IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS annual report 2007

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2007

CHAIRMAN'S MESSAGE

Stefan Nowak
Chairman

I am pleased to present the annual report of the IEA Photovoltaic Power Systems Programme covering the year 2007. It was another remarkable year for photovoltaic technology. Once again, a strong market growth could be observed, accompanied by important investments in research and development, in new products, as well as in new industrial production facilities of increasing size. Analysing this rapid development and contributing to a further sustainable growth of photovoltaic technology is both exciting and challenging. As a leading international network of expertise, IEA PVPS has the mission and privilege to co-operate on a global level in this rapidly expanding technology area. Providing objective and neutral high-quality information about relevant developments in the photovoltaic sector remained our highest priority. Due to the increasing recognition of photovoltaics as an important future energy technology, the interest in the work performed within IEA PVPS is continuously expanding.

2007 has indeed also been a special year for IEA PVPS: The third term of our collaborative programme was concluded at the end of the year and – due to a clear and pronounced need for further collaborative work – an extension had to be foreseen. Along the IEA procedures, an End-of-Term report was prepared together with a strategy for the next term. Our findings were presented to the Renewable Energy Working Party (REWP) and the Committee for Energy Research and Technology (CERT). Our collaborative programme was very well received and found to be a model of IEA collaboration, in terms of quality of the work, global coverage, outreach, impact and communication efforts. Both committees congratulated PVPS for its achievements and the extension for another 5-year term was unanimously approved.

2007 was also a year of outreach activities for PVPS. Based on the G8 Gleneagles Plan of Action, the IEA has placed additional emphasis on the technology networks and their outreach activities through the NEET initiative (Networks of Expertise in Energy Technology) in which PVPS participates. PVPS participated actively in the NEET workshops in South Africa and China during the year. One of our Executive Committee meetings was held in Greece in order to foster potential participation of Greece in the IEA PVPS programme. Membership in IEA PVPS was re-established by Turkey and Malaysia is on its way to become a regular member of the programme. New Zealand, Singapore and Thailand have also shown interest in IEA PVPS.

On the Task level, the PVPS Task 2 on Performance, Reliability and Analysis of Photovoltaic Systems was successfully concluded at the end of the year. My thanks for a remarkable effort and relevant results go to Germany as the leading country of this Task, the Operating Agent Ulrike Jahn for her outstanding commitment and dedication to the leadership of this Task as well as to the Task expert group who have been working together for many years. There was a clear recommendation from the Executive Committee, that the activities of Task 2 concerning quality assurance should form the topic of a new Task to be established in the coming year. The new Task 12 on “Environmental Aspects of Photovoltaics” started during the year with the support by the European Photovoltaic Industry Association (EPIA) and the United States as Operating Agents.

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 further supported by the PVPS website www.iea-pvps.org which was simplified and reorganised. Moreover, a booth at the industry exhibition of the 22nd European Photovoltaic Solar Energy Conference in Milan, again attracted a large number of visitors and provided an excellent forum for dissemination purposes.

2007 was another productive year for PVPS with many new results from the various ongoing projects. 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 efforts, contribute to the collaborative work and success of PVPS.

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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 agreements and 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 mid 2007, twelve Tasks were established within the PVPS programme, of which seven are currently operational. The latest task (Task 12) started in 2007.

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 through which photovoltaic solar energy becomes a significant renewable energy option in the near future.

The underlying assumption is that the market for PV systems is continuously expanding from the earlier niche markets of remote applications and consumer products, to the rapidly growing markets for building integrated and other diffused and centralised grid-connected 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 PVPS programme aims to realize the above mission by adopting the following objectives related to reliable PV power system applications for the target groups such as 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 PVs' 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 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.

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 PVs' potential and value and thereby provide advice to decision makers from government, utilities and international organisations.	• 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, Ebeltoft, Denmark, October 2007.

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 (concluded in 2007);
- 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. Begun in 2006. Follow-up of Task 3.
- Task 12. Environmental Health and Safety Issues of PV. Begun in 2007.

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.

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 NSRs 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. The responsibility for these national reports lies firmly with the national teams. 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.

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. The report is prepared by a small group from within Task 1 on the basis of the annual National Survey Reports and is funded by the IEA PVPS Programme. Copies are distributed by post by Task 1 participants to their identified national target audiences and are provided at selected conferences and meetings. *Trends* reports were initially produced every two years but are now produced annually to provide more timely information. The first issue was printed in March 1995 and a further eleven issues had been published by the end of 2007.

Trends in Photovoltaic Applications, Survey Report of Selected IEA Countries between 1992 and 2006.

SUBTASK 1.2: Newsletter

A printed, colour newsletter, *PVPower*, is prepared and distributed to stakeholders by post and also via the website approximately 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 seven issues of the newsletter had been published by the end of 2007.

SUBTASK 1.3: Special Information Activities

Under the auspices of Task 1, diverse 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, International PV collaboration and market developments, Finance and PV, Information gathering along the PV industry value chain and the Status of PV in the Asia Pacific region. Early activities included 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.

Fig. 1 - Osamu Ikki and Pius Huesser, Task 1 members from Japan and Switzerland respectively, were invited to co-chair a presentation session during the PVSEC-17 conference in Fukuoka, Japan in December 2007.

Fig. 2 - Task 1 member Jaime Agredano Diaz was a driving force behind Mexico's first Colloquium for the Promotion of PV, held in Zacatecas in June 2007, and Task 1's extensive involvement in the event.

SUMMARY OF TASK 1 ACCOMPLISHMENTS FOR 2007

The 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 website www.iea-pvps.org is a cost-effective means of communication and information dissemination for Task 1 members and the Programme as a whole, and is continually refined to best achieve these outcomes. Workshops remain a key avenue for exchanging information with industry. Also, Task 1 endeavors where possible to be an active contributor to other related workshops / events.

SUBTASK 1.1: Status Survey Reports

Most National Survey Reports were received on time in 2007 for the Trends report process. However, late reports and last minute changes to key data from some countries caused some challenges. The quality of the reporting is excellent in most cases with a number of countries managing a significant improvement in quality over the last year or so.

The 12th issue of the *Trends in Photovoltaic Applications* report was published in August 2007 and analyzed data collected between 1992 and the end of 2006. While some annual markets stagnated, others started to take-off during 2006 as support programmes began to take effect, notably in Spain, Korea, Italy, the USA and France. At the same time, the decline of domestic markets continued to be observed in Austria and the Netherlands. PV production saw the relative German market share in 2006 increase at the expense of the Japanese market share. Photovoltaic module production in Europe clearly surpassed that of Japan for the first time during 2006. Interestingly, total 2006 module production only increased by about 9 % over 2005 production in the IEA PVPS countries. Meanwhile, over the last decade, each year's installed market growth expressed as a percentage of total module production has ranged from 65 % in 1998 to a high of 91 % in 2006. Almost overnight it would appear that non-PVPS countries now account for over a quarter of global cell production and over 30 % of global module production, with East Asia as the emerging powerhouse for PV cell and module production internationally.

Two conference papers based on the 2007 Trends work were prepared: one was presented in a plenary by Japan's Izumi Kaizuka at the European PV Conference in Milano; the other was an invited presentation for PVSEC-17 in Fukuoka (presented by Austria's Roland Bründlinger).

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. *PV Power* issue 26 was published in June 2007. *PV Power* issue 27 was published in November 2007. Current and back issues of *PV Power* are available on the public website.

SUBTASK 1.3: Special Information Activities

During the year Malaysia completed a survey activity – *Awareness and capacity building programmes for PV* – with contributions from many member countries.

Task 1 participants contributed to workshops held in Israel (as part of the Sede Boqer BiPV workshop, February 2007), Mexico (as part of Mexico's first Colloquium for the Promotion of PV, in Zacatecas in June 2007) and Malaysia (in Putrajaya as part of the MBIPV Project in August 2007).

Task 1 organized a workshop, *Information gathering along the PV industry value chain*, in Italy (in conjunction with the European PV conference in Milano in September 2007) and a second workshop, *Status of PV in the Asia Pacific Region*, in Japan (as part of PVSEC-17 in Fukuoka in December 2007).

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2008

Task 1 activities will continue to focus on development of quality information products and effective communication strategies.

SUBTASK 1.1: Status Survey Reports

The target date for publication of the 13th issue of the *Trends in Photovoltaic Applications* report is August 2008. Electronic versions of the information will be made available on the public website in July 2008 and conference papers will also be developed. National

Fig. 3 - Participants in an IEA PVPS workshop, organized by Task 1 and supported by Japan's NEDO, PVSEC and JPEA, discussed the Status of PV in the Asia Pacific Region in Fukuoka, Japan in December 2007.

Survey Reports will be completed before the end of May 2008, based on the revised template, so that the information can be incorporated in and analyzed for the Trends report. NSRs will be made available from the public website.

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.

PV Power Nos. 28, 29 and 30 are planned to be published in May, September and December 2008 respectively, maintaining current editorial policy.

SUBTASK 1.3: Special Information Activities

Task 1 participants will organize or contribute to workshops being planned for Malaysia (in Kuala Lumpur as part of the MBIPV Project in March 2008) and Spain (in Valencia in conjunction with the European PV conference in September 2008).

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.

Newsletter PVPower issues 26 and 27.

LIST OF PARTICIPATING COUNTRIES, KEY TASK 1 PARTICIPANTS IN 2007 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	Roland Bruendlinger
Canada	Josef Ayoub	Natural Resources Canada
Denmark	Peter Ahm	PA Energy A/S
European Photovoltaic Industry Association	Christoph Wolfsegger	EPIA
European Union	David Anderson	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 Ricerca S.p.A.
Japan	Osamu Ikki	RTS Corporation
	Izumi Kaizuka	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
Malaysia	Wei-Nee Chen	PTM
Mexico	Jaime Agredano Diaz	IIE
The Netherlands	Job Swens	NOVEM
Norway	Fritjof Salvesen	KanEnergi AS
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Ulf Malm	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
United Kingdom	Sarah Davidson	IT Power Ltd.
United States of America	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.

KEY DELIVERABLES (2007 AND PLANNED)

The following were published and also made available on the public website during 2007:
Trends in Photovoltaic Applications in Selected IEA Countries between 1992 and 2006. Report IEA-PVPS T1-16: 2007 (plus papers and presentations at the conferences in Milano and Fukuoka).

Newsletter – *PVPower issues 26 and 27.*

Individual National Survey Reports are made available each year on the public website. An internal template and data collection pro forma for the NSRs are produced and updated each year.

Copies of the presentations from all workshops were made available on the public website.

