between Heerhugowaard, Alkmaar and Langedijk) and reached 3,7 MWp by the end of 2005.

FUTURE OUTLOOK

In the national renewable energy policy, no priority is given to market introduction of the more costly RE technologies, like solar PV. For PV, the Dutch policy focuses on R&D, especially on technology development for more cost efficient PV systems in the next decade. Nevertheless, existing PV installations may profit from the 9,7 EURct/kWh feed-in tariff, which the so-called MEP scheme offers. Also net metering for small domestic systems became available in 2005. Together, these two schemes allow private PV-owners a net subsidy of almost 30 EURct/kWh. As mentioned earlier, however, access to these schemes is complicated and expensive for smaller systems and is therefore not expected to generate any serious implementation.

From the new EOS programme, which opened at the end of 2004, the EOS - LT sub-programme appears to be favourable for fundamental PV RTD. In the first 2 calls, 3,4 MEUR of the total of 20 MEUR was awarded to PV RTD projects. The international orientation of the EOS programme led to a first French - Dutch bilateral project; bringing together the expertise of ECN and the University of Utrecht in the Netherlands, and the CNRS and CEA institutes in France. BOS and system integration issues, on the other hand, are not very well covered in the EOS programme so far. The EOS - Demo sub-programme, which is meant to demonstrate the feasibility of EOS - LT and IS results are expected to follow, in the long run, the outcomes of the EOS - LT and IS priorities, and is thus expected to support PV, as well.

Notwithstanding, the modest PV market in the Netherlands, several new ideas have been generated to set-up new consortia and develop new industrial activities. These include the Ubbink Solar module factory, a pilot plant for the production of CIS modules, as well as production facilities for RGS wafers.

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
HARALD RIKHEIM, THE RESEARCH COUNCIL OF NORWAY

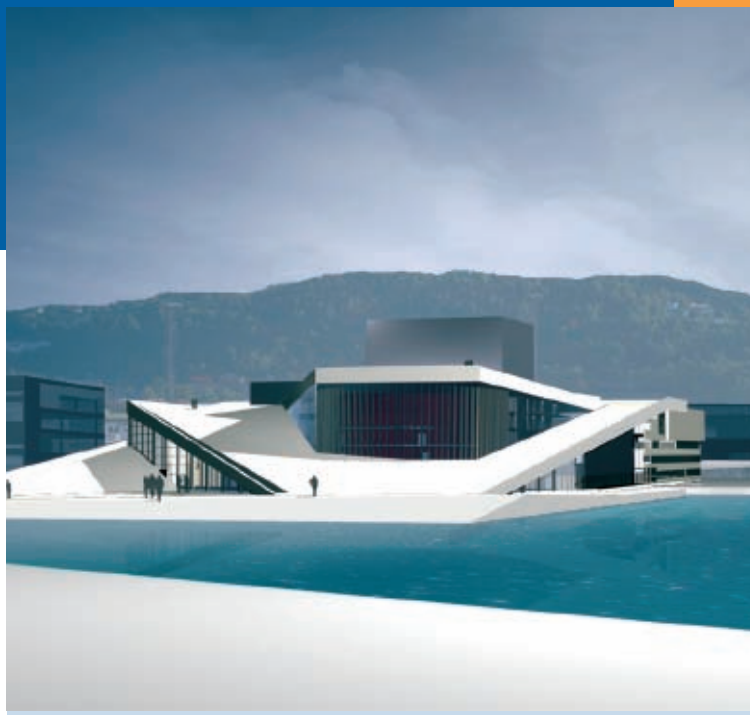

Fig. 1 - New opera house in Oslo planned with 400 m2 PV cells (photo Snoehetta AS).

GENERAL FRAMEWORK

The Norwegian electricity system is mainly supplied by hydropower. Increased usage and very little increase in production, i.e. new power plants, has lead to growing import. Increased import of fossil based electricity has increased the interest in renewable electricity production, such as wind and small hydro, but also in bioenergy as a substitute to electric space heating. There has also been an increased interest in research and development of ocean energy, such as wave and tidal.

Norway has no public schemes for supporting PV systems. Due to this, there are few large PV systems, and the main market for PV in Norway continues to be related to off-grid recreational applications and special areas such as lighthouses and telecom.

NATIONAL PROGRAMME

The energy research programme "Renergi" (www.renergi.com) in the Norwegian Research Council funds industry oriented research, basic research and socio-economic research within the energy field, including renewable energy sources. The total funds for PV-related R&D projects were appr. 6 MNOK for 2005. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells.

RESEARCH AND DEVELOPMENT

There are four main R&D groups in the institute sector of Norway:

- NTNU (Norwegian University of Science and Technology) Trondheim: 3 PhD studies. Focusing on silicon feedstock, refining and crystallisation.
- SINTEF Trondheim and Oslo: Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.
- Agder University College: Research on silicon feedstock with Elkem. Energy park with PV, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.
- IFE (Institute of Energy Technology): 3 PhD studies; second hand pilot line for solar cells recently acquired and installed. Supporting industry (Scan Cell and others).

At SINTEF Architecture and Buildings, PV research has mainly been conducted in "Smartbygg", a strategic research program in cooperation with NTNU. The project seeks to develop energy efficient building systems of the future. One project activity is innovative use of solar cells in buildings, where the solar cells are integrated in the building structure and energy system. In 2005, this research group joined PVPS Task 10. Within the framework of Task 10 "Urban Scale PV Applications," Subtask 2: "Planning, Design and Development," Norway is responsible for developing a computer based tool for analysing the integration of PV in the built environment. The work was initiated in 2005. The pilot version of the tool consists of two sections. The first section aims at determining the overall potential for applying PV in the analysis area. This section includes parameters related to solar exposure, overall energy profiles, and financial opportunities. By going through this first section, the user can get a rough overview of whether or not PV is a promising option for his/her development project. If the answer is yes, the user proceeds to the second part of the tool. This part consists of a more detailed analysis of the PV integration, including evaluation of architectural issues, energy system issues, constructional issues, economic issues, and added values like image, education, and environmental issues. Thus, the tool includes support in evaluating both qualitative and quantitative criteria related to the integration of PV in the built environment. A key feature of the tool is the evaluation assistance through a database of benchmarks and best practise examples from reference projects around the world.

SINTEF Materials and Chemistry has substantial activity related to photovoltaics and solar cell technology. The activities are centered around two aspects; - new sources and production methods for silicon to solar cell applications and - fundamental research on materials for photovoltaics. In their work on new sources for feedstock to the solar cell industry, they are involved in a number of EU projects and programmes in collaboration with European industry, universities and research institutes. Here can specifically be mentioned the strategic targeted project FoXy, within the 6th Framework, which is coordinated by SINTEF and has a wide range of participants from across Europe.

Within the field of photovoltaic materials research SINTEF works in close collaboration with the rapidly growing Norwegian industry in this sector, with financial support from the Norwegian Research Council. Norway's main industrial partners in this field are Elkem, REC and REC-ScanWafer, while NTNU and IFE are Norway's main partners on the R&D side. In particular, the project Crystalline Silicon Solar Cells - Cost Reduction can be mentioned. In this project, fundamental research on silicon as a photovoltaic material is conducted in order to lower the cost of electricity from solar cells. The project is supported by the RENERGI program within the Norwegian Research Council.

Fig. 2 - The solar cell system at DNV headquarters (photo DNV).

Fig. 3 - Vest Agder Clinic in Kristiansand, part of PV-NORD project (photo PV-NORD).

SINTEF Materials and Chemistry has together with NTNU invested in advanced laboratory facilities for the production as well as characterization of silicon based materials for solar cell applications. A unique pilot furnace with a total charge of 12 kg Si for directional solidification of silicon ingots, together with advanced characterization equipment covers the chain from raw materials to characterized wafers. This includes dedicated optical scanning equipment for crystal defect studies in silicon wafers (PVScan). In cooperation with Fraunhofer-ISE and Aescusoft Automation in Freiburg, Germany, SINTEF is developing advanced characterization equipment for the study on the lifetime of minority charge carriers based on the CDI principle.

SINTEF Materials and Chemistry work in collaboration with IFE which runs a pilot line for the processing of solar cells from wafers and together, they cover the whole production chain from raw materials to solar cells.

Agder University College has an Energy Park, which includes a 20 kW photovoltaic array, consisting of 10 kW amorphous cells and 10 kW multicrystalline cells. The focus of this installation has so far been demonstration of an integrated energy system, and the power produced by the PV-system has mostly been inverted and fed to the local electricity grid.

Institute for Energy Technology (IFE) is a private research foundation with about 550 employees. IFE's activity on solar electricity is comprehensive involving 15 persons; covering basic research on feedstock of silicon, process development, process optimalisation, processing and characterisation of silicon solar cells, and finally modelling and analysis of integrated PV-systems. IFE has a full inline solar cell processing line for silicon based solar cells. In addition, advanced characterisation laboratories for material, electrical and optical properties are also present.

IMPLEMENTATION

The main market for PV in Norway continues to be related to off-grid applications. This refers to both the leisure market (cabins, leisure boats) and the professional market (primarily lighthouses/lanterns along the coast and telecommunication systems).

Up to 1992, the leisure market, dominated by new installations in cottages and recreational homes grew rapidly. After 1992, this market slowed down due to saturation. However, some cabins have been fitted with additional power to serve new demands such as TV and refrigeration. Since the first installations are now more than 30 years old, it will probably make sense to begin replacing systems, rather than doing maintenance. Still however, there are not many reports about customers wanting to replace old installations with new ones. Most sales are only for new installations or expansions. In the 1990s, PV powered coastal lighthouses emerged as a significant new market. Even north of 70°, lighthouses may be powered by PV, provided the battery bank has sufficient capacity. The programme was launched by the Norwegian Coastal Administration in 1982 and was completed in 2000-2001. Approximately 1 840 installations with a total of 3 600 modules are now supplying lighthouses and coastal lanterns along the Norwegian coast. The smallest are equipped with one single module of 60 W, the largest with arrays counting up to 88 modules. A large number of the systems are powered by 3 to 4 modules of 60 W. The average is 135 W per installation. The cumulative installed PV power capacity is 215 kW. The installations are equipped with battery banks (NiCd) with spare capacity ranging from 10 to 120 days and mean lifetime of 20 years. In the future, solar power will be combined with other renewable energy technologies in hybrid systems. The Coastal Authority is presently testing small wind turbines in combinations with PV. Solutions including fuel cells are also being considered.

Norway does not have any incentive schemes supporting the installation of PV systems, and consequently, there are very few grid-connected systems. However, some building integrated installations are, however, been built during the last few years. Among these are NTNU in Trondheim (16 kW), the BP administration building in Stavanger (approximately 16 kW), the low-energy dwelling at Hamar (2,2 kW) and a private dwelling in Bergen (1,2 kWp). Other projects being planned or built are:

Vest Agder Clinic in Kristiansand: The PV system consists of a total of 48 modules arranged in two strings of 24 modules each. The module brand is GETEK PVP102012, made by GPV in Sweden. Each module has a 102 Wp capacity (12V). There are two inverters, one for

Fig. 4 - Production of silicon feedstock at Elkem Solar (photo Elkem Solar).

Fig. 5 - Pilot furnace at SINTEF Materials and Chemistry.

each string, type SMA Sunnyboy 2 100. The PV system is connected to the grid through two 16 A circuits. The system was made operational in February 2004, with an expected power production of 5 000 kWh/year. (see www.pvnord.org)

New opera house in Oslo: The most exciting building integrated project currently being planned is the use of transparent double glass modules on the 400 sqm southern façade of the new Opera house of Norway, to be located in the Oslo Harbour area, see picture. This is part of an EU project EcoCulture.

Det Norske Veritas (DNV) outside Oslo: The ongoing DNV project "Høvik Feasibility and Demo" includes a solar cell panel installation at DNV headquarters. The project has obtained funding from Enova (Norwegian Energy Agency). The goal of the Høvik Feasibility and Demo Project is to prepare a strategy for changing the energy usage at the DNV headquarters in Høvik towards more sustainable energy solutions. A conceptual design of viable renewable energy technologies is being developed for implementation at Høvik. Contributing to this goal, solar cell panels and ancillary equipment has been purchased and roof mounted at DNV headquarters in February 2005 to provide an estimated annual production of 1,900 kWh. The electricity generated is utilized in the existing charging units for electric cars. A real-time monitoring system is being installed to allow close tracking and analysis of both energy production and operational behaviour.

INDUSTRY STATUS

Elkem Solar (ES) was established in 2001 and its main objective is to develop a process for feedstock to solar cell production. With the developed metallurgical route, ES has the potential to be an important player in this market. During the last year of development, feedstock from ES has been tested industrially. Silicon from ES (ES-Si) has been mixed with standard feedstock in the range 25 to 65 per cent, and the obtained solar cell efficiencies are similar to what is obtained with standard charge. Results from these tests have been published at 19th EUPVSEC in Paris, June 2004 and the latest at the 31st IEEE PV Specialist Conference in Orlando, Florida, USA, January 3rd to 7th this year. Cell efficiencies above 16 per cent have been demonstrated. From being a research organisation, ES is now building up production capabilities. The first production plant will be a pilot scale unit planned to start operation in third quarter of 2005. The next development phase is a production unit with a minimum capacity of 2500 MT/year.
Renewable Energy Corporation (REC) is a significant player in the international solar energy industry. From the headquarters and R&D centre at Hövik outside the Norwegian capital of Oslo, subsidiaries are operated on three continents. REC is the only company in the world that covers the whole value chain of solar energy - from the manufacturing of solar grade polysilicon feedstock to the marketing of photovoltaic systems to the consumer.