During 2008 it is planned to produce the thirteenth issue of the *Trends in Photovoltaic Applications report*, *PVPower* issues 28, 29 and 30, a range of country and workshop information and a new version of the IEA PVPS website.

MEETING SCHEDULE (2007 AND PLANNED 2008)

The 29th Task 1 meeting was held in Zacatecas, Mexico 4-5 June 2007, with an associated national workshop.
The 30th Task 1 meeting was held in Tokyo, Japan 10-11 December 2007, immediately following PVSEC-17 in Fukuoka and associated Task 1 workshop.
The 31st Task 1 meeting will be held in Sophia Antipolis, France 17-18 June 2008.

TASK 2 - PERFORMANCE, RELIABILITY AND ANALYSIS OF PHOTOVOLTAIC SYSTEMS

Fig. 1 - PVPS Task 2 Meeting in Tokyo, Japan, March 2007.

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 concerns the information exchange between 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 work programme of its third phase in September 2004 and finished three years later, 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 updated performance data are available in the Internet at http://www.iea-pvps-task2.org and the complete database programme can be downloaded from the same website.

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 2007

During 2007, 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: IP Performance, PV Enlargement, PVSAT-2). Task 2 enhanced efforts to disseminate Task 2 results & deliverables to target audiences on the 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-effectively 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.

SUBTASK 1: International Database

The PV Performance Database was updated and the programme was released in May 2007 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 from 505 PV systems with different system technologies, located in 21 countries. The Performance Database programme (48 MB) is available from the Task website http://www.iea-pvps-task2.org and needs to be installed locally on the user's personal computer.

For faster access to the database information, a visualization tool for the web-based database was developed and optimized. The online database version contains the essential information of the original database and was particularly designed to meet the requirements of a broader target audience. The online database web page is available in five languages: English, French, German, Italian and Spanish. It contains PV system information on long-term performance presented in the form of photos (plant information), tables and graphs.

Task 2 focused on the dissemination and promotion of the Task 2 database. As a result, 5 000 database users from 110 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 2007, highest demand for the Performance Database came from users in Italy and Germany in the engineering sector and the private sector, followed by the education and industry sector.

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 from 21 PV systems operating over 106 years. Both, monitoring data, including hourly values of in-plane irradiance, module temperature and energy output of the inverter from 21 individual PV systems, as well as several years of maintenance and failure information were evaluated. PV system performance was analysed and compared at identical climatic conditions such as in-plane irradiance and module temperature. Different filter algorithms, visualizing even very small shifts in Performance Ratio (PR) were applied. First results were summarized and presented in a conference paper.

During the past six months, further long-term monitoring data were collected to gain quantified information and results on the systems' reliability and learning curves. The results of other failure detection algorithms (e.g. Failure Detection Routine of PVSAT) were compared to the analysed performance and failure curves for different examples. A draft report on *Long–Term Reliability of PV Systems* is in progress.

User's Awareness of PV System Performance

Task 2 conducted a survey on the technical operation of PV systems and on the users' awareness of grid-connected (GCS) and of stand-alone PV systems (SAS). They outlined the approach, the statistics and the results of their study on GCS in Japan and on SAS in Mongolia. Final results and the outcome of the investigations and analysis are being prepared and will be summarized in an internal Task document.

Performance Prediction

Activities concentrated on the possibility of using solar irradiation calculated from satellite images for PV systems performance prediction. Comparisons have been conducted first at the horizontal surface with ground based metrological stations and secondly on an inclined surface by comparison with measurements coming from the Task 2 Performance Database. The second part of this activity focused on the PV array performance prediction where output data from the Performance Database was compared to performance predictions made using satellite data and PV performance models.

A final report on *Performance Prediction of Grid-connected Systems Using Remote Sensing Photovoltaic* was prepared. The first part of this document reports on the possibility to use solar irradiation calculated from satellite images for performance predictions. In the second part, different system performance evaluation models are described. The use of calculated irradiations as an input to a simple parametric model is compared with measurements from systems existing in the Task 2 Performance Database. Conclusions are drawn on the related achievable accuracy.

SUBTASK 6: PV System Cost over Time

The global Economic Survey aimed at gathering information on plants, technical performance, maintenance and cost of as many PV systems as possible. The multilingual internet-based Economic Survey was started in June 2005 by placing the data acquisition tool to function on the public website www.iea-pvps-task2.org. The Economic Database included the capability to search, sort and export information towards a free excel environment and allowed Task 2 members to analyse all collected economic data. The survey was terminated at the end of 2006. At the end of the 18 months period of online data collection, the economic survey database contained 774 PV systems from 17 countries and 657 datasets containing useful data for a final report. The PV systems analysed are mainly located in central Europe, Japan and the United States and are dominated by grid-connected PV systems (98%). Future work should broaden the analysis by a significant increase of available datasets.

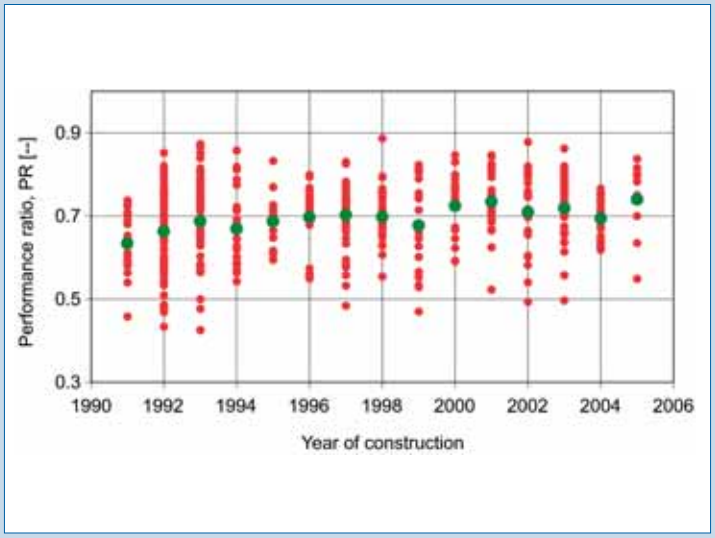

Fig. 2 - Trends of annual performance ratios (PR) of 461 PV systems installed between 1991 and 2005: average annual PR (green dot) increases from PR = 0.64 (1991) to PR = 0.74 (2005).

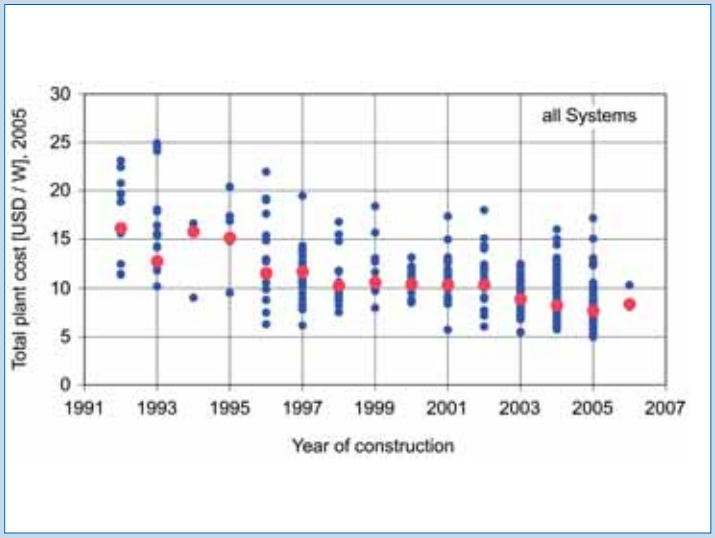

Fig. 2 - Trends of overall PV system costs for 527 grid-connected PV systems installed between 1992 and 2006: System cost in USD per watt decreases from average value of 16 USD/W in 1992 to 8 USD/W in 2006.

The sample analysed shows a trend towards higher technical performance (PR) and lower system costs for newer PV systems (Figures 1 and 2). As it is within the scope of Task 2 to disseminate results of PV system performance to the target groups, a public report was prepared to give a more detailed view on Performance and system cost over time.

Performance, reliability and cost data of PV systems are most important for a broad PV implementation and dissemination strategy in future. While the number of installed PV systems grows very rapidly in several countries (e.g. in Germany due to the feed-in tariff), the number of available PV systems, which are well monitored, seems to decrease at the same time. There is an essential need of reliable and long-term information on the economic and technical performance of PV systems.

Educational Tool

The web based educational tool of IEA PVPS Task 2 and Task 10 is available at www.bipvtool.com and is in the responsibility of the Swedish Task 2 and Task 10 participants. Task 2 contributed case studies for PV systems from the decision phase to the operational phase in Germany, Italy, Switzerland and the UK. The database sections on maintenance, monitoring and lessons learned were reviewed and substantially updated. This tool represents a detailed, practical source of information on building integrated PV from the idea to the long-term operation of a PV system.

Industry Involvement

Task 2 activities benefit from co-operation with PV industries, electric utilities and other parties, both for collection of performance & component data and for distribution of Task 2 products such as the Performance Database to target groups. Task 2 organized a meeting on Task 2 follow-up activities in conjunction with the European PV Solar Energy Conference and Exhibition in Milano on 3rd September 2007. This event was addressed to the PV industry and enabled a productive and direct exchange of experiences on the issues such as reliability, performance prediction and economic analysis of PV systems between PV industry and Task 2 members. The Milano dinner meeting was well attended by high-ranking representatives of the PV industry, manufacturers and systems houses as well as by the PV industry associations EPIA and BSW.

The European PV Industry Association (EPIA) and the German Solar Industry Association (BSW) clearly expressed their strong support for a follow-up of the Task 2 work in order gain and accumulate first-hand technical and non-technical information on performance and reliability issues. The quality aspect of PV systems and components is considered to be a major issue for the PV industry. It is important that the PV industry is effectively engaged in the continued Task work for collecting, analysing and exchanging information on quality aspects of PV systems and components.

KEY DELIVERABLES (2007)

The following were published during 2007 and made available on the public website:

- *Cost and Performance Trends in Grid-Connected Photovoltaic Systems and Case Studies,* Report IEA-PVPS T2-06:2007.
- *Performance Prediction of Grid-Connected Photovoltaic Systems Using Remote Sensing.* Report IEA-PVPS T2-07:2008.
- PV System Performance and Cost Analysis – A Report by IEA PVPS Task 2. In: 22nd European Photovoltaic Solar Energy Conference, Milan, Italy, September 2007.
- PVPS Task 2 Performance Database programme update with collected data from 505 PV systems, released in May 2007.

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 (2007)

The 6th Task 2 Participants' Meeting was held in Tokyo, Japan, 14-15 March 2007.
The 7th Task 2 Participants' Meeting was held in Erlenbach, Switzerland, 12-13 September 2007.