The value chain from silicon feedstock to solar systems, based on multicrystalline silicon wafers, consists of 6 distinct production steps. The research staff in Solar Grade Silicon is now conducting experimental tests in a pilot 200 ton/year fluid bed reactor (FBR) built in 2004 by Solar Grade Silicon. The experiments will study reactor design, further scale-up and process parameters for production of polysilicon from silane. The goal of the research is to determine the design of a commercial reactor for large-scale production of PV feedstock. REC Scanwafer is currently expanding its plant NR. 3 in south of Norway (Porsgrunn) started up 2003 and is ready to invest in a twin plant on the neighbour area. REC Scanwafers total capacity (silicon wafers) when these expansions are completed is estimated at ~ 450 MW/year against a capacity of 200 MW/year at year-end 2004. Further expansions are being prepared for the West-Coast of Norway in the Aardal industrial area. REC Scancell in Narvik produced 20 MW of solar cell in 2005. Production capacity was more than doubled to 45 MW by building a second production line. REC Scanmodule in Arvika, Sweden produced about 12 MW of modules. Major expansion of production capacity will be built during Q1 of 2006.

PORTUGAL

PV TECHNOLOGY STATUS AND PROSPECTS
PEDRO SASSETTI PAES, EDP S.A.

Fig. 1 - INETI installation: 12 kWp BIPV at INETI's Solar XXI Building (photo courtesy of INETI).

GENERAL FRAMEWORK

The national PV policy is part of the general strategy and framework on Renewables established by the government. In 2005, the major change at the national energy policy level was the publication of a new government Cabinet Resolution (169/2005), which stressed the strategy for the country's sustainable development. Improving energy efficiency, reducing CO_2 emissions and increasing the use of renewable energy sources (RES) are some of the most significant objectives under this framework.

NATIONAL PROGRAMME

The government established ambitious goals for RES-E to be reached by 2010, allowing Portugal to be able to meet the targets agreed to under the 2001/77/CE Directive - 39 % of the gross electricity consumption from renewables by 2010. Wind power will form the bulk of the new installed capacity (from the current 1 000 MW to about 5 100 MW by 2010), while PV's contribution is set to increase from the current level of about 3 MW to 150 MW. The PV market development mechanisms are mainly based on a favourable feed-in tariff, together with a financial incentive system (PRIME, 2000-2006), as well as other indirect market instruments (taxes).

The main legal and incentive framework related to PV is:

- Decree-Law 312/2001 defining the conditions regulating the awarding and management of grid interconnection points for Independent Power Producers (IPP).
- Decree-Law 33-A/2005 establishing a range of favourable feed-in tariffs for RES electricity.
- Decree-Law 68/2002 regulating the delivery of electrical energy into the low-voltage grid (micro-generators, including PV).
- PRIME (Incentive Programme for the Modernisation of the Economy), which provides financial incentives, namely for energy efficiency and endogenous energies projects.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Fundamental research activities are focused on amorphous and nano-crystalline thin film silicon technologies and involve mainly public bodies (Universities):

- CENIMAT: Department of Materials Science, Faculty of Sciences and Technology (New University of Lisbon).
- LAFS: Laboratory of Photovoltaic Applications and Semiconductors (University of Lisbon).
- Department of Ceramics and Glass Engineering/UIMC (University of Aveiro).

Other institutions, such as Public Research Laboratories (INETI - National Institute for Engineering Technology and Innovation), Energy Agencies (ADENE and regional agencies), utilities (EDP) and private research institutions (INEC Porto - Institute for Systems and Computers Engineering), are performing applied research and implementing PV demonstration projects. Besides these institutions, associations such as SPES (National Solar Energy Society) and APISOLAR (manufacturer and installer association) are also involved in dissemination activities.

IMPLEMENTATION

In 2005, the government agency DGGE (Directorate General for Geology and Energy), which manages the IPP licensing process, decided to close the quarterly allocation of grid interconnection points for PV. This was due to the huge amount of requests received (more than 3 000) which exceeded largely the national target by 2010 (150 MWp).

Fig. 2 - German School: 25 kWp grid-connected PV system at the Lisbon German School (photo courtesy of Jayme da Costa) .

From 2002 to 2004, about 104 MWp PV capacity had already been licensed (see Table 1). The remaining 46 MWp will likely be allocated through a tender process, to be launched yearly from 2006 on.

Furthermore, the feed-in tariffs for PV were revised in 2005, decreasing about 17 %: 0,28 EUR/kWh for systems with installed power above 5 kWp (0,32 EUR/kWh in 2004) and 0,45 EUR/kWh for systems up to 5 kWp (0,54 EUR/kWp in 2004), guaranteed for the first 15 years of operation or the first 21 GWh/MW provided to the grid (whatever comes first). Before this amendment, the tariff was guaranteed for the lifetime of the plant.

Financial incentives are available under the PRIME programme (2000-2006) - III EC Framework Programme. Grants are provided on the basis of energy and environmental value of the projects, up to 40 % of the total eligible cost, with a maximum grant of 150 kEUR per application. So far, only four PV projects applied and only two received support.

Indirect market development mechanisms for renewables consist of: reduction of VAT rate from 21 % to 12 % on renewable equipment, custom duties exemption and income tax reductions (up to 730 EUR for solar equipment).

In 2005 only a few of the already licensed grid-connected installations were realised: six small-scale (5 kWp) systems. Besides these, the following projects were also implemented:

- The first Portuguese building integrated project, at the Renewable Energy Department of INETI - the Solar Building XXI - consisting of 12 kWp multi-crystalline PV modules mounted on its vertical south facade (see Figure 1). This innovative project uses PV for power generation (mainly self-consumption) as well as for space heating (heat recovery from the modules back surfaces). The project was partly funded by the PRIME programme. Another PV system, composed of amorphous silicon modules with 6 kWp power, was also installed to provide shaded parking for the building's car parking lot.
- 25 kWp grid-connected system (multi-crystalline and amorphous) at the Lisbon German School (see Figure 2). This project is part of an initiative launched by the German Energy Agency (DENA) - Renewable Energy Export Initiative -, which aims at installing solar roofs on German schools and other institutions, both in country and abroad.

Also in 2005, two large power plants got the so called "establishment permit" or licence to construct:

- The world's largest centralised PV plant (~50 MWp), to be installed in east Alentejo (Moura municipality). BP Solar, one of the main stakeholders, will build a new module factory in the region. The project will likely start in 2006 (civil works, factory, 1st stage of the power plant).
- The PSIA power plant, a 2,15 MWp system to be installed in south Alentejo (Almodovar municipality), the modules being mounted on 2 axis tracking systems. The system is planned to start operation by the end of 2006.

INDUSTRY STATUS

So far there is no silicon/wafers production in Portugal. Lobo Solar is manufacturing Shell Solar module (mono- and multi-crystalline) in its assembly plant located in Evora. The maximum annual production capacity is 17 MWp. The factory employs about 90 people.

Batteries for PV stand-alone applications (solar type and stationary) are also manufactured in Portugal (Tudor and Autosil).

TABLE 1: PORTUGAL'S LICENSED PV CAPACITY FROM 2002 TO 2004

	JAN 02	MAY 02	SEP 02	JAN 03	MAY 03	SEP 03	JAN 04	MAY 04	TOTAL
Nbr.	1	3	5	11	13	3	17	6	59
P (kVA)	49 600	10	12 958	36 429	4 329	110	187	27	103 650

A dozen companies are supplying and installing PV modules and BOS components imported from the EU, USA and Japan. A few of these companies produce power electronics for stand-alone PV applications.
The estimated sales of the national PV industry was about 22,5 MEUR in 2005.

TABLE 1- PORTUGAL'S TOTAL INSTALLED PV CAPACITY END 2004

YEAR	STAND-ALONE (KWP)	GRID-CONNECTED (KWP)	TOTAL ANNUAL POWER (KWP)	CUMULATIVE POWER (KWP)
Up to 1995	324	12		336
1996	88	0	88	424
1997	98	5	103	527
1998	100	21	121	648
1999	50	146	196	844
2000	216	84	300	1 144
2001	115	51	166	1 310
2002	285	73	358	1 668
2003	396	5	401	2 069
2004	554	78	632	2 701
2005*	n.a.	73	n.a.	n.a.

**Provisional data.*

MARKET DEVELOPMENT

The Portuguese PV market presents a yearly steady growth of about 30 % rate, but remains based on off-grid applications. Only a few of the grid-connected installations approved so far were realised in 2005. For this reason, the market structure compared to previous years did not change significantly (~80 % off-grid and ~20 % on-grid), the total installed capacity reaching about 3 MWp by the end of 2005.

FUTURE OUTLOOK

The PV market in Portugal is expected to expand significantly in the next few years, from the current 3 MWp to about 100 MWp, provided all the already licensed plants will be carried out. The Moura power plant will represent half of this capacity. Furthermore, the market structure will switch from the current off-grid applications, with about 80 % market share, to a structure strongly based on grid-connected systems.

The confidence of the investors and PV promoters is decreasing due to the successive changes of the legal framework in the past 3-4 years, affecting namely the feed-in tariff conditions. Besides the need of a stable framework, other measures need to be adopted aiming at accelerating the permit procedures, especially for small grid-connected systems, which are currently too time consuming.

The development of the building integrated market (BIPV), almost inexistent, will require the establishment of specific building codes and regulations as well as information campaigns in order to increase the awareness of PV among the main building actors.

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

JAVIER SANZ, CENTRO NACIONAL DE ENERGIAS RENOVABLES, CENER

Fig. 1 - PV integration on façades at the CENER building.

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

The development achieved throughout 2005 has proven that the introduction of a new legal support system for renewable energy sources, as covered in the Royal Decree 426/2004, which came into force in March last year, is the right approach in order to boost the market growth. Nowadays, all PV investors have the perception that a reasonable profitability is achievable.

The deployment of installed capacity, in accordance with ASIF figures, reached 10 MW in 2004 and, although official figures are not yet available, 2005 will go far beyond last year. This growth has permitted that overall costs continued on lowering, despite some subcomponents which were increasing their prices. It is considered that the cost of new facilities has gone down around 5 %.

The other interesting effect of the new legal framework is that the average size of facilities is continuously increasing. And the obvious consequence is that the size of the investment is growing, as well. Venture capital funds and financial entities are looking with interest at the new business.

For 2006, the value of TMR (reference cost of the energy calculated as a projection of the whole year costs) has been increased by 4,8 % when compare to that of 2005. This will balance the increase in interest rates that was menacing future activities.

It is worth noting that the objective of the old "Plan de Fomento de las Energias Renovables (PFER)," approved in December 1999, was to have 135 MW installed between the years 2000 and 2010. In August 2005, the government approved a revised version that has increased the target well above 400 MW.

On top of all these regulation activities, the direct support for investments is still being provided, both through IDAE (the Spanish Institute for Diversification and Energy Savings) and through some regional authorities.

However, the present tendency is showing that the investors do not rely on direct support for investments, as the feed-in tariffs scheme is sufficient enough to make the business a reality. Experience has shown that subsidies to investments create much bureaucracy and are quite complicated and time consuming. Experience is also showing that a feed-in tariff system should be sufficient to give the necessary support to grid-connected photovoltaic power systems (PV). Of course this is not the case for isolated systems, for which direct support for investments is necessary.

The public perception of PV in Spain continues to be very positive, due to its environmental advantages, although high costs are still hurting market development. The new approach seems to be a step in the right direction.

Nevertheless, there are still some problems to be solved. One of them is the bureaucratic approval process that involves many different agents such as local and central governments, utilities, system operators and control authorities (environmental, industrial, etc.). Extremely long approval processes can kill many initiatives and in any case, seriously affect the business situation.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

No major changes to the previous year's initiatives have been made. R&D activities in Spain are carried out by both the PV industry and the research centres and universities. The main lines of activity can be summarized as follows:

- New semi-conductive substrates production technologies to manufacture solar cells. Practically all the Spanish PV scientific and relevant bodies are involved in this line.
- Production technologies, including industrial automation, more thin cells and improvements in efficiency.
- Concentration technologies.
- New materials (AsGa, silicon of "solar type," etc.)

There are some other programmes not exclusively devoted to PV as well, but clearly interrelated: electronics, inverters, integration with other power sources, etc.