LIST OF PARTICIPATING COUNTRIES, TASK 2 PARTICIPANTS IN 2007 AND THEIR ORGANISATIONS

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

COUNTRY	NAME	ORGANISATION
Austria	Stefan Mau	Arsenal Research, Vienna
Canada	Yves Poissant	CANMET Energy Technology Centre, Varennes
European Photovoltaic Industry Association	Daniel Fraile	European Photovoltaic Industry Association (EPIA), Brussels
European Commission	Harald Scholz	DG Joint Research Centre (JRC), Ispra
France	Didier Mayer	Centre Energétique, Ecole Des Mines de Paris
Germany	Ulrike Jahn (Operating Agent)	Bavarian Center for Applied Energy Research (ZAE Bayern), Erlangen
	Ugo Caminoli	Bavarian Center for Applied Energy Research (ZAE Bayern), Erlangen
	Tristan Mahlow	Bavarian Center for Applied Energy Research (ZAE Bayern), Erlangen
Italy	Salvatore Castello	ENEA C.R. Casaccia
Japan	Kenji Otani	National Institute of Advanced Industrial Science and Technology (AIST)
	Takeshi Igarashi	Japan Electrical Safety & Environment Technology Laboratories (JET)
Poland (Observer)	Tadeusz Zdanowicz	Wroclaw - University of Technology
Sweden	Jonas Hedström (passed away)	Energibanken AB, Stockholm
	Mats Andersson	Energibanken AB, Stockholm
	Carina Martinsson	Ångpanneföreningen ÅF-Process AB
Switzerland	Thomas Nordmann	TNC Consulting AG
	Luzi Clavadetscher	TNC Consulting AG
United Kingdom	Stephen Pester	Building Research Establishment Limited (BRE)
United States of America	Andrew L. Rosenthal	Southwest Technology Development Institute (STDI), New Mexico
	Kevin Lynn	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.

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

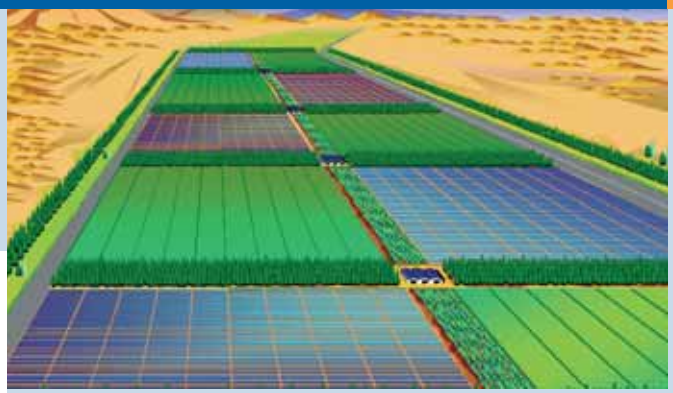

Fig. 1 - Image of a VLS-PV System in a Desert Area.

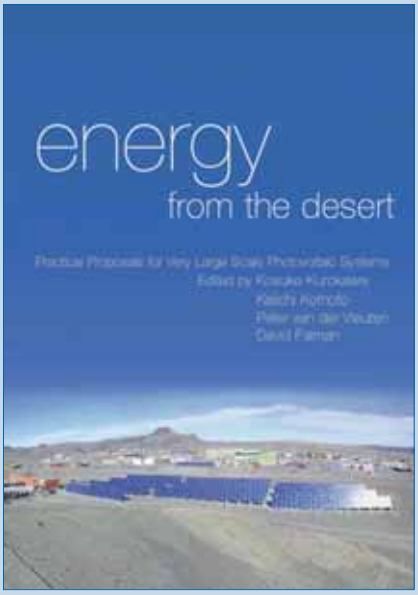

Fig. 2 - Energy from the Desert: Practical Proposals for very Large Scale Photovoltaic Systems (cover page).

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 1 (1999-2002), key factors that enable VLS-PV systems feasibility were identified, 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. Mid- and long term scenario options for making VLS-PV systems feasible in some given areas were also proposed.

Based on the mid- and long-term scenario options of Phase 1, in Phase 2 (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 were discussed.

In Phase 3 (2006-2008), toward a realization of VLS-PV Systems, specific case studies from viewpoints of local, regional and global aspect are carried out, and financial and institutional scenarios and a general instruction for practical project proposals are developed. Also, considerable future technical options implementing VLS-PV system are analysed.

MEANS

To complete the overall objectives, participants carry out three subtasks in the third phase.
Subtask 2: Case studies for selected regions for installation of VLS-PV system on deserts
Subtask 5: General instruction for practical project proposals to realize VLS-PV systems in the future
Subtask 6: Future technical options for realizing VLS-PV systems

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 previous phases, 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. Feasibility and potential of VLS-PV on deserts will be evaluated from viewpoints of local, regional and global aspect.

Major Activities

The following are working items proposed, and some case studies will be carried out in parallel:

Case studies of selected large-scale PV systems
- System configuration
- Operation and maintenance
- Transmission and grid-connection issues

Case studies/feasibility studies for implementing VLS-PV project
- Existing CDM and emission trading project
- Feasibility for CDM or emission trading project
- Technology transfer and industry development

Potential evaluation from environmental viewpoints
- Life-cycle analysis, including LCC
- Micro climate analysis
- Desert and agriculture development scheme: impact on regional environment

Survey and analysis of global solar resource
- Solar resource analysis

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

Objectives

Detailed practical instructions and training kit for the development of other practical project proposals, to enable others to sustainable implement VLS-PV systems in the future, will be discussed. Employing the results developed under Subtask 4, financial and institutional scenarios will be further discussed, and the guidelines for practical project proposals will be developed.

Fig. 3 - The Task 8 family in front of the 450 kW PV system, Casalnoceto, Italy, at the 18th Task 8 Experts Meeting.

Major Activities

The following are working items to be discussed in Subtask 5:

Survey of existing large-scale PV systems in the world, as useful information

- Centralised or integrated PV systems which have a capacity of Multi-MW (several hundreds kW, in case of desert)

Technical aspect of VLS-PV

- Successful and unsuccessful factors
- Variety and adoption of PV and/or solar technologies
- System and array design (including CPV)
- Transmission availability and interconnection condition

Survey of existing institutional, organisational and financial scheme, as useful information

- Support scheme for PV installation and operation
- Existing financial schemes and relative organisations

Socio-economic aspect of VLS-PV

- Successful and un-successful factors
- How to develop a financial plan
- How to commercialise (mainly, in developed countries)
- Effective assistance for sustainability (mainly, in developing countries)
- Risk assessment

SUBTASK 6: Future Technical Options for Realizing VLS-PV Systems

Objective

Various technical options for implementing VLS-PV systems, including scenarios for storage and for reliable integration of VLS-PV systems into the existing electrical grid networks, will be proposed and analysed. From the viewpoint of future electrical grid stability, a global renewable energy system utilizing globally dispersed VLS-PV systems as the primary electrical energy source will be also analysed.

Major Activities

Following working items have been proposed and discussed.

Electric Grid Network Scenario

- Grid connection (similar issues as for PV and wind)
- Transmission (HVDC, HTSC, others)
- Negative load technique

Energy storage

- Cloud mitigation
- Load matching (storage batteries, capacitors, flywheels, others)

Solar hydrogen scenario Concentrator

- Low concentrator
- High concentrator

OTHER ACTIVITIES

Technical Report Publication

A technical report based on the Phase 2 activity, entitled “Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems” was published by Earthscan in January 2007 (See Fig. 2). A summary of the book is available from the IEA-PVPS website.

International Symposium: “Energy from the Desert: Very Large Scale Photovoltaic (VLS-PV) Systems,” in Athens, Greece, and in Milan, Italy.

As a side event of the 2nd Photovltaic Mediterranean Conference (PVMED), an international symposium, “Energy from the Desert: Very Large Scale Photovoltaic (VLS-PV) Systems,” was taken place on 20 April 2007 in Athens, Greece. The international symposium “Energy from the Desert: Very Large Scale Photovoltaic (VLS-PV) Systems,” took place on 6 September 2007 in Milan, Italy, as a side event of the 22nd European Photovoltaic Solar Energy Conference and Exhibition (EU-PVSEC). Task members introduced the results of the Phase 2 activity and the Summary Booklet of “Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems” was distributed to the participants.

Contribution to International Conferences

As dissemination activities, Task 8 contributed to following International Conferences.

- 22nd EU-PVSEC in Milan, Italy (September 2007)
- 17nd PVSEC in Fukuoka, Japan (December 2007)

At the 17th PVSEC, two papers from Task 8 activity won a paper award and a poster award.

- Paper Award: “Environmental Potential of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems on Desert,” presented by K. Komoto et al.
- Poster Award: “Financing a Very Large Scale Photovoltaic System in Gobi Desert,” presented by K. Megherbi et al.

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: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems", James and James, 2003 (ISBN 1 902916 417)
Report: "Summary – Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems," 2003
Report: "Summary – Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems," 2006
Book: Energy from the Desert:
Practical Proposals for very Large Scale Photovoltaic Systems, "Earthscan, 2007 (ISBN 1844073 637)

MEETING SCHEDULE (2007 AND PLANNED 2008)

17th Task 8 Meeting, 21-22 April 2007, Athens, Greece
18th Task 8 Meeting, 31 August – 2 September 2007, Milan, Italy
19th Task 8 Meeting, April 2008, the Netherlands
20th Task 8 Meeting, September 2008, Europe

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	Mr. John S MacDonald	Day4Energy Inc.
Germany	Mr. Claus Beneking	ErSol Solar Energy AG
	Ms. Ulrike Orlishausen	ErSol Solar Energy AG
	Mr. Matthias Ermer	SunTechnics Solartechnik GmbH
	Mr. Edwin Cunow	PVConsult
Israel	Mr. David Faiman	Ben-Gurion University of the Negev
Italy	Mr. Fabrizio Paletta	CESI RICERCA
	Mr. Angelo Sarno	ENEA
	Mr. Gianluca Gigliucci	ENEL
	Mr. Michelle Appendino	Solar Ventures
Japan	Mr. Kosuke Kurokawa (OA)	Tokyo University of Agriculture and Technology (TUAT)
	Mr. Keiichi Komoto (OA-alternate)	Mizuho Information & Research Institute (MHIR)
	Mr. Masanori Ishimura (secretary)	Photovoltaic Power Generation Technology Research Association (PVTEC)
Korea	Mr. Jinsoo Song	Korea Institute of Energy Research (KIER)
The Netherlands	Mr. Peter van der Vleuten	Free Energy International bv
	Mr. Remko Knol	Siemens Nederland N.V.
USA	Mr. Thomas N. Hansen	Tucson Electric Power Company
	Mr. Herb Hayden	Arizona Public Service
France (observer)	Mr. Fabrizio Donini Ferretti	Dexia Credit Local
	Mr. Karim Megherbi	Dexia Credit Local
Mongolia (observer)	Mr. Namjil Enebish	National Renewable Energy Center

TASK 9 - PHOTOVOLTAIC SERVICES FOR DEVELOPING COUNTRIES

RATIONALE AND OBJECTIVE

Photovoltaics, and other renewable energy technologies, can contribute to the economic and social development of the 2 billion people in the world who do not have access to electric lighting, adequate clean water supplies, 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. It is generally accepted that the potential for renewable energy to transform people's lives is enormous. For example, in the area of primary health care, PV refrigeration has transformed the delivery and vaccination services by agencies such as the World Health Organisation (WHO) and United Nations Children's Fund (UNICEF) (Figure 1).