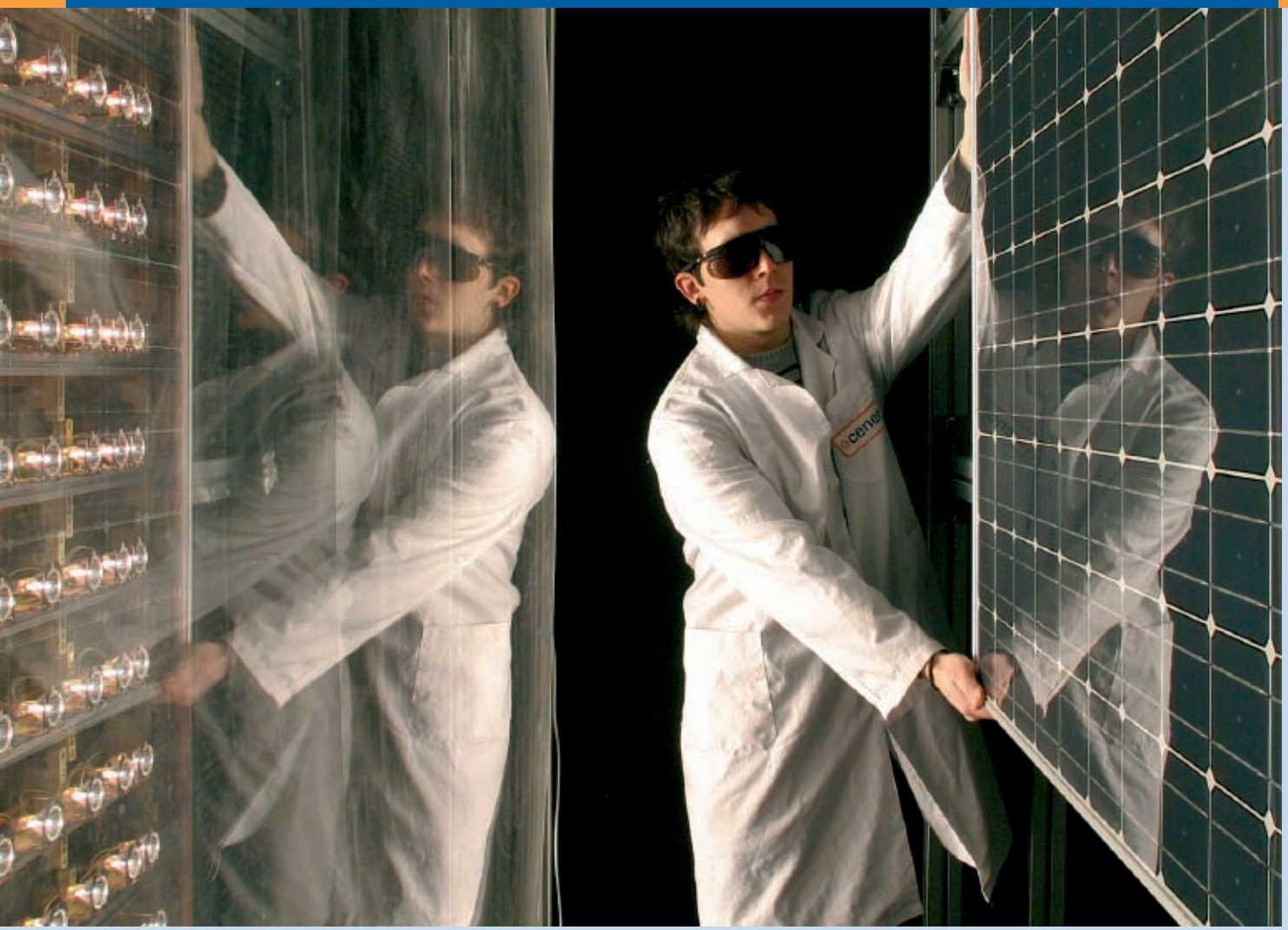

Fig. 2 - PV panels' degradation testing in the CENER facilities.

Other activities are related to satisfy the necessities of the Spanish PV industry related to certification of new products and components, creation of new standards and methodologies for validation and analysis of new PV systems, and improvement of services related to the entire PV chain.

MARKET DEVELOPMENT AND FUTURE OUTLOOK

As of December 2005, indicative and non official figures point to 40 MW at December 2005 as the installed PV grid-connected capacity in Spain. This figures shows how strong the market development is when compared to 2004 (16 MW) and 2003 (9,18 MW).

The Spanish PV industry has made a considerable effort in investments during the past few years. From January 1999 to October 2005 the cumulative investments of the PV sector (including both manufacturers and installers) reached 290 MEUR.

The total workforce reached 4 195 for direct employment in October 2005; of which 1 895 correspond to manufacturers of cells and modules, and approximately 1 200 to installers. The corresponding total figure by the end of 2004 was 3 700, and the difference consistently reflects the strong impulse that the PV Spanish industry is experiencing as a result of the new support scheme. Furthermore, there are another 2 197 who are indirectly employed by the industry. Therefore, the total workforce related to the Spanish PV industry can be estimated to have reached a total of 6 292.

The perspectives for the immediate future are optimistic. The public perception of PV is more and more favorable, and the support mechanisms seem to be working adequately. In the past, and due to the limitation of size of 5 kW, many "solar farms" were created (installations of, approximately, 100 kW with several owners, none of them owning more than 5 kW, and promoted by a unique body, in charge of connection and maintenance services). The number of these farms is being increased, since the limitation of 5 kW no longer exists, and there is a growing public consciousness of PV power plants economic profitability.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
MARIA HALL, SWEDISH ENERGY AGENCY, ULF MALM, UPPSALA UNIVERSITY,
ANDREW MACHIRANT, SPIA, MONIKA ADSTEN, ELFORSK AB

GENERAL FRAMEWORK

The bulk of the Swedish electricity supply of about 150 TWh per year is generated by nuclear power (almost 50 % of the electricity production) and hydropower (about 45 %, depending on precipitation). Although growing rapidly, mainly due to the introduction of a national renewable electricity certificate system in 2003, the contributions of wind power and biomass-fuelled combined heat and power to national electricity supply are rather small (0,6 % and 5 % respectively). The installed PV capacity has reached a mere 4 MW whilst electricity production from PV is less than 3 GWh. This is mainly due to a previous lack of market incentives for PV. During 2005, however, a subsidy scheme was introduced (see Implementation and Market Development).

NATIONAL PV PROGRAMME

In Sweden, PV research is not organised as a separate programme and does not have a fixed budget. Instead, PV is part of the national long-term energy research programme, which has a budget of about 60 MEUR per year for the period 2006-2008. In addition, the government plans to present a new energy research bill to the Parliament during spring 2006.

Government funded energy research is managed by the Swedish Energy Agency (www.stem.se), which is the national authority responsible for issues regarding the supply and use of energy. Its main task is to implement the Swedish energy policy programme, which is decided by the Swedish parliament. The aim of the programme is to develop a more sustainable energy system and to secure energy supply. Main emphasis is on energy efficiency and on the development and promotion of renewable energy such as biomass, hydropower, wind power and PV.

The Swedish Energy Agency provides funding for PV research, cost-shared technological development, demonstration and business development. The budget for PV is in the range of 2 to 2,5 MEUR per year, depending on which projects that are currently running.

In addition to international cooperation through the IEA PVPS, Sweden is participating in PV-ERA-NET, which is an EU-funded network for national programme managers and financers. The PV-ERA-NET project started in October 2004 and runs over four years. The objective of the project is increased collaboration and coherence between the national PV R&D programmes in the European Research Area.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

During the period 1996-2004, the Swedish Energy Agency and the Swedish Foundation for Strategic Environmental Research funded a joint programme for PV R&D, the Ångström Solar Center (www.asc.angstrom.uu.se), which received a total funding of about 16 MEUR. The research at Ångström Solar Center had dual goals: to contribute to a sustainable energy system in the future and to increase Swedish industrial competitiveness in the field of solar energy technology. The approach was to depart from leading scientific platforms and evolve progressively, via scale-up and prototype manufacturing, towards commercialisation. Following the completion of the programme, thin film CIGS and Grätzel cell research now receives continued funding from the Swedish Energy Agency in the order of 0,6 MEUR per area and year.

The thin film CIGS research is performed at Uppsala University and the focus is on CIGS deposition by co-evaporation. The technology is close to industrial realisation and a spin-off company, Solibro AB, was launched in 2003 (see Industry Status below). The aim is to achieve high performance and simultaneous cost reduction whilst utilising processes and materials that minimise the impact on the environment. For the development of the next generation CIGS technology, elimination of cadmium from the buffer layer, minimisation of the thickness of the active layer and increased process speed are main objectives.

The research on Grätzel cells, which is performed at the Center of Molecular Devices (www.moleculardevices.se) at the Royal Institute of Technology in Stockholm and at the public-private partnership company IVF AB, aims at developing nano-structured dye-sensitized electrochemical cells and modules which can be manufactured at very low cost. However, conversion efficiency is still low and the durability is poor compared with cells of conventional crystalline silicon or CIGS. The competitiveness for this technology is therefore currently in the area of niche products. Basic research is aimed at finding new combinations of dyes and electrolytes which can increase the cell efficiency and stability in order to reach the longer term objective of manufacturing efficient and inexpensive solar cells for large scale electricity production.

The SolEl programme is a national R&D programme with a focus on PV systems and their applications. The programme is financed by the Swedish Energy Agency, Swedish utility companies, manufacturing companies (PV and other), construction companies and property managers - the budget is set to approximately 0,5 MEUR per year. The present programme period runs until the end of 2007. The programme is managed by Elforsk AB, which is the Swedish electricity utilities' R&D company (www.elforsk.se).

The main objectives of the SolEl programme are to support technological development, demonstration of interesting applications, analysis of performance and costs of PV systems (both technical and non-technical) as well as information dissemination. The programme also follows international development of PV in general and grid-connected BIPV in particular, e.g. through funding participation in international conferences and reports on the state-of-the-art in PV. It also serves as a reference group for Sweden's participation in IEA PVPS and is a recognised national forum for information dissemination.

Fig. 1 - A 3 kWp semitransparent PV installation at the Royal Institute of Technology, Stockholm. The system has been in operation since January 2006 (photo Energibanken AB).

The programme also finances feasibility studies on procurement, installation and operation of Swedish PV installations and has implemented web based monitoring of the electricity production from about 20 grid-connected PV installations in Sweden (www.elforsk.se/solenergi). This activity is closely related to the work performed within IEA PVPS Task 2. Development of concentrating PV systems and PV-thermal systems is also included in the programme.

Due to the strong international development in the field of BIPV, the interest from the Swedish building industry in the SolEl programme has increased during the last few years. The involvement of property managers and architects in the programme has shifted the focus of the programme somewhat, from stand-alone systems towards building integrated PV. Recent programme activities include the development of a tool (www.solcell.nu) for executing PV projects in the built environment in the form of a web based information platform for architects, constructors and other actors and serves as a guide through the process.

IMPLEMENTATION AND MARKET DEVELOPMENT

The market for PV in Sweden is dominated by domestic stand-alone PV systems. The majority of these systems are small and predominantly used to supply electricity to recreational homes where grid-connection is unavailable. Apart from the off-grid domestic market, there are some off-grid non-domestic systems, supplying electricity for telecommunication systems, lighthouses, etc., and a few grid-connected systems. Until last year, the grid-connected systems that were installed were mostly demonstration projects intended to demonstrate the PV technology in general or to conduct research.

The lack of market incentives or subsidies for PV had resulted in a comparatively slow development of the PV market in Sweden until May 2005. Total cumulative PV power installation in Sweden amounted to approximately 4 MW. The market growth rate has been rather constant over the last ten years with a slight upturn (about 6-7 % per year) over the last three years. The capacity installed during 2004 was 285 kW.

From 15 May 2005 until 31 December 2007, a 70 % investment subsidy has been made available for the installation of PV systems in public buildings. The subsidy is a part of an investment programme for energy efficiency and renewable energy in public buildings such as sports centres, conference halls, churches, schools, airports, railway stations, etc. A cap of 100 MSEK (about 11 MEUR) exists, which corresponds to 2-3 MW in additional capacity. The subsidy functions as a tax deduction of 70 % of the investment costs for a completed system installation, with a maximum limit per building of 550 000 EUR and covers both material and labour costs; The programme was specifically designed to further the development of professional know-how among installers, architects, project developers, etc. The subsidy scheme has jump-started the domestic market for PV in Sweden (from previously being entirely focussed on export). On 1 January 2006, a third of the budget had been applied for and the Swedish Energy Agency expects that all 100 MSEK will be fully subscribed by Q4 2006, mainly due to high interest shown by population dense city authorities (Stockholm, Gothenburg, Malmö). Hence the total installed PV capacity in Sweden will increase by about 70 % in two years time and the installed capacity of grid-connected BIPV applications will increase tenfold.

INDUSTRY STATUS

The PV industry in Sweden has grown significantly over the last couple of years. In 2005, the industry organised itself to launch the SPIA, a Scandinavian Photovoltaic Industry Association, which represents market actors from Denmark, Norway and Sweden. The association's objectives are to further research & development, promote successful policy support mechanisms and improve the general framework conditions to accelerate PV market deployment in the Nordic region.

Today, there are four companies in Sweden that produce PV modules. All of them buy cells from abroad and assemble modules, which are to a large extent exported. The most established and largest module producer in Sweden is Gällivare Photovoltaic AB (GPV). GPV is a fully owned subsidiary of the German company SolarWorld AG. In 2004 GPV shipped about 11 MW of modules. Further increase of production capacities are foreseen for 2006.

The module manufacturer ArcticSolar AB was started in 2001 and has increased its production volume steadily since the start to approximately 6 MW during 2004. The production plan for 2005 is 8 MW. The company is partly owned by the manager of the company (10 %), German Alfasolar Vertreibsgesellschaft mbH (45 %) and Finnish Naps Systems Oy (45 %). The modules produced at ArcticSolar are sold in Germany under the Alfasolar label.

ScanModule AB, which is a subsidiary of the Norwegian Renewable Energy Corporation, commenced its module production in 2003 and has 15 employees. The production in 2004 was 5 MW and this figure is expected to have increased during 2005.

Fig. 2 - The Grynnan Building in Hammarby Sjöstad, Stockholm, is the second in a pair with PV integrated into the facade, balcony railings and semi-trasparent windows. The 17 kW PV installation was planned at an early stage of the building process and in close co-operation between architects, builders and PV installers (photo Ulf Malm).

The fourth PV module manufacture company is PV Enterprise Sweden AB, which was started in 2003. During 2004, the production amounted to 4 MW of modules.

Despite the new investment subsidy, the annually installed PV capacity in Sweden only constitutes a small fraction of the approximately 26 MW of modules produced. The share of the production that is exported varies from manufacturer to manufacturer, but is generally more than 80 %.

A growing number of small to medium-sized enterprises exist, which design, market and sell PV products and systems. There are currently no feed-stock or cell manufacturers in Sweden nor any manufacturers that produce PV specific balance of systems components.

FUTURE OUTLOOK

The company Solibro AB is currently up-scaling the processes for the production of thin film CIGS. During 2006, a pilot line for production of CIGS modules will be demonstrated. In parallel to the demonstration of the complete process, the construction of a large manufacturing plant is planned. The aim is to have modules on the market in early 2008. Solibro AB is financed by three large corporations and two investment funds and the Swedish Energy Agency co-finances technology development in the company.

The PV installations in the residential area Hammarby Sjöstad in Stockholm, which were installed during 2002-2004, were among the first true BIPV projects in Sweden, and the 60 kW PV system on the IKEA building in Älmhult has been the largest installation in Sweden since its construction in 1997. However, within the subsidy scheme there is an application for support for a 75 kW system to be built in Malmö during 2006, as well as for the installation of PV on the Swedish embassies in Athens and Tel Aviv.

FURTHER READING ABOUT PV IN SWEDEN

Sweden - Country information:

- www.stem.se
- www.elforsk.se/solel
- www.solcell.nu

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
BY STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.,
ON BEHALF OF THE SWISS FEDERAL OFFICE OF ENERGY (SFOE)

Fig. 1 - 280 kWp flat roof system at Geneva airport with AluStand® mounting system (PV design: Enecolo, photo Urs Bühler).

GENERAL FRAMEWORK

Following the budget reductions of the *SwissEnergy* Programme (www.swiss-energy.ch) decided during 2003, the consequences of these reductions persisted in 2005. In particular, no new pilot and demonstration systems could be supported by the federal government. This represents a severe cut along the chain from technology development towards the market and thus affects rapid transfer of results from R&D into industrial solutions and products. Electric utility organisations and governments of cantons can provide support for pilot and demonstration systems but photovoltaics are generally not a first priority.

Different matters related to energy policy are presently on the political agenda. In part, this concerns the introduction of a CO_2 tax on fossil fuels. The legal basis for the introduction of such a tax is defined by the Carbon Law which has been in force for a number of years. As an alternative to the CO_2 tax, voluntary measures can be proposed. During 2005, the Climate Cent Foundation was established as a voluntary measure of the Swiss industry (http://www.stiftung-klimarappen.ch), in accordance with the Carbon Law. For the mobility sector, instead of introducing a CO_2 tax, a climate-cent of 1,5 cents CHF per litre is charged by the private oil association on imported petrol and diesel. This will generate around 100 million Swiss Francs annually which will go towards closing the gap in CO_2 emissions reductions. These reductions of 1 800 000 t in 2012 are planned to be achieved through CO_2 emission reduction projects both in Switzerland (200 000 t) and abroad (1 600 000 t). For the heat sector, the political debate about the introduction of the CO_2 tax is ongoing.

The second issue on the policy level, of greater relevance for photovoltaics, is a new proposal for a liberalisation of the electricity market. After the rejection by public referendum of the first attempt on this subject in 2002, a new law has been proposed. Within this proposal, a goal of additional 5 400 GWh from renewable energies by 2030 is formulated. Here, the political debate concerns the instruments to be used to achieve this goal, namely a bidding model or feed-in tariffs. During 2005, the National Council (large chamber of the federal parliament) has favoured the introduction of a feed-in tariff system for "new" renewables and a bidding model for hydro. The Council of States (small chamber of the federal parliament) will have this debate in the course of 2006. Final decisions on this subject are expected by the end of 2006 on the parliamentary level, upon which a public referendum may be possible during 2007. Finally, the framework for the energy research remains otherwise unchanged: The energy research strategy is defined by a 4 year energy RTD master plan for the period 2004 - 2007. The master plan developed by the Federal Commission for Energy Research (CORE), in cooperation with the Swiss Federal Office of Energy (SFOE), is based on strategic policy goals (energy & environment, science & education, industry & society). By the end of 2005, work had started for the next 4 year energy RTD master plan, covering the period 2008 - 2011.

Fig. 2 - 110 kWp roof integration on a farmhouse with Solrif® frames (PV design: Solstis, photo NET).

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach (www.photovoltaic.ch). This national photovoltaic programme focuses on R&D,D in a system and market oriented approach, from basic research, over applied research, product development, pilot and demonstration projects all the way to market stimulation. As indicated above, activities in pilot and demonstration projects had to be further reduced in 2005. On the technical level, thin film solar cells and building integration are the foremost topics of priority. The programme is organised along the entire value chain and addresses the critical gaps from technology to the market place. Thorough component - in particular for photovoltaic modules and inverters - and system analysis aims at increasing efficiency, reliability and performance. Accompanying measures to raise the quality and reliability of photovoltaic power systems include work on standards and design tools. On the market side, deployment is promoted by a customer-oriented approach in the campaign "solar electricity from the utility." Finally, the programme places emphasis on information and communication in order to raise the awareness for opportunities involving photovoltaics. Direct promotion of the market through incentive schemes is within the responsibility of the cantons on a voluntary basis. This has led to regional differences whereby the governments of the cantons define their priorities between promotion of energy efficiency and/or renewable energies. Photovoltaics is generally not a priority and support through direct subsidy schemes is presently limited to a few cantons.

Through the bias of Task 9 of the IEA PVPS Programme, the subject of technology co-operation with developing countries continues to be expanded. During 2005, the new interdepartmental platform for the promotion of renewable energy in international co-operation - REPIC - was continued (www.repic.ch) and supported photovoltaic projects of Swiss entities in developing countries.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Swiss Photovoltaic RTD Programme is based on a 4 year RTD master plan, presently covering the period 2004 - 2007. Overall, 65 projects, supported by various national and regional government agencies, the research community and the private sector are conducted in the different areas of the photovoltaic energy system. Market orientation, cost reduction, industrial viability and transfer as well as increased efficiency and reliability are the main objectives of the technical R&D.

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (amorphous and microcrystalline silicon, compound semiconductors, dye-sensitised cells). During 2005, emphasis on transfer from R&D to industrial processes and products continued. Work on thin film silicon at the University of Neuchâtel concentrated on micromorphous solar cells and the rapid large area deposition of its individual layers of amorphous and microcrystalline silicon. In this area, strong co-operation with the companies VHF-Technologies and Unaxis Solar continued. VHF-Technologies has increased the annual capacity of their pilot manufacturing plant of amorphous silicon solar cells on plastic substrates to 100 kWp. During 2005, the equipment manufacturer Unaxis confirmed the strategic priority of the solar photovoltaic business area and increased its development efforts as a leading supplier of manufacturing systems of thin film silicon solar cells on glass. With regard to CIGS solar cells, the Federal Institute of Technology in Zurich focused the work on high efficiency flexible CIGS cells on plastic and - as a new substrate - aluminium. During 2005, the spin-off company FLISOM was founded in view of transferring the promising R&D results into industrial products. For dye-sensitised solar cells, work continued on new dyes and high temperature stability of the devices. Flexible solar cells were also a subject for this technology.

Fig. 3 - 12 kWp facade system on the highly energy efficient commercial building Wattwerk (PV design: Holinger Solar, photo NET).

Emphasis continues to be given to the application of building integration, both for new solutions involving thin film solar cells as well as for new mounting systems and structures for sloped roofs and facades.

With the ongoing market development, quality assurance of products and systems, as well as standardisation, continue to be of high priority. The centres of competence at the Technical Universities of Burgdorf and Lugano carefully evaluate products such as PV modules, inverters and new systems. Long term experience with the operation of photovoltaic power systems is carefully tracked for a number of grid-connected systems, ranging between 10 and more than 20 years of operation. Continuous development of system solutions has resulted in a number of industrial products which are increasingly being exported.

The visionary project of a non-stop flight around the world in a solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard was defined in its technical concept. With its wingspan of 80 m, a weight of about 2 tons, and about 40 kWp of photovoltaic power, this exceptional airplane should rise to an altitude of 12 000 m during day time and slowly descend during the night. Exceptional efforts in photovoltaic cell and system technology, energy management and design will be required to achieve this ambitious goal. The project has the scientific support of the Swiss Federal Institute of Technology in Lausanne, the University of Neuchâtel and other organisations in Switzerland and abroad.
International co-operation continues to form a strong pillar of the R&D activities with 16 projects running in the 5th and 6th framework RTD programmes of the European Union during 2005.

Participation in new Integrated Projects has been successful in 2005. International projects are also carried out as part of programmes such as the European Space Agency. The co-operation within the IEA PVPS programme has remained a further strategic activity for which target-group specific dissemination is crucial. For this purpose, a national IEA PVPS pool has been founded in 2005 which receives support from electric utilities of the city of Zurich, the Canton of Basel and the Mont-Soleil Association; further partners are under negotiation. The support to Swiss IEA PVPS activities could thus be broadened, in particular for activities in Tasks 2 and 10.
On the programme level, international co-operation is also taking place through the PV-ERA-NET project (www.pv-era.net) and the newly established European Photovoltaic Technology Platform (www.eupvplatform.org).

IMPLEMENTATION

Market implementation of PV systems continues to be mainly driven by the campaign for "solar electricity from the utility" and similar approaches related to green power marketing. Since the introduction of the *naturemade*® labels for renewable electricity, utilities have started introducing different product brands, some with a mix of different renewable energy sources and others with technology specific products, e.g. the product *"Premium Solar"* by the utility of the city of Zurich. Increasingly, solar electricity is thus part of mixed green power products, according to *naturemade star*® labelled brands. With a strong and consistent marketing approach, typically around 5 % of the customer base can be attracted to pay the comparatively high prices for solar electricity, in the best cases. With mixed products, more customers can be attracted. Market implementation is further supported by regional initiatives, for example in the cantons of Basel and Geneva.

Fig. 4 - Unaxis Solar KAI 1200 mass production system for thin film silicon solar modules (photo Unaxis).

INDUSTRY STATUS

Some years ago, Swiss industrial PV products covered mainly system components such as inverters, both for grid-connected and stand-alone applications, components for electrical connection, mounting systems for building integration and custom designed PV modules. Over the past years, industrial activities in the area of solar cells, solar modules and manufacturing equipment for both of these areas have considerably increased.

In the inverter area, some products have achieved a high export rate. The Sputnik Company produces grid-connected inverters at a capacity of 125 MW/year and presently ranges as number 3 in the European market. The Studer Company produces stand-alone inverters and is also very successful in exporting. On the PV industry supply side, different products count among the world leaders, e.g. for wire-sawing machines from HCT as well as from Meyer & Burger; and measuring equipment for PV module manufacturers from Belval. In addition to the solar plugging systems made by Multicontact, another company, Huber & Suhner, has entered into this market. The Alustand® and SOLRIF® mounting systems for building integrated applications have been very successful on the market. Sarnafil, which has developed a flexible, water-tight flat roof PV system based on thin film silicon solar cells, is taking part in a joint venture with the American company Solar Integrated Technologies (SIT).

As indicated above, industrial activities evolve in the field of process equipment (Unaxis Solar, Figure 4) and small scale products based on thin-film technology (Flexcell from VHF-Technologies, FLISOM). Furthermore, Swiss Solar Systems (3S) is building some of the world's largest PV module laminators. 3S has established a strategic cooperation with the German company Schmid and is the first Swiss manufacturer dedicated solely to photovoltaics which has gone public in 2005.

Based on the long term experience and the large number of installed systems, considerable know-how is available amongst engineering companies for the design, construction and operation of a large variety of different applications, ranging from small scale, stand alone systems for non-domestic, professional applications and remote locations, over small domestic grid-connected systems to medium and large size grid-connected systems in various types of advanced building integration. The export volume of Swiss photovoltaic products has surpassed 80 MCHF in 2005 and thus represents at least four times the size of the national market. Besides an increased interest from the manufacturing industry, the finance sector continues to promote financial services directed towards renewable energy. Increased investments have occurred in the renewable energy sector, including photovoltaics, and dedicated funds are operated by important finance organisations. This trend is manifested by the regular investment analysis reports published by the Bank Sarasin.