The MDGs were reaffirmed at the UN Summit in 2005. Since then the G8 Summit at Gleneagles in 2005 agreed to a Plan of Action, including clean energy for the developing world. The IEA is supporting this, as is the World Bank which has committed to a target of a 20 % annual average increase in its financing of renewable energy and energy efficiency. This is an important move towards a sustainable operation and environmental friendly generation of electricity, especially relevant in developing countries. There is now a consensus that tracking global climate change by reducing emissions must also address the problem of highly polluting diesel generators as widely used where there is no electricity grid. Figure 2 shows a rented conventional generator producing electricity at low efficiency and with insufficient emissions control and environmental management.

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 Photovoltaic Services for Developing Countries (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, and is increasingly becoming a part of the work of PVSDC. In many locations, small wind generators can be used in the same way as PV and at lower level cost. China is well known for its rapid increase in PV manufacture, almost all for export. PV systems can play an important role for the education, particularly in rural areas with insufficient electricity supply (Figure 3).

In 2005, the Renewable Energy and Energy Efficiency Partnership (REEEP) began providing additional support to include other RETs, and in 2006, close cooperation was agreed with the Global Village Energy Partnership (GVEP). Both REEEP and GVEP were launched at the World Summit on Sustainable Development (WSSD), held in South Africa in 2002.

Fig. 1 - Demonstrating the SolarChill vaccine refrigerator at Rastrapati Bhavan for His Excellency former President Dr. A.P.J. Abdul Kalam.

Fig. 2 - Conventional electricity generation unit running at low efficiency and causing problems in environmental mangement.

Fig. 3 - This computer room in a college on a remote Pacific island will soon have 24h power supply.

Fig. 4 - PV training for local staff, India.

Fig. 5 - Recommended practice guide for RESDCs.

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. The training and building of local expertise is an important issue, which is addressed more and more (Figure 4).

In 2007, important relationships to the European Photovoltaic Industry Association (EPIA) and the Alliance for Rural Electrification (ARE) have been launched. 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 2007

Task 9 PVSDC 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 PVSDC. 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 *"Renewable Energy Services for Developing Countries"* and includes micro-hydro and wind energy technologies.

Fig. 6 - Installing a borehole pump as part of a training course by DENG in Ghana.

The document presents an overview of PV deployment in developing countries and the key points and messages of PVSDC, and 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 has been expanded to cover applications such as water supply and community services, and has now been published (Figure 5). Clean water can transform lives; and in 2007 the RESDC team expanded its work relating to Water Services (Figure 6). Water Services were discussed in detail at a Workshop in Bangkok in June 2007.
An important element of this was the participation of industry experts from Mono, Grundfos, Wirz Solar and Entec.

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

Fig. 7 - Task 9 PVSDC webpage.

Fig. 8 - PV water pumping system in Ouled Aoun, Tunisia.

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.

There is a particular interest of the G8, IEA, REEEP and other institutions in co-operation with the five major energy consuming and greenhouse gas emitting developing countries, known as the "G8+5;" Brazil, China, India, Mexico and South Africa. PVSDC has been active in China and developed close links, as reported previously. In June 2007, PVSDC organised a water pumping workshop in Bangkok, where the work of the IEA and IEA PVPS Task 9 PVSDC was presented.

In August 2007, Task 9 PVSDC contributed to the PVPS booth at the European Solar Conference and Exhibition in Milan. The exhibition posters included other renewable energy technologies, as well as PV.

The 16th Experts' Meeting was held in March 2007 in Eschborn, near Frankfurt, hosted by GTZ. Germany's contribution to PVSDC is through the Gesellschaft für technische Zusammenarbeit (GTZ), financed by the German government. The GTZ is the world's largest agency of it's type and conducts a major multi-country Energy for Sustainable Development Programme. Currently 65 energy related projects are underway in developing countries. These projects are backed by 150 energy experts.

The 17th Experts' meeting was held in Brussels in October. This was a significant meeting, as it was hosted by the strategic partner organisations EPIA and the Alliance for Rural Electrification (ARE) and with the direct participation of the EU commission, namely from EACI, department "Renewable Energy & Sustainable Energy in Developing Countries." EPIA is a stakeholder for the European PV Industry and for the deployment of PV systems in general. The European Photovoltaic Industry Association (EPIA) is a sponsor member of PVPS. EPIA has agreed to work closely together to develop a new joint work plan. PVSDC attended EPIA's 5th Round Table in Brussels in November 2007. ARE is the most important European association dedicated to the development of rural areas via the electrification through deployment of various renewable energy technologies.

In 2007 two flyers (one for Water Services and another one on hybrid systems) have been prepared. The booklet "Renewable Energy Services for Developing Countries - In Support of the Millennium Development Goals: Recommended Practice & Key Lessons" has been finally published.

In the second half of 2007 the PVPS/Task 9 PVSDC webpage was improved to provide important information to members and externals (Figure 7).

Support and expertise has been provided to the African Development Bank (AfDB) in 2007. For 2008 the provision of a training workshop for employees and decision makers of the AfDB Tunis is foreseen. Part of the planned workshop will be a site visit of a PV water pumping system in Ouled Aoun (Figure 8).

SUBTASK 40: PV Energy Services for Rural Electrification and Poverty 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, 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. The impact on mobile phones across the world is enormous. This is especially the case in Africa where communications have been traditionally very poor, but this is

Fig. 9 - Solar-wind powered WIFI repeater grid in Nauru.

Fig. 10 - PV installer training programme in Ghana.

changing rapidly. Better contact with family and friends is transforming lives. Figure 9 is an example of a solar-wind powered WIFI and mobile phone repeater in Nauru in the Pacific.

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 gained in 2007 by organising a workshop on Water Services in Bangkok. It was supported by representatives from the industry and widely deemed as an important contribution and a massive success.
The design of a flyer on "PV Energy for Water Services" to be used on events like exhibitions to transport the message of PVSDC and offer the expertise of the PVSDC group was done in 2007. It awaits its approval by Task 9 members who are expected to increase their activities in this Task during 2008. A paper about PV and Diesel Hybrid Systems has also been drafted. A case study about the economic assessment and layout of a PV system in the health, education and ICT sector has been prepared in 2007.

SUBTASK 50: Market Penetration Activities

Training and capacity building are essential for sustainable market development. The RPGs prepared by PVSDC are used for these purposes. PVSDC also co-operates and assists with training courses.

Figure 10 illustrates an internationally – accredited PV installer training programme underway in Ghana.

This Subtask also investigates technical and economic aspects of PV power packs and larger scale 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-supported applications in developing countries. The work is being co-ordinated with Task 11. The main outputs will be review documents and a number of relevant case studies.

SUBTASK 60: PV and the Kyoto Mechanisms

The Executive Committee agreed at its 28th meeting to cancel the Sub Task.

PLANS FOR 2008

The focus of work in 2008 will shift more towards policy and the Water Services sector. There is a considerable expansion in interest in and support for renewables for rural electrification and the MDGs.

TASK 9 PARTICIPANTS

Unfortunately Italy has withdrawn itself from Task 9. The USA no longer participates but has not formally withdrawn from the Task.

COUNTRY	NAME	AFFILIATION
Australia	Geoff Stapleton	GSES
	Paul Cowley	IT Power
Canada	Fayez Malek	CIDA
Denmark	Peter Ahm	PA Energy
France	Anjali Shanker	IED
	Lara Bertarelli	IED
	Taric de Villers	IED
Germany	Dieter Uh	GTZ
Japan	Sakurai Masahiro	JPEA
	Takayuki Nakajima	JPEA
	Tetsuji Tomita	IEEJ
Sweden	Anders Arvidson	SEI
	Yong Chen	SEI
Switzerland	Alex Arter	ENTEC
United Kingdom	Bernard McNelis	IT Power
	Rebecca Gunning	IT Power
	Anselm Kröger-Vodde	IT Power
ARE	Ernesto Macías	ARE
EPIA	Ernesto Macías	Isofotón
Zambia	Geoffrey Musonda	Department of Energy
	Langiwe Chandi	Department of Energy

Global expenditure is set to increase significantly. The Task 9 PVSDC Team is established as a well experienced, balanced and impartial group and has the capacity to advise on policy and resulting programme design. Contributions to policy groups will be increased. After the massive success in Bangkok, another workshop on Water Services and in particular on PV water pumping will be offered in Tunis to the African Development Bank (AfDB); which particularly requested the expertise of the PVSDC group. Invitations for workshops in Zambia and Uganda will probably give PVSDC the chance to gain a higher impact in these countries. The participation at the AGUASAN workshop in Switzerland is planned for 2008, as well as the attendance of the World Water Week in Stockholm. The European Solar PV Conference and Exhibition in Valencia will be an important opportunity where RESDC will present itself to the international audience. Development and software tools for the planning of hybrid systems and rural electrification systems will be reviewed and classified in 2008.

The 18th Experts Meeting will possibly be in Cameroon in conjunction with a workshop. The meeting will also have an internal planning workshop including water services.

MEETING SCHEDULE (2007 AND PLANNED 2008)

2007

16th Experts' Meeting, 29-30 March 2007, Eschborn, Germany.
17th Experts' Meeting, 11-12 October 2007, Brussels, Belgium.

2008

18th Experts' Meeting - Not yet fixed.
19th Experts' Meeting - Not yet fixed.