MARKET DEVELOPMENT

The market development has been mainly driven by the federal campaign "solar electricity from the utility" or similar schemes, supported by promotional programmes and actions in some cantons. For 2005, the annual market for grid-connected systems was of 4,3 MWp, substantially higher than in previous years. This rise is partly due to two large systems (850 kWp and 1 MWp) completed during the year by the electric utilities of Berne and Geneva. The

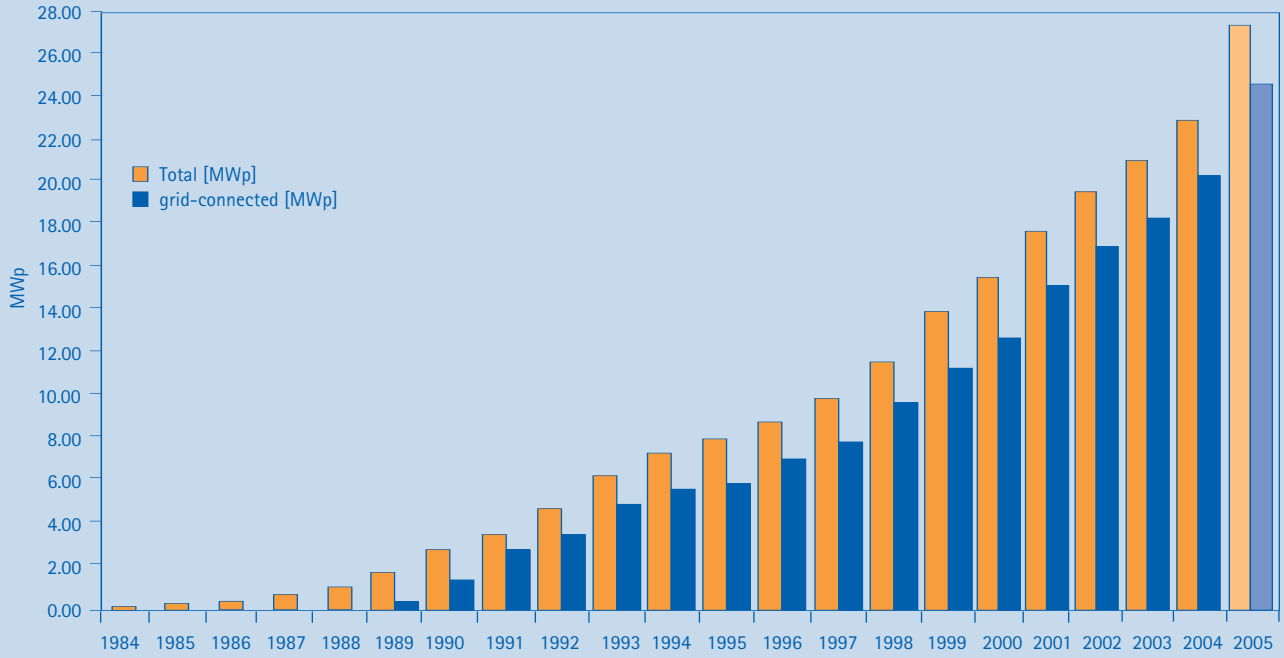

Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2005 (total and grid-connected, estimated values for 2005).

total installed capacity has thus risen to more than 27 MWp (Figure 5), corresponding to about 3,9 Wp/capita.The PV energy statistics have been established by tracking the energy produced by grid-connected PV systems and their statistical distribution since 1992 (Table 1). The total energy production of grid-connected photovoltaic systems up to 2004 is thus approaching 16 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue with an ever-increased focus on industrial developments, new products for niche markets and ongoing international involvement. For solar cells and modules, the effort to bring Swiss technology to the market place will continue. Efforts in the technology development will concentrate on market oriented approaches and continuous quality assurance. The strategy to promote international co-operation on all levels will continue, related to activities in the 6th framework programme of the European Union, the European PV Technology Platform, the IEA PVPS programme and increasingly in technology co-operation projects. Stronger co-operation with other European PV RTD Programmes will be established in the framework of the PV-ERA-NET project.

In the near term, PV market implementation will continue to depend on the initiatives of regional authorities and even more on those from the private sector, namely the utilities. A market volume of about 2,0 to 3,0 MWp/year can be expected under these circumstances. Depending on the outcome of the political debate during 2006, on the new electricity law, concerning the future promotion of renewable electricity, the situation could change to a more favourable situation by 2008 at the earliest.

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2004 (GRID-CONNECTED SYSTEMS)

Year	Number of New Systems	Total Number of Systems	Installed Capacity [MWp DC]	Energy Production [MWh]	Specific Energy-Production [kWh / kWp]
1989	60	60	0,3		
1990	110	170	0,8	400	
1991	210	380	1,8	1 100	
1992	110	490	3,1	1 800	800
1993	110	600	4,0	3 000	810
1994	80	680	4,8	3 500	800
1995	60	740	5,4	4 000	815
1996	80	820	6,2	4 700	825
1997	130	950	7,4	6 000	880
1998	150	1 100	9,2	7 100	860
1999	125	1 225	11,0	7 700	770
2000	100	1 325	13,0	10 000	810
2001	125	1 450	15,0	11 000	800
2002	75	1 525	17,0	12 000	810
2003	75	1 600	17,9	15 100	875
2004	100	1 700	19,5	15 700	815

(grid-connected systems)

UNITED KINGDOM

PV TECHNOLOGY STATUS AND PROSPECTS
SARAH DAVIDSON, ENERGY SPECIALIST, IT POWER LTD.

Fig. 1 - The 391 kW PV system on Manchester's CIS building will be Europe's largest vertical solar façade.

GENERAL FRAMEWORK

Implementation of UK energy policy is delivered by a Sustainable Energy Policy Network which includes representatives from the Department of Trade and Industry (DTI), Department of the Environment, Food and Rural Affairs, the Office of the Deputy Prime Minister and the Department of Transport.
The Renewables Obligation (RO) forms the main element of the Government's strategy for renewables deployment. The RO began in 2002 and sets out targets for electricity suppliers to source an increasing amount of their electricity from renewable resources. Certificates, or ROCs, are awarded to generators using renewable sources. ROCs can be traded to make up any shortfall. It was designed to enable the UK to make progress towards its target of generating 10 % of its electricity from renewable energy sources covered by the Obligation by 2010. The current obligation level is 5,5 % for 2005/06 rising to 15,4 % by 2015/16.

A review of the Renewables Obligation took place in 2005, with the aim of making some changes to the eligibility of electricity generated from mixed wastes; modify future rules for low cost technologies and simplify the administrative arrangements.

The Renewables Innovation Review was published in February 2004 and identified:

- the key renewable technologies for the delivery of the UK targets and aspirations for renewables.
- the barriers to the development and deployment of the key renewable technologies;
- the most cost effective Government measures to facilitate delivery of the UK targets.

The International Energy Strategy was launched in October 2004, and states that the UK Government will tackle climate change, curb carbon emissions and diversify the energy mix to lessen our dependence on fossil fuels.

NATIONAL PROGRAMME

The UK's National Programme for photovoltaics consists of the following elements:

- Research and development, under the DTI's Technology Programme and various programmes of the Engineering and Physical Sciences Research Council (EPSRC)
- Field trials and demonstrations, under DTI programmes
- Participation in international programmes (EC and IEA)

The overall goal is to develop the capabilities of industry and to encourage sustainable growth in the market by removing barriers to the deployment of PV.

The renewables innovation review, described in the section above concluded that with current technology, solar PV installation is expensive under UK conditions. It recommended that research should focus on 3rd generation PV and collaborative efforts with nations with complementary capabilities. Future grant funding for PV should come through a technology blind programme to support building integrated renewables and energy efficiency technologies.

The DTI held a consultation over the nature of the new national programme for micro-generation during 2005 and will publish its microgeneration strategy and details of the Low Carbon Buildings Programme in spring 2006.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Academic research in the UK is largely funded by the Engineering and Physical Sciences Research Council (EPSRC). In addition to companies' internal research activities, some pre-competitive industrial Research and Development projects are supported by the Department of Trade and Industry (DTI) mainly under the Technology Programme.

The DTI's Technology Programme funds industrially focused collaborative research. Funded research projects relating to PV are currently focused on third generation technologies and cost reduction measures.

The EPSRC Sustainable Power Generation and Supply (Supergen) Project 'Photovoltaic Materials for the 21st Century' was launched during 2004. The project consortium is made up of six universities (University of Wales Bangor, University of Durham, University of Bath, University of Northumbria, University of Loughborough and University of Southampton) and seven companies. The project aims to develop low-cost thin-film solar cell devices fabricated from inorganic semiconductors. Work includes the development of novel low cost electrodeposition routes to fabricate films of materials such as copper indium sulphide/selenide (CIS/CIGS).

Fig. 2 - Building mounted small wind is beginning to take off in the UK and will be supported along with PV by the new Low Carbon Buildings Programme, to be launched later in 2006 (photo Courtesy of Berwickshire Housing Association).

Fig. 3 - PV is popular with housing Associations and Local Authorities where it is used to reduce social tenant's electricity bills (photo Courtesy of Sustainable Energy Installations).

Since 2000 there have been three PV field trial and demonstration programmes in the UK:

- The Domestic Field Trial (DFT) which ran in two phases between 2000 and 2003. The DFT aimed to use the design, construction and monitoring of the installations as a learning opportunity for utilities, building developers and other key players. A total of 741 kW has been installed, the majority of which is on social or mixed housing. Monitoring of the systems is being carried out to assess performance over the two years following commissioning.
- Large-Scale Building-Integrated PV Trial (LSBIPV): In November 2001 and March 2002 together a total of 7,2 MGBP was allocated for large building integrated PV projects (i.e. >20 kW). The objectives of the programme were to raise awareness and create confidence in the application of PV, increase UK capabilities in the application of the technology, as well as to assess the potential for BIPV in the near term and its role in future energy policies and strategies. The programme so far has provided between 60 % and 100 % funding and a total of around 3 MGBP for 12 completed projects. All the designs are for true building integrated systems, on a variety of construction types and all completed installations are being performance monitored for a period of two years; the results of this are to be used to make best practice recommendations. The systems installed within the programme are all high profile installations on public buildings and as such are playing an important role in raising public awareness of PV.
- The PV Major Demonstration Programme (MDP) was officially launched in 2002 and 20 MGBP was made available by the Department of Trade and Industry for a three-year programme. Since then a further 11 MGBP additional funding was announced in 2004 and another 750 000 GBP in 2005, to enable the scheme to run until Spring 2006. Grants are available for both on and off-grid applications and are eligible for modules, inverters and installation. Subsidy levels are on average 50 % and for small scale applications are subject to a maximum amount per kW. All grant applications require the use of approved products and accredited installers and designers.

Amongst the projects supported by the programme during 2005 is the Eden project in Cornwall, where PV modules are incorporated into the buildings unique architecture which is based on the Fibonacci series. When viewed from above the panels spiral outward in a ring around the centre of the building, forming the shape of a flower with eleven individual petals. The MDP is also supporting the construction of the UK's largest PV system, a 391 kW PV façade on the building of Co-operative Insurance Services in Manchester. The project is using PV modules manufactured in the UK by Sharp in Wrexham.

The MDP is due to finish in March 2006 and will be superseded by the new Low Carbon Building programmme. The new programme will support PV as well as other renewable energy technologies suitable for building integration.

IMPLEMENTATION

The total capacity of grid connected installations during 2004 was 2 197 kW, which represents over 97 % of the annual total. This was an increase of 35 % with respect to that installed during 2003. This is largely due to the completion of a number of projects under the DTI's grant supported programmes (mentioned above) and in particular the Major Demonstration Programme. Of the off-grid installations, one third was installed on residential properties with the remaining installations for a range of applications including street lighting and furniture.

INDUSTRY STATUS

Crystalox, the producer of multi-crystalline silicon blocks, saw continued growth in annual production capacity during 2004. Sharp, which opened its new PV module manufacturing facility in Wrexham in July 2004 is now the single largest employer in the UK PV industry. The facility expanded its annual production capacity from 20 MW to 40 MW during its first 6 months of operation. Romag, the specialist glass manufacturer now produces semi transparent crystalline PV laminates at its new 6 MW/year lamination facility in Consett, County Durham.

Fig. 4 - The unique building integrated PV array at Eden Project in Cornwall received funding from the DTI's Major Demonstration Programme (photo courtesy of The Eden Project).

MARKET DEVELOPMENT

The cumulative installed PV generation capacity increased by 38 % during 2004, reaching a total of 8,2 MW. Much of this increase is due to the rapid expansion of the grid-connected markets.

FUTURE OUTLOOK

Further installations under the Major Demonstration Programme will facilitate a continued healthy rate of grid-connected PV installation during 2005 and 2006. The current programme is due to end in March 2006 and will be replaced by the Low Carbon Buildings programme which will support PV as well as other renewable energy technologies suitable for building integration.

PV module manufacturing is set to increase in 2005, following the opening of two new manufacturing facilities by Sharp and Romag during 2004 and subsequent increase in capacity at the Sharp factory from 20 MW to 40 MW. An increase in silicon feedstock production capacity sufficient for a further 10 MW of PV cells is due to be completed during 2005 at the Crystalox plant.

THE UNITED STATES OF AMERICA

PV TECHNOLOGY STATUS AND PROSPECTS IN THE U.S.A.

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GENERAL FRAMEWORK

The U.S. Department of Energy's (DOE's) Solar Energy Technologies Program (SETP), part of the Office of Energy Efficiency and Renewable Energy, is responsible for developing solar energy technologies that convert sunlight to useful energy and make that energy available to cost-effectively satisfy a significant portion of U.S. energy needs. The SETP supports research and development addressing a wide range of applications, including on-site electricity generation, thermal energy for space heating and hot water, and large-scale power production.

The SETP has created a management structure that blends program administration with scientific oversight. Program administration is done by a relatively small DOE staff that focuses on implementing Administration policy. Two DOE national laboratories -- the National Renewable Energy Laboratory and Sandia National Laboratories -- provide scientific oversight of the solar R&D tasks being performed by universities, industry, and national laboratories. Laboratory management of the tasks enables detailed technical evaluations to become a part of each programmatic decision made by DOE.

The bulk of the SETP Photovoltaic Subprogram's activities are carried out through two primary research centers: the National Renewable Energy Laboratory (NREL) in Golden, CO, and Sandia National Laboratories (SNL), in Albuquerque, NM. Brookhaven National Laboratory (BNL), in Upton, provides program support in the area of environmental health and safety. NREL, SNL, and BNL are all partners in the National Center for Photovoltaics (NCPV), which provides guidance to DOE PV research efforts. In addition, DOE's Golden Field Office (GO), in Golden, CO, and the Albuquerque Operations Office (ALO), in Albuquerque, NM, administer and manage contracting activities assigned by headquarters.

The photovoltaic Subprogram's research is focused on increasing domestic capacity by lowering the cost of delivered electricity and improving the efficiency of modules and systems. The program emphasizes long-term innovative research, thin-film development, manufacturing R&D, and systems development and reliability. Long-term research is focused on "leapfrog" technologies such as polymers and nanostructures. In thin films, new levels of efficiency and stability in prototype modules have been achieved, as well as higher laboratory cell efficiencies. Near-term research is focused on reducing cost through manufacturing advancements and improving system reliability.

In 2005, photovoltaics (PV) generated excitement in the United States, with PV systems being installed at an unprecedented scale. Public support for PV appears to be increasing as well, as evidenced by public support of PV incentives mentioned later in this report.

NATIONAL PROGRAMME

Mission and Goals

The SETP's mission is to improve U.S. security, environmental quality, and economic prosperity through public-private partnerships that bring reliable and affordable solar energy technologies to the marketplace. The goals are to reduce the cost of solar energy to the point that it becomes competitive in relevant energy markets and for solar technology to reach a level of market penetration to enable a sustainable U.S. solar industry. Table 1 shows specific long-term goals for PV.

To accomplish its goals, the SETP combines research, design, and development of technology with value analysis, an integrated-systems approach, and partnering. Central to this strategy is the "Systems-Driven Approach," which emphasizes the importance of how materials, processes, components, products, applications, and markets for a technology are related to each other.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION

There are three areas of SETP-sponsored PV research, development, and demonstration: fundamental research, advanced materials and devices, and technology development. Below are brief descriptions of these areas and select 2005 highlights. A comprehensive list of accomplishments is available in the DOE Solar Energy Technologies Program FY 2004 Annual Report, which can be obtained at www.osti.gov/bridge.

Fundamental Research

Fundamental Research investigates the physical mechanisms of charge carrier transport, band structure, junction formation, impurity diffusion, defect states, and other physical properties of PV materials and devices. Among the research topics are innovative ideas and

TABLE 1 - LONG-TERM GOALS FOR PV LEVELISED COST OF ENERGY (LCOE) AND INSTALLED SYSTEM PRICE BY MARKET SEGMENT

	Current U.S. Market Price (USD/kWh)	Target for PV LCOE in 2011 (USD/kWh)	Target for PV LCOE in 2020 (USD/kWh)	Required 2020 Installed PV System Price (USD/Wp with 0,01 USD/kWh O&M
Residential	0,25 - 0,32	0,13 - 0,18	0,08 - 0,10	2,25 - 3,00
Commercial	0,18 - 0,22	0,09 - 0,12	0,06 - 0,08	2,00 - 2,75
Utility	0,15 - 0,22	0,10 - 0,15	0,05 - 0,07	1,50 - 2,25

(Source: US DOE Solar Energy Technologies Program, Solar Energy Technologies Program Multi-Year Program Plan 2007-2011. September 2005)

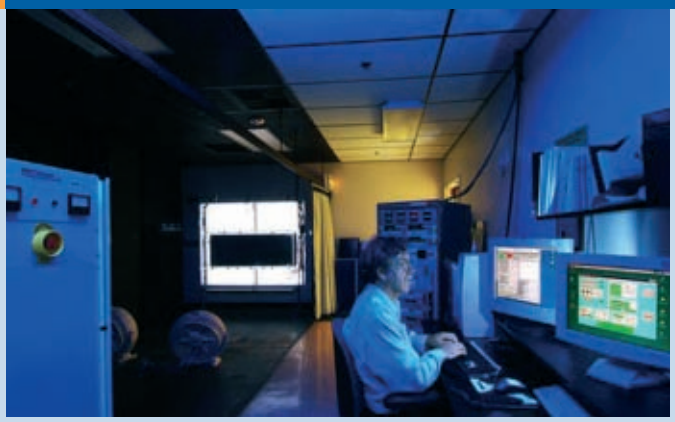

Fig. 1 - A researcher operates NREL's large area continuous solar simulator as part of the Measurements and Characterization activity.

Fig. 2 - Automated module manufacturing at a Shell Solar Industries plant in Camarillo, California. Shell Solar is a PV Manufacturing R&D Project subcontractor.

technologies with the potential to "leapfrog" current approaches, leading to new, nonconventional concepts that could dramatically improve cost effectiveness in the long term. The following are Fundamental Research topics and sample 2005 accomplishments.

Measurements and Characterization -- Provides test, measurement, and analysis support and research for the SETP, including national laboratories, external research partners in university and industry laboratories, and PV manufacturers.

- Expanded ISO 17025 accreditation from secondary reference cells to include primary reference cells and modules and developed a prototype minority-carrier lifetime measurement system capable of accurately measuring both crystalline and multi-crystalline silicon wafers in an in-line manufacturing environment.

Electronic Materials and Devices -- Carries out research in semiconductor materials, device properties, and fabrication processes to improve the efficiency, stability, and cost of PV.

- Invented fire-through agents that enable inkjet-written Ag contacts to silicon solar cells through silicon nitride antireflection coating.

Crystalline Silicon Project -- Directs fundamental crystalline silicon R&D involving universities and national laboratories.

- Demonstrated a 17 %-efficient heterojunction silicon (a-Si/c-Si) solar cell and demonstrated a bifacial heterojunction silicon solar cell process for p-type c-Si wafers that resulted in 12,5 %-efficient cells. This work is being used to evaluate deposition temperature and crystal orientation of the substrate.

High-Performance Photovoltaics -- Explores the ultimate performance of PV technologies, aiming to approximately double their sunlight-to-electricity conversion efficiencies.

- Demonstrated a 39 %-efficient GaInP/GaInAs/Ge cell verified by NREL at 236 suns. This is the highest NREL-confirmed efficiency ever measured for any PV device. This record used three-junction GaInP/GaInAs/Ge concentrator solar cells grown on a Ge substrate incorporating epitaxial device features to optimize their performance under the concentrated terrestrial spectrum and processed at Boeing Spectrolab, under an NREL subcontract.

Solar Resource Characterization -- Addresses solar resource assessment including access to data and characterization of the solar resource.

- Evaluated performance of three candidate solar radiation models for the National Solar Radiation Data Base and to implement the IEA "Solar Resource Knowledge Management" Task for benchmarking international solar resource data sets. This project addresses solar resource assessment and includes access to data and characterization of the solar resource for the needs of designers, modelers, and resource assessment interests, both in the United States and internationally.

Environmental Health and Safety -- Minimizes potential EH&S impacts associated with current and future PV energy systems and applications.

- Advanced CdTe recycling by accomplishing a 99,99 % separation of Cd from Te at a projected cost of 0,02 USD per watt. Ongoing outreach and information dissemination efforts were also conducted because the PV industry is undergoing changes in type and quantities of materials, manufacturing processes, and scale.

Advanced Materials and Devices

The Advanced Materials and Devices effort carries out research in semiconductor material properties, device mechanisms, and fabrication processes to improve the efficiency, stability, and cost of PV. The effort focuses on thin films, module manufacturing methods, and module reliability. The following are Advanced Materials and Devices research areas and sample 2005 accomplishments:

Thin Film PV Partnership -- Directs subcontracted and collaborative R&D in thin films including CIS, CdTe, amorphous silicon, CIGS, and film silicon.

Fig. 3 - This view of NREL's Outdoor Test Facility shows the laboratory building and some of the test beds used to evaluate PV systems under field conditions.

- Two Technology Partners broke ground on major manufacturing expansions (First Solar 25 MW to 75 MWp CdTe, and Uni-Solar 25 MW to 50 MWp a-Si). The Thin Film PV Partnership supported the transition to successful first-time manufacturing of key thin-film technologies during the fiscal year. This is the Partnership's most important activity in the short term, because it will help establish thin films in the marketplace, improve their chances of future growth and success, and help define the transition of technologies that have been successfully developed by DOE funding to the private sector.

PV Manufacturing R&D -- Assists the U.S. PV industry through cost-shared manufacturing R&D.

- Continued with "Large-Scale Module and Component Yield, Durability, and Reliability" subcontracted efforts with the selection of 11 industry partners. This solicitation focuses on: the improvement of module manufacturing processes to increase module reliability, system and system component packaging, system integration, manufacturing and assembly; product manufacturing flexibility; and balance-of-system (BOS) development including storage and quality control.

PV Module Reliability R&D -- Develops and applies advanced measurement techniques, diagnostic methods, and instrumentation to help mitigate degradation, reduce module costs, and improve performance. To conduct these activities, NREL and SNL develop and apply advanced measurement techniques, diagnostic methods, and instrumentation. The intent of this R&D is to optimize the time and funding applied to advancing module technologies from the prototype to the commercial production stage, with respect to meeting acceptable performance, reliability, and costing requirements.

- Initiated unique high-voltage stress testing experiment that measures module leakage currents to ground on a bipolar array of Shell Solar's CIGSS modules. Also, a cooperative testing program was initiated on SunPower's high-efficiency crystalline-Si modules including light soaking, thermal cycling, and damp heat exposure indoors, and real-time outdoor exposure geared toward helping SunPower improve fabrication of its solar cells.

Inverter and BOS Development -- Supports engineering advancements through characterization feedback of newly developed power electronics and BOS hardware and establishes suitability for incorporation of new inverters and BOS into integrated systems.

- Assessed alpha inverter and controller prototypes for conformity to utility interconnection requirements, performance objectives, and manufacturing objectives. Additionally, the "High-reliability Inverter Initiative" took a first step toward higher reliability at no increase in unit cost, namely the improvement of mean-time-between-failures to more than 10 years. This advance had a significant positive impact on calculated levelised cost of energy of PV systems.

Technology Development

The Technology Development activity advances PV performance and systems engineering, improves systems reliability, and develops technology suitable for integration into residential and commercial building structures. The following are Technology Development research areas and sample 2005 accomplishments.

PV Systems Engineering -- Characterizes performance and reliability of emerging PV technologies, assists with development and implementation of codes and standards, and provides world-class solar irradiance capabilities, measurements, and standards.

- Generated 24 performance reports for PV systems monitored at the NREL Outdoor Test Facility. These reports provide world-class and traceable measurements and instrumentation for solar radiometry. The resultant precision and accuracy of the PV system (and module) performance measurements are determined by the quality, precision, and accuracy of the measurements of the incident (on the PV arrays) solar irradiance (i.e., "power in"). This project also includes very important activities aimed at supporting the development of industry-consensus/adopted codes, standards, and certification that cover PV systems, components, and installation practices.

System Evaluation & Optimization -- Provides laboratory and field-test information to establish the performance and reliability of current PV systems and identifies opportunities for improved system design and component integration in next-generation systems.

- Implemented the PV System Optimization Laboratory, which can perform detailed performance and long-term reliability

research on 14 separate nominally 3-kW PV systems with multiple array/inverter combinations. Working with SNL, both General Electric and Xantrex are currently active in Phase III of the "High-reliability Inverter Initiative" and have extensive and critically timed commercialization plans for the products developed out of this program. Xantrex expects to use the fundamental high-reliability design as a basis for its next-generation family of products. GE is vertically integrating its newly acquired PV module manufacturing capabilities with the new inverter development into its existing new construction housing market.

Domestic PV Applications -- Provides a focal point for DOE activities through developing projects, disseminating information, promoting public awareness, managing subcontracts, and providing technical assistance.

- Supported development of standardized program acceptance criteria for evaluation of U.S. Department of Agriculture (USDA)\Rural Utility Service and the USDA Farm Bill proposals.