TASK 10 – URBAN SCALE PV APPLICATIONS

INTRODUCTION

As Task 10 approaches its final year, a great deal of work is being completed. 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 urban environment. Task 10 work was initiated in January 2004, with a 5 year planned period of work. There were delays of resource commitment to the Task, but during the third year additional resource commitments were made through the PVPS and the European Commission project, "PV in Urban Policies: a Strategic and Comprehensive Approach for Long-term Expansion," PV-UP-Scale. PV-UP-Scale intended to expand Task 10 country contributions to include more European countries not formally participating in Task 10 (Netherlands, Spain, Germany and UK), enhance some current contributions (Austria and France), while utilizing the Task 10 participants to broaden the market perspectives most important to the European Commission.

Task 10 is a broad range of work to facilitate creative solutions in the urban energy market. The initial intent for Task 10 was to develop completed analysis and research into multiple communication products according to stakeholder needs. Due to the late commitment of resources, most analysis is just being completed during this last year. However, the possibility of a concise report of results and conclusions which weaves a common thread of urban solutions is being explored. Additionally, an executive summary, a power point presentation and a one paragraph description will be developed for every analysis report.

OVERALL OBJECTIVE

The Task 10 objective 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, as well as solar thermal and photovoltaics usage. Value analysis, policy incentives, education 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;
- 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.

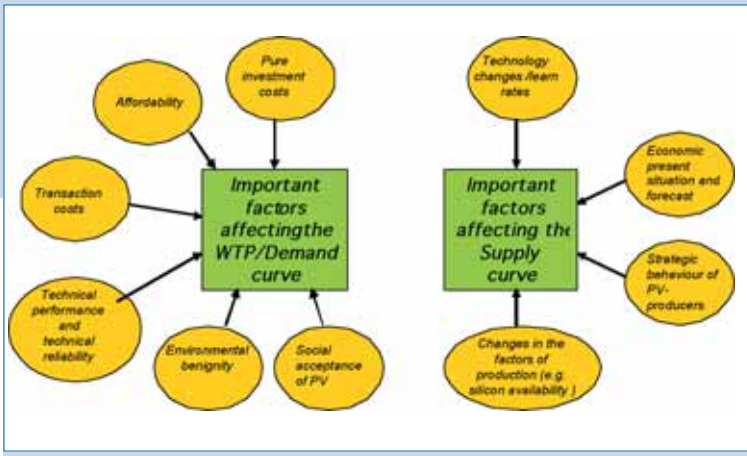

Fig. 1 – Factors affecting WTP/demand curve and Supply curve.

Fig. 2 – Task 10 and Task 11 Joint Meeting; Fukuoka, Japan.

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 are four subtasks in Task 10. 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. 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 and associated goals is:

- Building Sector: builders and developers, urban planners, architects, engineers, permit and code authorities;
  Goal – Solar technologies and energy efficiency – whole building energy design – is an option in all design, development and construction and a market differentiation as a standard feature.
- End-Users: residential and commercial building owners;
  Goal – Full awareness of the financial, operational, and comfort features resulting in whole building energy design.
- Government: supporting, regulatory and housing agencies;
  Goal – The benefits to government revenue, infrastructure and services, such as jobs, gross regional product, import/export,

environmental and security are metrics to the development and revisions to energy market transformation policies.

- Finance and Insurance Sector: Banks, insurance companies, loans for houses;
  Goal – The benefits and risks from both a credit and disaster perspective are included in the development of rates. As insurance companies base rates on the height above sea level of structures in a region, so could the resilience of the energy infrastructure influence rates.
- PV Industry: system manufacturers, PV system supply chain, retail sector;
  Goal – PV industry has clear market knowledge, ensuring fair profitability throughout the supply chain, particularly to the influence of other stakeholders. An additional goal is internationally consistent standards and certification (to the extent possible, with differences clearly defined), as well as access to retail energy consumers.
- Electricity Sector: network and retail utilities; and
  Goal – A full understanding of the business and operational opportunities related to energy efficiency and solar technologies. The comparative economics of generation planning will include the full life cycle economics of both traditional network design and whole building design as well as the energy coordination benefits such as disaster resilience and demand side management.
- Education Sector.
  Goals – Basic education will include alternative energy and the life cycle impacts and benefits of energy choices. Specialised education in the building, sciences, and engineering sectors will include alternative energy options.

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 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.
The report, “Analysis of PV System’s Values Beyond Energy” draft was completed and balloted in 2007. Edits requested during the ballot process will be completed and the report will be available to the public in March 2008. An executive summary is under development for this report.

Activity 1.2 Barriers Resolution

Recommendations to stakeholders will be developed for removing barriers to mass market uptake of PV. Austria leads this activity.
As the report for this activity has progressed, it has been determined that the barriers are dependent on market activity and drivers. Larger markets like Japan and Germany have very few barriers.
At one point during the year, this work was thought to be folded into the market drivers report. A questionnaire was developed for participants to complete and will be reported on at the spring 2008 technical experts meeting.

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 develop best practice scenarios. Austria leads this activity.
Following the completion of the PV-UP-Scale report, “Economical Drivers and Market Impacts of Urban PV," in 2006. The expanded Task 10 report is currently being balloted. A major objective of this study is to analyse which measures affect consumer’s willwillingness-to-pay (demand) ingness-to-pay (demand) and which rebates are necessary to achieve a favourable change of the supply curve. These effects are explained in detail in Figure 1.

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. Switzerland leads this Subtask.

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.
This activity has been dropped from the work plan, because no resources were ever committed. However, it is still an important part of the overall need to reach the objective of mainstreaming PV and will be included as a recommendation for further work in the final report.

Activity 2.2 Urban Planning

A guide will be developed for integrating PV and the whole community energy infrastructure element into urban planning practices by 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. Norway leads this activity.

There are three deliverables for this activity:
Norway has developed a model of criteria and indicators which are used to lead planners to solar energy choices. This should be completed in 2008.
Switzerland is developing a case study analyzing electricity purchasing conditions for the city of Neuchatel to determine the economic consequences of including PV in purchasing mix. This work along with the information from a questionnaire filled in by Task 10 participants will develop into a report on urban economic planning and purchasing economics.
The UK, through PV-UP-Scale has gathered case studies on urban palling and design from start to implementation, with specific risks/barriers and associated solutions/instruments. This will be developed into both a web site and expanded to include additional Task 10 results into a book by France.

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. Japan leads this Subtask.

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.

There are three deliverables for this activity:
The report, “Urban BIPV in the New Residential Building Industry,” has been balloted and will be ready for electronic distribution in March 2008. This report collected residential building statistics by country, analyzed processes for change in the building industry and calculated the potential for BIPV by country.
The on-line version of the Task 7 database was updated to accept BIPV, public developments, and products. This was a PV-UP-Scale deliverable with contributions from Task 10. There are 250 new projects in the database.
The report on PV Community Developments is in final draft and will be balloted in the first quarter of 2008. The report includes single family housing developments, multi-family housing and public building developments. Each development will have a two page brief which can be a can be used as a separate document and the main text of discussion summarizing the information. This will also be included in the database above.

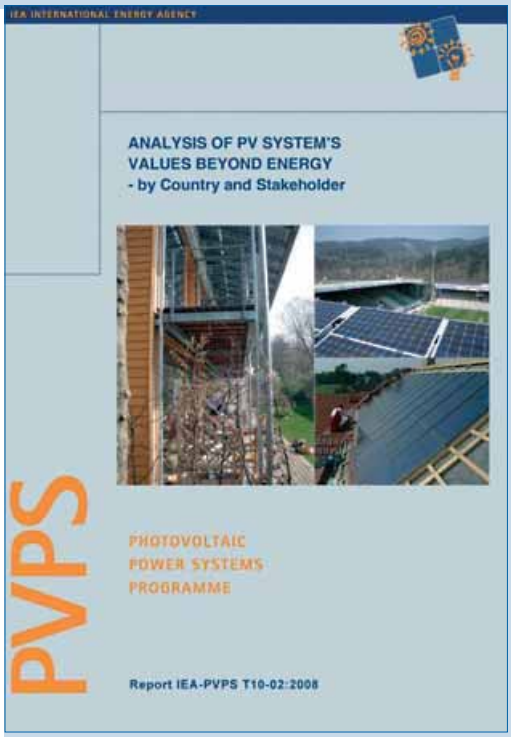

Fig. 3 - Task 10's report, "Analysis of PV System's Values Beyond Energy - by Country and Stakeholder".

Activity 3.2 Codes and Standards

This activity was initially planned to evaluate both electrical and structural codes as related to buildings. However, upon further investigation it was determined that this body of work should be a separate task. Instead the activity will develop a matrix of existing codes and standards and incorporated into the report on Network technical factors. Denmark is the lead for this activity.

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. Japan leads this activity for Task 10 and Germany leads this activity for PV-UP-Scale.
The two deliverables for this Task 10 activity will be a comprehensive report and a visualisation tool. The report will include a matrix of the grid effects and impacts, guidelines and certification practices, counter measures and case studies. The report will be completed in the third quarter of 2008. The Grid Effect Visualisation Tool is in a power point format and animates/narrates grid issues and solutions. The visual tool is in final draft and will be balloted in the second quarter of 2008.

PV-UP-Scale has developed a report on a network issue literature review, a report on utilities perception (developed through extensive utility interviews) and voltage drop software calculation. These deliverables are available at www.pvupscale.org .

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.
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," will be included as an annex in the report on network issues.

SUBTASK 4: Targeted Information Development and Dissemination

This subtask is focused on the information dissemination of all deliverables produced in Task 10. Some major accomplishments during this third year include the final drafts of reports in both Subtask 1 and 3. During the final 2007 Task 10 meeting, participants were asked to consider the remaining resources for Task 10, the work completed and expected relative to what types of products are most useful to achieve the Task 10 Goal of mainstreaming PV. Due to limited resources, the original plan of developing multiple stakeholder targeted products from each deliverable is not possible. The result of the discussion was to take an alternate approach to targeted products. All agreed that everything must be electronic, with high speed internet available almost everywhere. Along these lines, whenever possible, PowerPoint graphics of results and conclusions for each deliverable will be developed and posted. Each product will be developed into tiered levels of detail:

- The first tier will be a one paragraph description that can be easily translated. The paragraph can be used for email notification of stakeholders and as the description on the front web page. The stakeholder targeted electronic notification was tested when PV-Up-Scale completed its first two reports on Grid Issues. France wrote a one paragraph description of the work and sent it to all French utilities. This resulted in a large increase of website activity specifically looking at these two reports.
- The middle level is an executive summary of results and conclusions, similar to the executive summary the European Photovoltaic Industry Association developed for the Energy Payback report which has proven much more popular than the full report.
- The full reports with analysis methodology and full appendices are the most detailed tier.

France is the Subtask leader, and is also the Work Package leader for the corresponding Work Package in the PV- UP-Scale project.

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	NRCan/Climate Change Technology Early Action Measures/Ontario
Denmark	Mr. Kenn Frederiksen	Energimidt Erhverv A/S
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. Hee-Jin Lim	Korea Photovoltaics Development Organization Korea University
Malaysia	Mr. Ahmad Hadri Harris	Malaysia Energy Center, PTM
European Union	Mr. Henk Kaan	Energy research Centre of the Netherlands Through EU, PV-UP-SCALE
Norway	Mrs Inger Andresen Mr. Tommy Kleiven Mrs. Anne Grete Hestnes	SINTEF Civil and Environmental Engineering
Portugal	Mrs. Maria Joâo Rodrigues Mrs. Joana Fernandes	Center for Innovation Technology and Policy Research Instituto Superior Têcnico (Technical University of Lisbon)
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

This is the official participant list for Task 10. However, through PV-UP-Scale, Spain, The Netherlands, Germany, and the United Kingdom have made contributions to the Task work.

TABLE 2 – MEETING SCHEDULE (2007 AND 2008 PLANNED)

MEETING	DATE	PLACE
8th Task 10 Technical Experts and PV-UP-Scale	March 12-13, 2007	Freiburg, Germany
9th Task 10 Technical Experts with _ day joint with Task 11	November .30-December 1, 2007	Fukuoka, Japan
10th Task 10 Technical Experts	March 3-4, 2008	Langkawi, Malaysia
11th Task 10 Technical Experts (tentative)	November 2008	Sydney, Australia

Activity 4.1 Educational Tools

The educational tool is a tool for posting both the start to finish process of BIPV installation as well as an information databank for related installation issues such as interconnection, net metering, and tender documents.

Activity 4.2 Competition

The second Lisbon Ideas Challenge was completed. At the end of the projects submission period 121 projects registered from 37 countries. Entrants were to present intervention ideas for the low-income residential neighborhood of Lisbon, Bairro do Padre Cruz, Carnide, where urban renovation and rehabilitation is a priority action for the Municipality of Lisbon. During this second competition, entrants could submit either a detailed project or a plan for 1 MW of PV over the whole neighborhood. All entries were for projects.

Activity 4.4 Stakeholder Perceptions

This activity will analyse and assess the community, utility and customer perception and preferences regarding i) the security of energy, (including revenue protection) ii) certain and homogenous Quality and Safety levels. Additionally this activity will develop products in response to misconceptions such as energy required in manufacturing (Life Cycle Analysis). Denmark leads this activity.

Progress includes the report IEA-PVPS T10-01-2006 “Compared Assessment of Selected Environmental Indicators of Photovoltaic Electricity in OECD Cities,” developed by France. The executive summary of this report as well as the country results were published by EPIA and are available on the European Photovoltaic Technology Platform website. This report was developed in response to the misconception of the energy required for PV manufacturing being more than ever produced in the operation of the system. The report did not perform lifecycle analysis, but rather took the most recent results, combined with solar energy availability to determine energy and environmental factors. Additionally, Denmark has developed a draft report on revenue protection which identifies ways to maximise the revenue from a PV plant regardless of size.

4.5 Continuous Communication

France leads this activity.

With France leading this activity under this subtask, as well as the similar work in PV-UP-Scale, the Task will continue to progress. A stakeholder meeting was held in Malmo, Sweden. Whereas most publications will be electronic, EPIA agreed to print the executive summary of the environmental indicators report. The website and resources for Task 10 remain up to date.

INDUSTRY INVOLVEMENT

As Task 10 moves into its last year, industry participation appears minimal, relative to the technical experts participating in the Task (except utilities). However, in individual countries and throughout Europe, it is evident that industry is giving feedback to Task 10. The Activity under Subtask 1, “Market Roadmap” was merged with the activity “Market Drivers” because industry (EPIA and SEIA) felt that presenting the information as market drivers rather than a roadmap was more appropriate for Task 10 Also, the second Lisbon Ideas Challenge was supported by industry.

KEY DELIVERABLES (2007 AND PLANNED 2008)

The following key deliverables were prepared and presented in 2007:
Completed 2nd Lisbon Ideas Challenge

- Participated in Spanish seminar organised by PV-UP-Scale
- Final draft of “Urban BIPV in the Residential Building Industry”
- Final draft of report “Solar Cities Around the World”
- Final draft of report “Value Analysis of PV”

The following key deliverables are planned for 2008:

- Report “Economic and Institutional Barriers ”
- Report “Municipal Utility Economics”
- Municipal Decision Tool
- Book “Photovoltaics in Urban Plans and Developments”
- Report “Impacts & Effects of PV Connection, Guidelines & Network Operation Policies, Countermeasures & Technologies, and Case Studies (including annexes of codes and standards and certification practices)”
- Report “Results of the 2nd Lisbon Ideas Challenge”

TASK 11 - HYBRID SYSTEMS WITHIN MINI-GRIDS

INTRODUCTION

Task 11 is concerned with PV based hybrid electricity generation and distribution systems that combine PV with other electricity generators and also energy storage systems. A particular focus is on mini-grid systems in which energy generators, storage systems and loads are interconnected by a “stand-alone” AC distribution network with relative small rated power and limited geographical area. The mini-grid concept has potential applications that range from village electrification in less developed areas to “power parks” that offer ultra-reliable, high quality electrical power to high tech industrial customers. These systems can be complex, combining multiple energy sources, multiple electricity consumers, and operation in both island (stand-alone) and utility grid connected modes.

TASK 11 STRATEGY AND ORGANIZATION

In general, Task 11 follows a strategy, similar to previous PVPS Tasks, in which the current states of technology and design practice in the participating countries are first assessed and summarized. Further work will then focus on those areas where technology improvements or better design practices are needed. This may require new research or data, or simply an expert consensus on best practices.

Task 11's work plan is divided into four subtasks and a number of detailed work activities on key aspects of PV hybrid and mini-grid technology and implementation.

SUBTASK 10: Design Issues

Subtask 10 addresses PV hybrid system design practices. Tradeoffs have to be made between first cost, energy efficiency, and reliability. The correct choice of components and system architecture is critical. The task has the following three activities:

- Review, analysis and documentation of current hybrid mini-grid system architectures
- Evaluation and comparison of system design methodologies and tools and development of guidelines for design tools
- Development of best practices for design, operation, and maintenance of PV hybrid projects

SUBTASK 20: Control Issues

Subtask 20 addresses the need for new coordinating control mechanisms in hybrid mini-grids to maintain grid stability and to optimize the contribution of all generation sources. It has the following five activities:

- Investigate existing methods for stabilizing voltage and frequency in mini-grids and develop new, improved methods if required
- Investigate data communication architectures and protocols for mini-grids
- Develop supervisory control parameters and strategies for mini-grids
- Evaluate the role of energy storage technologies to stabilize mini-grid operation
- Investigate technical issues associated with autonomous and interconnected operation of mini-grids and a main utility grid.

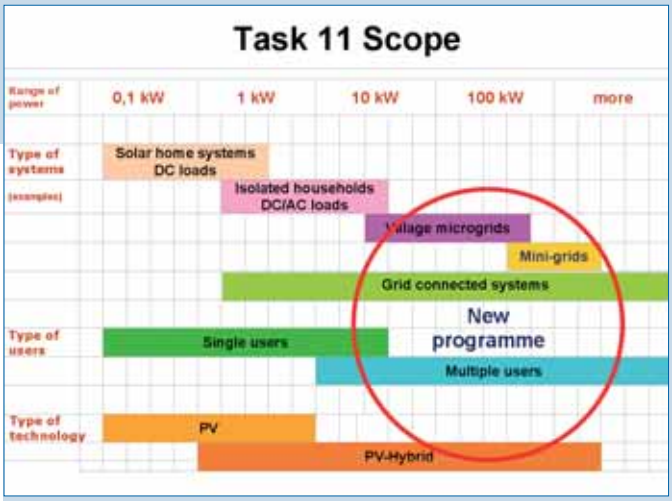

Fig. 1 - Scope of the Task 11 Program.

SUBTASK 30 - PV Penetration in Mini-Grids

Subtask 30 addresses the goal of increasing the use of the PV resource in PV hybrid systems and displacing fossil fuel resources. It has the following two activities:

- Develop performance assessment criteria for PV hybrid systems that allows for objective comparison of different systems
- Develop recommendations to maximize the solar fraction in hybrid systems through demand side management, dispatch strategies and optimization of the battery energy storage system.

SUBTASK 40 - Sustainability Conditions

Subtask 40 addresses the social, political, economic, and environmental factors necessary for successful implementation of PV hybrid power systems within mini-grids. It has the following three activities:

- Develop case studies that demonstrate the social and political framework for successful operation of PV hybrid systems within mini-grids
- Evaluate the financial aspects of PV hybrid power systems, considering both first costs and operating costs, and determine the conditions for economic sustainability
- Evaluate the environmental impacts and benefits of PV hybrid systems with focus on greenhouse gas emission mitigation and potential for recycling of system components

PROGRESS IN 2007

Task 11 has moved well along on its assessment of the current state of technology and design practices. Progress in individual subtasks is summarized below.

SUBTASK 10: Design Issues

Subtask 10 has compiled a list of the existing published guides and reports on design of PV hybrid systems and mini-grids and has started reviewing the documents with the goal of assessing current design practices and trends.

A survey of software design tools used to design PV hybrid systems and size components received responses from almost all participating countries. The survey questionnaire and subsequent analysis dealt with:

Fig. 2 - Hermannsburg Solar Power Station, part of a diesel mini grid in Central Australia. 8 x 24 kW (192 kW) solar concentrating dishes by Solar Systems Pty Ltd (photo Novolta/W Meike).

a. Tool availability (generally available or proprietary) and cost,
b. Tool features and application area (e.g. feasibility analysis, system sizing and design, simulation)
c. Characteristics and quality of user interface and documentation

Results were obtained for over 20 software tools. In addition to tools focused on PV hybrid systems, the survey also gathered information on tools for the design of distribution networks for mini-grids. The final outcome of the survey will be a report that provides an overview of available software tools and guidelines for the selection and use of the tools for particular applications.

SUBTASK 20: Control Issues

The first phase of this subtask is also to assess the current state of the art. Subtask 20 has examined current PV hybrid mini-grid system architectures and has classified them into four categories for further study. The classification is based on which ac power sources in the mini-grid perform the “grid forming” function to control the mini-grid frequency and voltage.