Building-Integrated PV -- Fosters widespread acceptance of PV-integrated buildings by overcoming technical and commercial barriers and facilitating the integration of PV into the built environment through technology development, applications, and key partnerships.

- Implemented the 2005 Solar Decathlon university competition involving 18 university design teams to raise awareness of the potential of solar technologies. Student teams from around the globe participated in an unparalleled solar competition to design, build, and operate the most attractive and energy-efficient solar-powered home. More than 120 000 attendees toured the homes on the Washington D.C. Mall, and the official Solar Decathlon Web site, www.solardecathlon.org, received approximately 73 000 unique visits during the event.

Million Solar Roofs (MSR) -- Facilitates installation of solar energy systems on U.S. buildings.

- Added five new MSR State and Local Partnerships, bringing the national total of participants to 926 partnerships.

PV System Analysis -- Performs systems performance and cost modeling, market/value/policy analysis, and benchmarking projects.

- Expanded the number of default markets/systems included in the Solar Advisor Model and expanded partnered activities on commercial and utility-scale systems to further refine determinations of life-cycle cost, system reliability, and system availability. Additionally, a working version of the SolarDS model was developed with an initial set of scenarios and expanded work on PV value analysis to include both identifying best practices and information sharing, aimed at helping to inform state-level policymaking.

Regional Experiment Stations -- Provide technical support to the SETP, including reducing systems costs, improving systems reliability, improving system performance, and removing barriers to deployment.

- Four inverters were placed in service for long-term performance testing at each Regional Experiment Station. Additionally, technical assistance and installer workshops to the industry and users have resulted in an evolving design review and approval standard that provides guidance for uniform designs and system documentation. This activity promotes a level of quality recognized and practiced by other industries that develop products in successful markets.

IMPLEMENTATION

Industry Roadmap and Technical Plans

According to the U.S. PV Industry Roadmap, "success of PV in the United States depends on the direction, resources, best scientific and technological approaches, use of the best technologies, and continued efforts of the best and brightest among industry, federal laboratory, and university partners" (SEIA, 2003). The SETP worked with industry to lay the groundwork for a "Systems-Driven Approach" to guide new PV work that meets the goals of the industry roadmap and that will be funded by DOE. See the industry roadmap at www.seia.org/roadmap.pdf.

Federal and State Policies Promote PV

The U.S. PV Industry Roadmap states, "Effective policies sustained over time increase solar power production, dramatically grow markets, improve technology, and reduce costs (SEIA, 2003)." In the United States, federal and state policies are in place to promote PV. The Energy Policy Act of 2005 offers consumers and businesses federal incentives for many renewable energy and energy efficiency technologies. For example, the act established a 30 % tax credit for qualified PV system expenditures up to a maximum of 2 000 USD for equipment placed in service during 2006-2007. The U.S. PV industry is promoting extension of this incentive.

The most notable state PV incentive program is the California Solar Initiative. Enacted in 2005, it is the largest state solar incentive program in the United States. It allots 2,9 billion USD for solar energy rebates in California over 10 years. The goal is to increase the solar capacity installed on California rooftops by 3 000 MW by 2017. The initial PV incentive levels were set at 2,80 USD per watt effective Jan. 1, 2006, to be reduced by an average of approximately 10 % annually. For more information, visit the California Public Utilities Commission site at www.cpuc.ca.gov.

Numerous additional state policies promote PV throughout the United States. For example, more than 20 states have renewable portfolio standards, requiring that a certain proportion of a utility's

generating capacity or energy sales be derived from renewable resources. For more information on state incentive programs, see the Database of State Incentives for Renewable Energy at www.dsireusa.org.

INDUSTRY STATUS

According to PV News, U.S. PV production grew 10 % from 2004 to 2005, reaching 153 MW (Maycock, 2006). World production exceeded 1 700 MW in 2005. In part, market growth is being driven by innovations in technology and manufacturing that continue to increase efficiency, boost product lifetime and reliability, and simplify installation. As a result, average costs and prices declined to make solar power more competitive with conventional energy sources.

A consequence of the rapid growth of PV has been the emergence of a solar-grade silicon supply shortage. This supply shortage, which is believed to be temporary with new supplies coming on line throughout 2006 and 2007, has created an opportunity for thin-film PV and concentrator technologies, which do not use polysilicon feedstock, to accelerate their move from the laboratory into manufacturing and large-scale production.

While PV has been growing rapidly worldwide, the United States has lost its lead in PV development. According to the U.S. PV Industry Roadmap, in 1997, U.S. solar power manufacturers captured nearly 100 % of the domestic market; in 2003, they captured only 73 % (SEIA, 2003). According to PV News, in 1997, U.S. manufacturers captured more than 40 % of the world market; in 2005, they captured only 9 %. In 2005, U.S. production grew by 10 % from the previous year. Meanwhile, shipments from Europe grew by 44 % and shipments from Japan by 38 % from 2004 (Maycock, 2006).

MARKET DEVELOPMENT

The main objectives of deployment facilitation are to provide technical support in assisting market growth and to retrieve technical performance, cost, and reliability information from fielded applications. This information is fed back to researchers, providing direct, market-based data that can drive decisions. Deployment facilitation activities are geared to produce an impact on overall market volume across the spectrum of market sectors, including residential, commercial, industrial/utility, off-grid, and international.

The SETP meets these deployment facilitation opportunities in a variety of ways. For example, DOE's Million Solar Roofs Initiative is a public/private technology deployment partnership aimed to overcome barriers to market entry for solar technologies and to facilitate the installation of residential, commercial, and industrial systems. Another example is DOE's Solar Decathlon, which brings college and university teams from around the world to compete in designing and building houses that demonstrate the benefits of solar technologies.

International partnerships also play a role in deployment facilitation because the majority of domestically produced solar products are currently shipped overseas, and international solar markets will

Fig. 4 - The 2005 Solar Decathlon, held in Washington, DC, exposed more than 100,000 visitors to PV technologies (photo Stefano Paltero, Solar Decathlon).

continue to grow in the foreseeable future. Therefore, knowledge and information from solar activities outside the United States provide business opportunities to U.S. solar companies in developed markets, such as Japan and Europe, and developing markets, such as India and China. The SETP also supports the International Energy Agency (IEA), specifically through the IEA Photovoltaic Power System Implementing Agreement. Activities include technical assistance, demonstration of the technical feasibility of new technologies and applications, training, development and promotion of norms and standards, and fostering business development, such as facilitation of joint-venture agreements between foreign and U.S. companies.

To facilitate continued market growth, it is important to develop appropriate and reasonable codes, standards, and certification programs. The SETP focuses support on collaborative efforts with standards organizations, including the National Fire Protection Association, the Institute for Electrical and Electronic Engineers, the American Society for Testing Materials, Underwriters Laboratories, and the International Electrotechnical Commission. Specific opportunities in this arena are improved utility interconnection standards that include communications and controls for grid stabilization, a standardized communications protocol for inverters and system controllers, hardware certifications to improve consumer confidence, and standardized practices for certification of PV system designers and practitioners, assuring up-to-date knowledge on advances in technology, safety, or interconnect practices.

FUTURE OUTLOOK

The U.S. PV industry believes the next 10 years are critical for worldwide solar power development. This period will determine which nations reap the economic, environmental, security, and reliability values that solar power offers. Actions by government and industry will determine whether solar power is catapulted to a new level and whether the United States will regain its position at the forefront of solar power development. Investment decisions over the next decade for research, new manufacturing, and creating new markets will determine where solar power will thrive (SEIA, 2003).

Industry Targets and Projections

Projections from the U.S. PV Industry Roadmap suggest that, at robust growth rates achievable through proven policies for technology and market development, "the cumulative capacity of installed solar electric systems in the United States will grow from less than 0,4 GW in 2003 to 200 GW by 2030" (SEIA, 2003). In the short term, the annual growth in U.S. solar generation capacity is projected to track growth in worldwide solar power equipment sales, at over 35 %. U.S. exports likely will remain flat. Most U.S. solar power equipment will remain in the United States, and domestic demand will fuel industry growth if the United States invests in technology and market development programs. According to the industry roadmap, "By 2020, the U.S. industry should install nearly all its output -- 7,2 GWp per year -- in the United States. After 2015, growth rates will moderate to 26 % annually until 2020, as technology and markets mature. Annual growth rates will decline to a sustainable 1 % to 2 % annual increase in 2030 -- the classic S-shaped market penetration curve for new technologies. By 2030, the industry is targeting cumulative installed solar capacity of 200 GW, and the industry will install 19 GW per year" (SEIA, 2003). At that point, the industry predicts that solar power will be a substantial share of U.S. peak generating capacity and a major source of electricity. As soon as 2015, the system selling price is projected at 3,68 USD per watt if the policies recommended in the industry roadmap are implemented. With incentives, the cost of solar electricity will be as low as 0,057 USD per kWh -- a level that is lower than current retail rates for many consumers.

In summary, the potential of solar energy in the United States will be realized through concerted R&D efforts via public/private partnerships to reduce the cost of solar energy systems and to maximize solar energy's promise over the next 20 years. Solar energy represents an opportunity to diversify the United States' primary energy requirements and future energy demands while creating jobs in high-tech manufacturing, installation, and operation of solar power equipment.

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COMPLETED TASKS
TASK 3 - USE OF PHOTOVOLTAIC POWER SYSTEMS IN STAND-ALONE AND ISLAND APPLICATIONS

OVERALL OBJECTIVE

Task 3 was established in 1993 to stimulate collaboration between IEA countries in order to improve the technical quality and cost-effectiveness of photovoltaic systems in stand-alone and island applications.
When the **first programme (1993-1999)** was approved, the stand-alone photovoltaic sector was largely comprised of solar home systems for rural electrification, remote 'off-grid' homes in industrialised countries and PV consumer goods. PV hybrid systems and niche off grid applications such as PV powered bus shelters were also being introduced in certain countries.
As part of this programme, a number of documents were published as information about installed stand-alone PV systems worldwide. These included a **lessons learned book** featuring case studies from each country, as well as a survey of **PV programmes in developing countries**.

Task 3's **second programme (1999-2004)** was initiated against this background with the following overall objectives:

Considering all types of stand-alone photovoltaic systems, ranging from small PV kits to power stations supplying micro-grids, the main objective of Task 3 is to improve the technical quality and cost-effectiveness of PV systems in stand-alone and island applications.

TASK 3 Aimed:

- To collect, analyse and disseminate information on the technical performance and cost structure of PV systems in these applications
- To share the knowledge and experience gained in monitoring selected national and international projects
- To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems
- To contribute to the development of improved photovoltaic systems and subsystems"

The main target audience of Task 3 activities were technical groups such as project developers, system designers, industrial manufacturers, installers, utilities, Quality organisations, training providers, end users.

The 1999-2004 work programme included the following subtasks and activities:

SUBTASK 1: QUALITY ASSURANCE

Activity 11: Critical Review of Implementation of Quality Assurance Schemes

To develop quality assurance schemes that will lead to a warranty for all system installations at reasonable cost.

Activity 12: Technical Aspects of Performance Assessment on Field - Quality Management

To identify and establish practical performance assessment guidelines.

SUBTASK 2: TECHNICAL ISSUES

Activity 21: Hybrid Systems

To contribute to cost reduction through standardisation and modularity in order to facilitate large scale dissemination of PV hybrid systems.

Activity 22: Storage Function

To provide recommendations to decrease the cost of storage in PV and PV hybrid systems.

Activity 23: Load/Appliances : Load Management and New Applications

To provide a technical contribution to cost reduction by showing the cost efficiencies associated with effective load management and efficient appliance selection.

Collaborative activities had to develop knowledge based on project implementations, technological improvements from the equipment manufacturers, R&D programmes results, and feed-back coming from the field.

PUBLICATIONS

Task 3 publications can be downloaded from the IEA PVPS website www.iea-pvps.org and are listed below:

TECHNICAL REPORTS PUBLISHED BY TASK 3 DURING THE PERIOD 1999-2004

TITLE	REFERENCE NUMBER
Survey of National and International Standards, Guidelines and Quality Assurance Procedures for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-07:2000
Recommended Practices for Charge Controllers	IEA-PVPS T3-08:2000
Use of Appliances in Stand-Alone Photovoltaic Systems: Problems and Solutions	IEA-PVPS T3-09:2002
Management of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems	IEA-PVPS T3-10:2002
Testing of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-11:2002
Selecting Stand-Alone Photovoltaic Systems - Guidelines	IEA-PVPS T3-12:2002
Monitoring Stand-Alone Photovoltaic Systems: Methodology and Equipment - Recommended Practices	IEA-PVPS T3-13:2003
Protection Against the Effects of Lightning on Stand-Alone Photovoltaic Systems - Common Practices	IEA-PVPS T3-14:2003
Managing the Quality of Stand-Alone Photovoltaic Systems - Recommended Practices	IEA-PVPS T3-15:2003
Demand Side Management for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-16:2003
Selecting Lead-Acid Batteries Used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-17:2004
Alternative to Lead-Acid Batteries in Stand-Alone Photovoltaic Systems	IEA-PVPS T3-18:2004

SCOPE FOR FUTURE ACTIVITIES

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, " PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website: www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities: Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

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COMPLETED TASKS
TASK 5: GRID INTERCONNECTION OF BUILDING INTEGRATED AND OTHER DISPERSED PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 5 was to develop and verify technical requirements, which served as the technical guidelines for grid interconnection with building-integrated and other dispersed PV systems. The development of these technical requirements included safety and reliable linkage to the electric grid at the lowest possible cost. The systems to be considered were those connected with a low-voltage grid, which was typically of a size between one and fifty peak kilowatts. Task 5 was officially concluded in 2003.