For each of these mini-grid architectures, Subtask 20 is studying the following issues:

- Grid forming control techniques
- Power sharing among ac sources
- Control of PV generation
- Demand side management techniques to manage loads and limit fuel consumption
- Connection of the mini-grid to an external grid

A study for one of the architectures is complete, based on systems and techniques developed by the Institut für Solare Energie-versorgungstechnik (ISET) in Germany. Work is now focusing on gathering information on the other three architectures and on various mini-grid subsystems that support mini-grid control.

A questionnaire on data communications systems and data acquisition systems used for mini-grid control and operation was circulated to Task 11 participants. Responses have been received and analyzed from 7 participants. This information, plus information on international standards development for data communications in distributed generation, will be used as basis for a report on the current state of the art and future trends.

Recent reports on energy storage technologies that may be applicable to mini-grid stabilization were collected and reviewed. Seven energy storage technologies were selected for further study. Draft reports on four of these technologies were completed by the end of 2007.

A questionnaire has also been prepared and distributed to assess the differing national situations (regulatory, technical, financial, political strategy) with regard to interconnection of mini-grids to the main grid.

SUBTASK 30: PV Penetration in Mini-grids

A first draft of a set of performance assessment criteria for PV hybrid systems has been prepared. The next step is peer review by Task 11 particpants.

SUBTASK 40: Sustainability Conditions

This Subtask is using a case-study approach which will study the sustainability conditions for a number of PV hybrid mini-grid systems in locations around the world. The study is proceeding through the following steps:

1. Write and deliver a “light” case study template to all Task 11 participating countries to collect information on candidate PV hybrid mini-grid systems.
2. Produce a methodological tool to manage data collection and analysis with a focus on the social, financial, and environmental aspects of the systems,
3. Analyze the light case studies received from Task 11 participants and select a short list of «interesting» case studies for deeper analysis (considering the sustainability context),
4. Gather case study information using the tool developed in step 2,
5. Analyze the collected system data according to the 3 topics (social, financial, environmental) and summarize to highlight key issues and recommendations.
6. Prepare draft and final reports.

Fig. 3 - In the first photo - Local community members installing PV panels. In the second photo - Distributed PV connected to the Diesel powered Mini-Grid (photos NRCAN/A.Swingler).

TABLE 1 - LIST OF TASK 11 PARTICIPANTS

COUNTRY	NATIONAL CONTACT	CONTACT ORGANISATION
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A total of 36 system descriptions using the light case study template have been submitted by Task 11 countries. The systems have a worldwide spread, with varying architectures, power ratings, and data availability. The next step is to select the short list of in-depth case studies (10 to 12) and, in parallel, to determine the main indicators of social, economic, and environmental sustainability in order to assess the systems and extract the sustainability conditions for the deliverable reports. Draft proposals for the economic, social and environmental indicators have been prepared.

PLANS FOR 2008

In 2008, Task 11 expects to largely complete the information gathering and assessment phases outlined in its Activity work plans. Work will start on detailed analysis of the information. In some Activities, work will begin on production and review of first drafts of deliverable reports.

Some early results from Task 11 will be disseminated in papers presented at the 4th European PV Hybrid and Mini-grid conference to

Fig. 4 - 225 kW Kings Canyon Solar Power Station, part of a diesel mini grid in Central Australia. Owned by Power And Water Corporation, the local electric utility. Concept and Design by Wolfgang Meike (photo Novolta/W Meike).

be held in Athens in May, 2008. Task 11 is also planning a workshop on software design tools for PV hybrid mini-grid systems at the European PVSEC conference in Valencia in September, 2008.

PUBLICATIONS AND DELIVERABLE ITEMS

There are as yet no formal reports or publications from the Task 11 Activities. However papers have been presented to publicize the Task and outline its mission and Work Plan. Task 11 participated in the IEA PVPS Workshop @ PVSEC17 in Fukuoka, Japan and also presented a paper on its activities at the PVSEC 17 Plenary Session on Terrestrial PV Systems.

INDUSTRY INVOLVEMENT

Task 11 is fortunate to have significant industrial participation from manufacturers and system integrators. The table below summarizes the 2007 industrial (private sector corporate) participation.

TABLE 2 - INDUSTRIAL PARTICIPANTS IN TASK 11

COMPANY	COUNTRY	BUSINESS ACTIVITY
Caterpillar Inc.	USA (observer)	Engine-generator manufacturer
Conergy AG	DEU	PV system integrator and equipment manufacturer
Fronius International Gmbh	AUT	PV inverter manufacturer
Nissin Electric Co.	JPN	PV system integrator and equipment manufacturer
Novolta Pty.	AUS	Engineering Consultant
PHK Consultants	FRA	Consultant
Project Consult	DEU	Consultant and PV system integrator
SMA Technologie	DEU	PV inverter manufacturer
Sputnik Engineering AG	CHE	PV inverter manufacturer
Steca Gmbh	DEU	PV inverter and charge controller manufacturer
SunTechno	JPN	Consultant
Sustainable Energy Technologies	CAN	PV inverter manufacturer
Sweco Groener AS	NOR	Engineering Consultant
Trama TecnoAmbiental	ESP	PV system integrator and equipment manufacturer
Transenergie	FRA	PV system integrator
Xantrex Technology Inc.	CAN	PV inverter and charge controller manufacturer

TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

INTRODUCTION

The growth of the PV market is based on the promise of environmentally friendly energy generation, and is sustained by the support of the environmentally conscious public via market incentives, direct subsidies and R&D support. Without such support the industry can not grow to levels that would enable the reduction of direct (production and installation) costs to the levels of conventional energy generation. Furthermore, continuing diligence on EH&S issues is necessary to safeguard the environment, which is the promise of photovoltaics.

OVERALL OBJECTIVES

The goal of Task 12 is to facilitate a common understanding of EH&S issues among the various country members, and disseminate the Task group's knowledge and understanding to stakeholders and to energy and environmental policy decision makers.

Task 12 aims at fostering international collaboration in the areas of safety and sustainability which are crucial for allowing PV to grow and make major contributions to the energy needs of the member countries and the world. There are both technical and perception issues that need to be addressed.

The overall objectives of the Task are to:

a) Quantify the environmental profile of PV in comparison to other energy technologies.
b) Define and address EH&S and sustainability technical and perception issues that are important for market growth.
c) Disseminate the results of the EH&S analyses to stakeholders, policy makers and the general public.

The first objective can be served with life cycle analysis (LCA) that describes energy, material and emission flows in all the stages of the life of PV. The second objective will be addressed by assisting the collective action of PV companies on defining material availability and product recycling issues and on communicating "lessons learned" from incidents, or preventing incidents in PV production facilities. The third objective (i.e, dissemination) will be accomplished by presentations to broad audiences, producing simple fact sheets documented by comprehensive reports, and engaging industry associations and the media in the dissemination of the information.

APPROACH

The approach to meet Task 12 objectives is to subdivide the Task into four relevant subtasks and a number of detailed work activities on key aspects of PV Environmental Health and Safety activities.

SUBTASKS AND ACTIVITIES

The current subtasks and activities are as follows:

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

This subtask addresses the following objectives:

- Assist the development of collection infrastructure by examining and evaluating the collection infrastructure of other recyclables (e.g., electronics, liquid crystal displays).
- Enhance the interaction among industry players so that they share information and resources for collection and recycling.
- Show the technical and cost feasibility of collection and recycling (to environmental policy makers, e.g., WEEE, RoHS).
- Identify common tasks where financial resources can be shared (e.g., separation of EVA from the module).

The proposed activities to achieve the announced objectives are the following:

11) Define collection infrastructure paradigms that can be useful in PV module take programs in various countries.
12) Define the technical and economic feasibility of recycling manufacturing waste and spent PV modules
13) Investigate technologies for the recovery of valuable elements from PV modules

Workshops will be held in conjunction with PVCYCLE activities sponsored by EPIA and other PV associations and possibly the LCA workshops described below.

SUBTASK 2: Life Cycle Assessment

This subtask aims at establishing and demonstrating that PV systems are safe and environmentally friendly and that future very large-scale implementation will provide clear environmental benefits.

This will be accomplished through the following activities:

21) Compare the EH&S profiles of PV technologies with those of other energy technologies.
22) Show the improvement trends of the PV environmental profile by certain indicators (e.g., EPBT, GHG emissions, waste reduction, materials' recycling/recovery).
23) Continue showing such progress in annual updates over the course of Task 12 (5 years).
24) Valuate the environmental benefits of PV by showing avoided impacts or avoided "external" costs.
25) Credible communication and dissemination of results.

These activities will start with developing guidelines for a consistent methodological approach and LCI (Life Cycle Inventory) databases, enabling well-balanced and transparent comparisons among PV and other energy technologies.
The results of this subtask may continue to benefit the PV industry by developing tools to monitor and report progress on process EH&S and product sustainability, and potentially benchmark the performance of individual companies.

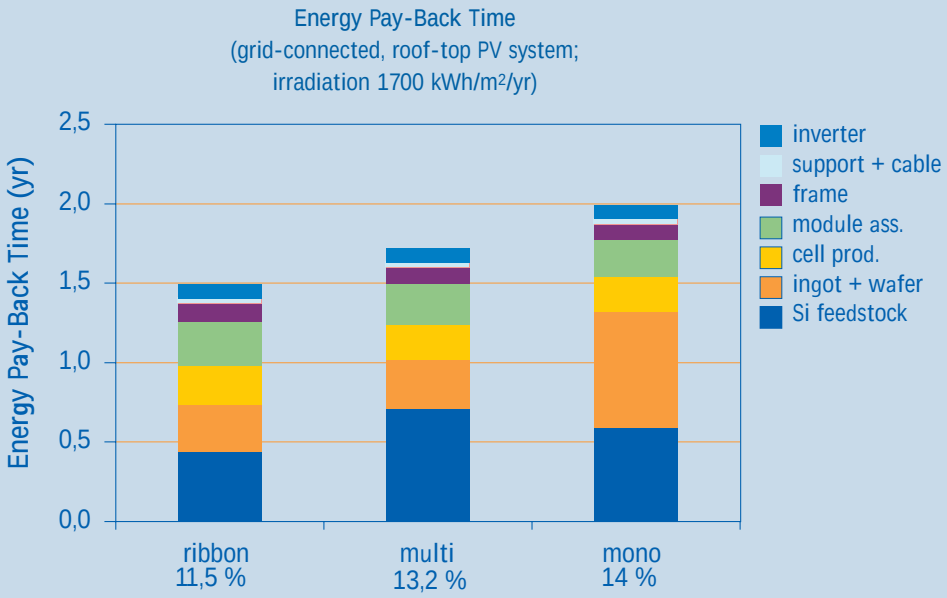

Fig. 1 - Energy Pay-Back Time of crystalline silicon PV systems in 2006 (rooftop system in S.-Europe, irrad. 1700 kWh/m²/yr, PR=0,75) (from: Alsema and De Wild-Scholten, Reduction of the Environmental Impacts in Crystalline Silicon Module Manufacturing, 22nd European Photovoltaic Solar Energy Conference, Milano, 2007).