MEANS

Participants carried out five subtasks; Subtasks 10,20,30,40 and 50 in order to achieve these objectives. The objectives of each subtask were as follows:

SUBTASK 10: Review of Previously Installed PV Experiences (From 1993 to 1998)

To review existing technical guidelines, local regulations and operational results of grid interconnection with building- integrated and other dispersed PV systems to aid Subtask 20 in defining existing guidelines and producing concepts for new requirements and devices.

SUBTASK 20: Definition of Guidelines to be Demonstrated (From 1993 to 1998)

Utilizing the results of Subtask 10 and a questionnaire, existing technical guidelines and requirements to be demonstrated will be defined, and concepts for new requirements and devices will be developed; with safety, reliability, and cost reduction taken into consideration.

SUBTASK 30: Demonstration Test Using Rokko Island and/or Other Test Facilities (From 1993 to 1998)

To evaluate, by demonstration tests, the performance of existing and new technical requirements and devices defined in Subtask 20.

SUBTASK 40: Summarizing Results (From 1993 to 2001)

To summarize the results of Task 5 and to produce a general report for all participating countries of Task 5, as well as for the ExCo members.

SUBTASK 50: Study on Highly Concentrated Penetration of Grid Interconnected PV Systems (From 1999 to 2001)

To assess the net impact of highly concentrated PV systems on electricity distribution systems and to establish recommendations for both distribution and PV inverter systems in order to enable widespread deployment of solar energy.

TASK 5 REPORTS AND WORKSHOP PROCEEDINGS:

Task 5 produced the following reports and workshop proceedings:

Task 5 Reports

1. "Utility aspects of grid interconnected PV systems", IEA-PVPS T5-01: 1998, December 1998
2. "Demonstration tests of grid connected photovoltaic power systems", IEA-PVPS T5-02: 1999, March 1999
3. "Grid-connected photovoltaic power systems: Summary of Task V activities from 1993 to 1998", IEA-PVPS T5-03: 1999, March 1999
4. "PV system installation and grid-interconnection guideline in selected IEA countries", IEA-PVPS T5-04: 2001, November 2001
5. "Grid-connected photovoltaic power systems: Survey of inverter and related protection equipments", IEA-PVPS T5-05: 2002, December 2002
6. "International guideline for the certification of photovoltaic system components and grid-connected systems", IEA-PVPS T5-06: 2002, February 2002
7. "Probability of islanding in utility networks due to grid connected photovoltaic power systems", IEA-PVPS T5-07: 2002, September 2002
8. "Risk analysis of islanding of photovoltaic power systems within low voltage distribution networks", IEA-PVPS T5-08: 2002, March 2002
9. "Evaluation of islanding detection methods for photovoltaic utility-interactive power systems", IEA-PVPS T5-09: 2002, March 2002
10. "Impacts of power penetration from photovoltaic power systems in distribution networks", IEA-PVPS T5-10: 2002, February 2002
11. "Grid-connected photovoltaic power systems: Power value and capacity value of PV systems", IEA-PVPS T5-11: 2002, February 2002

Task 5 Internal Reports (Open to Public)

1. "Grid-connected photovoltaic power systems: Status of existing guidelines and regulations in selected IEA member countries (Revised Version)", IEA-PVPS V-1-03, March 1998
2. "Information on electrical distribution systems in related IEA countries (Revised Version)", IEA-PVPS V-1-04, March 1998

Proceedings of Final Task 5 Workshop

1. Introduction and table of contents
2. Flyer of the workshop
3. List of participants of the workshop
4. Final programme of the workshop
5. Key note speech
6. Islanding detection methods
7. Probability of islanding in power networks
8. Risk analysis of islanding
9. Conclusions of task V islanding studies
10. Recapitulation of first day
11. Overview of (inter)national interconnection guidelines for PV-systems
12. State of the art inverter technology and grid interconnection
13. Impacts of PV penetration in distribution networks
14. Power value and capacity of PV systems

DELIVERABLES - Where to get them?

All reports are available for download at the IEA PVPS website: http://www.iea-pvps.org
A Task 5 CD-ROM including all the reports was published for distribution. This can be ordered at the contact address below.

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COMPLETED TASKS
TASK 6 - DESIGN AND OPERATION OF MODULAR PHOTOVOLTAIC PLANTS FOR LARGE SCALE POWER GENERATION

OVERALL OBJECTIVE

Task 6 officially completed its activities in May 1998. The main objective of this Task was to further develop large-scale modular photovoltaic plants for peaking and long-term baseload power generation in connection with the medium-voltage grid.

MEANS

The Task 6 work was performed by structural engineers and PV industry experts. The work was structured into four sub-tasks, for a total of fifteen activities.

SUBTASK 10: Review of Design and Construction Experiences of Large-Scale PV Plants

To perform, on the basis of the Paestum Workshop results, an in-depth review of existing large-scale PV plants aimed both to identify the remarkable technical solutions adopted in such plants and the main common criteria applied for their design, installation, operation, monitoring, and to perform a detailed cost analysis of the plants taken into account.

SUBTASK 20: Review of Operational Experiences in Large-Scale PV Plants

To perform, also utilising the work in progress of Subtask 10 and on the basis of the Paestum Workshop results, an in-depth review of operational experiences in existing large-scale PV plants. The analysis of the acquired data was focused on the comparison between the expected and actual results, both technical and economical; the information flow was continuously updated through acquisition of data from all the plants in operation.

SUBTASK 30: Development of Improved System Design and Operational Strategies for Large-Scale PV Plants

Based on the work of Subtasks 10 and 20, the evaluation work, together with the information gathering activity, let the assessment of most appropriate, innovative technical options for modular design of large-scale PV plants. Both PV and BOS components were dealt with, taking into account: performances improvement, costs reduction, and realisation simplification.

The co-operation among utilities and industries of many countries offered the opportunity to review in detail the performance data and the technical aspects which determined the design approach of the largest PV plants in the world, and to develop improved system design, and operational strategies for such plants.

SUBTASK 40: Outlook of Perspectives of Large-Scale PV Plants

Based on the assumption that large grid connected PV power plants have proven their applicability under the technical point of view, the Subtask was aimed at identifying the path in order to let such plants become a substantial option and play an increasing role in a future oriented energy concept in OECD countries, as well as in developing countries.

TASK 6 REPORTS AND WORKSHOP PROCEEDINGS

Task 6 produced the following reports and workshop proceedings from 1993 to 1998:

1. The Proceedings of the Paestrum Workshop.
2. A PV Plant Comparison of 15 plants.
3. The State of the Art of: High Efficiency, High Voltage, Easily Installed Modules for the Japanese Market.
4. A document on "Criteria and Recommendations for Acceptance Test."
5. A paper entitled: "Methods to Reduce Mismatch Losses."
6. Report of questionnaires in the form of a small book containing organized information collected through questionnaires integrated with statistical data of the main system parameters and of the main performance indices.
7. The "Guidebook for Practical Design of Large Scale Power Generation Plant," edited by the Japanese expert.
8. The "Review of Medium to Large Scale Modular PV Plants Worldwide."
9. Proceedings of the Madrid Workshop.

DELIVERABLES – Where to get them?

All reports are available for download at the IEA PVPS website: http://www.iea-pvps.org

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COMPLETED TASKS
TASK 7 - PHOTOVOLTAIC POWER SYSTEMS IN THE BUILT ENVIRONMENT

OVERALL OBJECTIVE

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. The objective was also to assess and remove non-technical barriers for their introduction as an energy-significant option.

It is expected that successful integration of PV systems into the built environment (BIPV) will contribute significantly to the future spread of PV.

For this, active involvement of urban planners, architects and building engineers is required. Task 7 motivated the collaboration between these groups and PV system specialists, utility specialists, PV and building industry and other professionals involved in photovoltaics.

Task 7 considered all grid connected systems other than classified as "ground based arrays". Primary focus of this Task was on the integration of PV into the architectural design of roofs and facades of residential, commercial and industrial buildings and other structures in the built environment (such as noise barriers, parking areas and railway canopies), and on other market factors, both technical and non-technical, that need to be addressed and resolved before wide spread adoption of PV in the built environment will occur. Task 7 officially started on January 1, 1997 and finished end 2001. In 2002, the last reports and deliverables were published. At the end of 2003 there remained only one outstanding issue: the publication of the book "Designing with Solar Power". This book is expected in Spring 2005.

SUBTASK 1: Architectural Design of Photovoltaic Power Systems in the Built Environment

Participants worked on the improvement of the architectural design of PV systems as an integral element in buildings and other structures in the built environment. For this purpose, existing PV projects were documented. In addition, case studies were followed and evaluated by the Task Participants. Many of these case studies were realised as demonstration projects.

SUBTASK 2: Systems Technologies for Photovoltaic Power Systems in the Built Environment

Participants worked on the development of new concepts for photovoltaic power systems in the built environment that can enhance the electrical performance or the performance of the PV system as a building component. New concepts, developed by the Participants shall enhance market opportunities for the industry. This Subtask aims for a number of standardised and certified PV elements for integration in buildings and other structures in the built environment. The Subtask will also provide a number of options to effectively utilise PV electricity and to connect PV systems safely and reliably to the electricity grid, as far as this topic is not addressed by Task 5 of the PVPS Implementing Agreement.

SUBTASK 3: Non-Technical Barriers in the Introduction of Photovoltaic Power Systems in the Built Environment

Participants assessed the non-technical barriers to be removed to make PV in the built environment an energy-significant power supply option. The purpose of this Subtask was to identify the barriers on one side and the (technical, economic, market) potential of PV in the built environment on the other. The main result of this Subtask will be an executive IEA report on strategies for barrier removal and utilisation of the PV potential.

SUBTASK 4: Demonstration and Dissemination of Photovoltaic Power Systems in the Built Environment

The results of the other Subtasks were brought to the market by dissemination of collected information and the demonstration of new concepts. Demonstration of mounting and system concepts takes place through the EPFL Demosite. Results are disseminated by the use of different media (ranging from papers, books, and brochures to new media such as a CD-ROM or a WWW-site). Dissemination will also occur through the second and third International Solar Electric Buildings Conferences and national workshops in conjunction with the semi-annual meetings of the Task. Furthermore, the possibility of a training and education program was assessed and resulted in a CD-ROM.

TASK 7 REPORTS

Task 7 produced the following reports from 1999 to 2002:

1. Literature Survey and Analysis of Non-technical Problems for the Introduction of BIPV Systems, B. van Mierlo & B. Oudshoff, IVAM Environmental Research, 1999. To be ordered at IVAM Environmental Research, NL, Fax + 31 20 525 58 50
2. PV in Non Building Structures - A Design Guide, M.A. Romero, EcoCode-Miljö och Architectur, 1999. To be ordered at Energiebanken, SE, Fax: +46 652 13 427
3. Potential for Building Integrated Photovoltaics, M. Gutschner, Nowak Energy Technologies AG, 2001. To be ordered at NET, CH, Fax: +41 26 49 40 034
4. Guidelines for the Economic Evaluation of Building Integrated Photovoltaics, P. Eiffert, National Renewable Energy Laboratories, 2002. To be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance.
5. Market Deployement Strategies for Photovoltaics in the Built Environment, R. Haas, Technische Universität Wien, 2002. To be ordered at Technische Universität Wien, AT, Fax: +43 1 588 013 7397
6. Innovative electric concepts, H. Wilk, Energie AG, 2002. To be ordered at Energie AG, AT, Fax: +43732 9000 3309
7. Reliability of Photovoltaic Systems, H. Laukamp, Fraunhofer Institute für Solar Energiesysteme, 2002. To be ordered at Fraunhofer Institute für Solar Energiesysteme, GE, Fax: +49 761 4588 217
8. PV/Thermal Solar Energy Systems, Status of the Technology and Roadmap for future Development, H. Sorensen, Esbensen Consulting, 2002, To be ordered at Esbensen Consulting Engineers, DK, Fax: +45 33 26 73 01
11. Executive Summary Report - Non-technical Barriers to the commercialisation of Photovoltaic Power in the Built Environment, P. Eiffert, National Renewable Energy Laboratories, to be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance

DELIVERABLES – Where to get them?
All reports are available for download at IEA PVPS website: www.iea-pvps.org.
In addition, all reports and many other deliverables are summarized on CD-ROM, which can be ordered at Novem, The Netherlands.

Task 7, Project Results and Documents.
To be ordered at:
Novem, Publication Centre
PO Box 8242
3503 RE Utrecht
The Netherlands
Tel.: +31 30 2393493
Email: publicatiecentrum@novem.nl.

Task 7 book: Designing With Solar Power"
To be ordered at:
The Images Publishing Group Pty Ltd
6 Bastow Place
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PARTICIPANTS

In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

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Task 7 website: www.task7.org
Task 7 demosite: www.demosite.ch
PV Projects database: www.pvdatabase.com

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ANNEX B

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