SUBTASK 3: EH&S in Manufacturing Facilities

The main objectives within this subtask are:

31) Develop risk factors and compare with other energy technologies.
32) Identify accident prevention and control options for specific technologies.
33) Identify pollution control technologies for major types of PV manufacturing facilities.
34) Identify prevention and control strategies for green-house gases (GHG) in PV manufacturing facilities.

The activities proposed to achieve them are:

- Host EH&S Tutorials during major PV conferences.
- Report to the Intergovernmental Panel for Climate Change (IPCC) the findings on the GHG emission assessment.

SUBTASK 4: EH&S Information Dissemination

The methods and results obtained from sub-tasks 10-30 above will be communicated and disseminated by various target-oriented communication tools, such as:

41) Short and simple “fact sheets”, documented by peer-review publications
42) Reports summarizing the activities undertaken for accomplishing the objectives of the task and the task results.
43) Presentations and peer-review publications

PROGRESS IN 2007

This new Task got underway with a kick-off meeting in Brussels, in March 2007, which was attended by 11 experts in the field of EH&S, from seven different countries. This meeting’s accomplishments were primarily in the areas of Task organization and the technical work program planning.

A second Task 12 Experts Meeting was held in Milan, in September 2007, in order to evaluate the work progress of the different participants within the Task.

A third one, The 1st IEA LCA Experts Meeting, was held in New York, in November 2007, where worldwide experts in the field of LCA have met in order to develop the “Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment.” A draft document is presently being circulated among the Task member and will be published later in 2008.

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

A significant breakthrough has been achieved with the creation of the PV CYCLE association in Brussels, July 2007. This association was founded by EPIA and BSW and is supported by the German Federal Ministry for the Environment. PV CYCLE now counts with the participation of 17 worldwide Industries. Its goals are the introduction of a voluntary take-back and recovery system for PV modules within Europe. Technical and cost feasibility of collection and recycling are being analyzed for both crystalline and thin films technologies.

SUBTASK 2: Life Cycle Assessment

- A database called EcoInvent has been updated on behalf of the European Photovoltaics Industry Association and the Swiss Federal Authority for Energy. Data have been collected in this project directly from manufacturers and were provided by other research projects. LCA studies from different authors are considered for the assessment. The information is used to elaborate a life cycle inventory from cradle to grave for the PV electricity production in grid-connected 3 kWp plants in Switzerland, in the year 2005.

  The inventories cover mono- and multicrystalline silicon cells, ribbon silicon cells, as well as amorphous silicon, CdTe and CIS thin film cells. Environmental impacts due to cell and module production for all production steps including feedstock and wafer production, metal winning and refining, and production of special

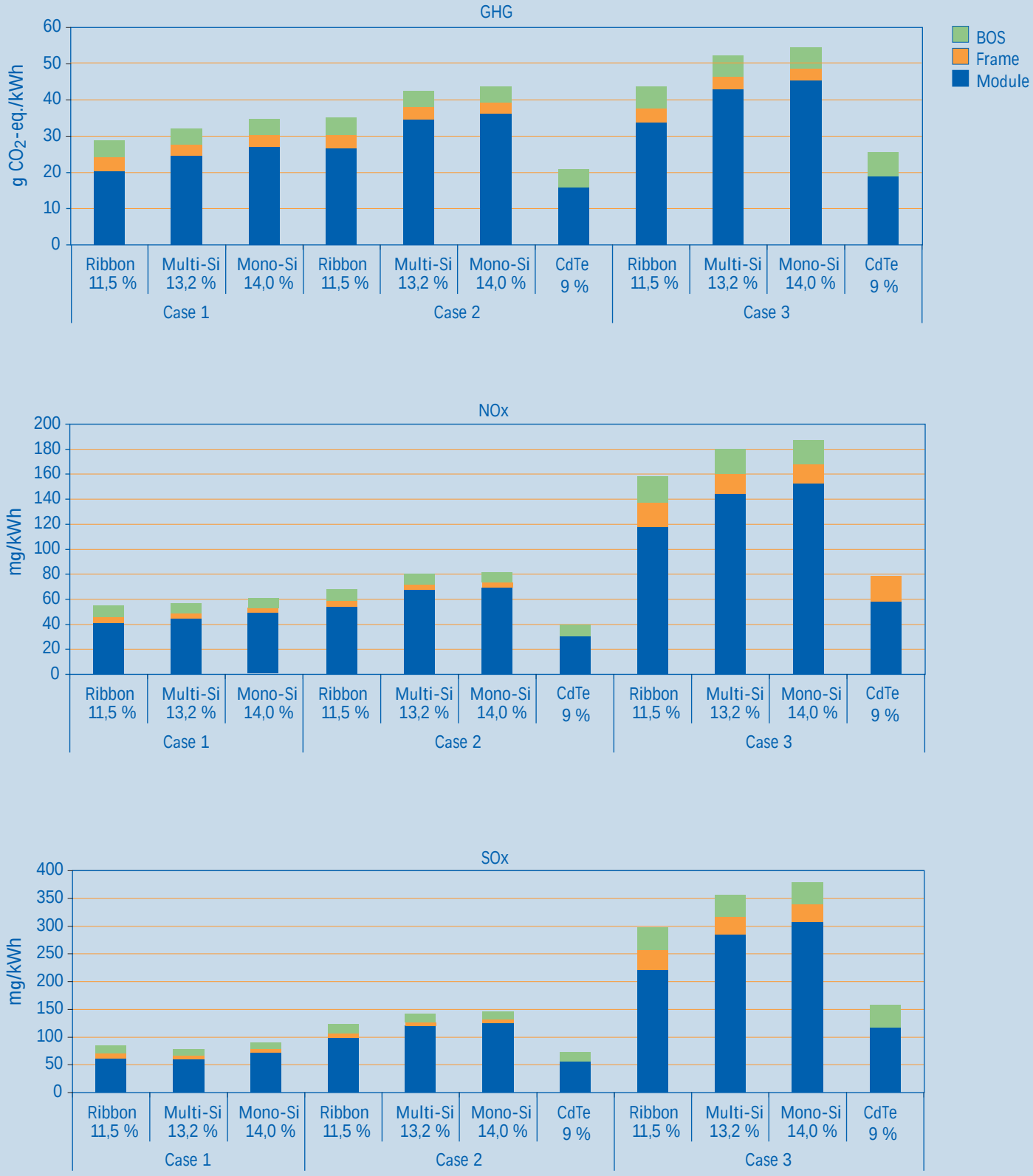

Fig. 2 - Life-cycle emissions from silicon and CdTe PV modules. BOS is the Balance of System (i.e., module supports, cabling and power conditioning). Ground-mounted systems, Southern European insolation, 1,700 kWh/m²/yr, performance ratio of 0.8, and lifetime of 30 years. Case 1- current electricity mixture in Si production-CrystalClear project and Ecoinvent database. Case 2- UCTE grid mixture and Ecoinvent database. Case 3- US grid mixture and Franklin database (Source: Fthenakis, Kim and Alsema, Emissions from Photovoltaic Life Cycles, Environmental Science and Technology, in press).

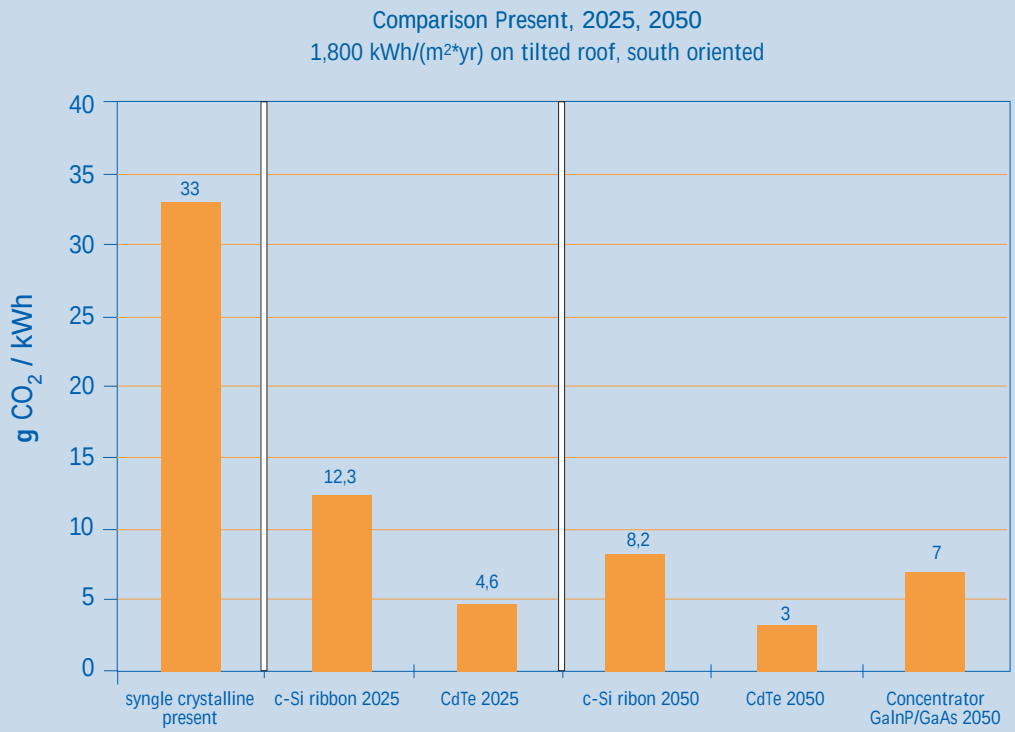

Fig. 3 - Preliminary GWP results for the Optimistic/Realistic scenario analysis of future PV systems performed within the NEEDS project (with fixed background data).

chemicals are considered. For standard materials the EcoInvent data v2.0 may be used as a background database. The content of the PV LCI datasets for crystalline silicon modules and BOS components is publicly available via the website of ECN (http://www.ecn.nl/docs/library/report/2007/e07026-LCIdata-cSiPV-pubv2_0.xls), while the complete LCI dataset for all technologies is accessible for EcoInvent members at www.ecoinvent.org. The latter dataset will also be offered as part of a database extension by major LCA software distributors. Issues related to the representation of thin-film PV and BOS in ECOINVENT were identified (The model used in ECOINVENT for CdTe modules lacks representativeness, since it is largely based on production data for a company modules which only makes up a very small percentage of the total CdTe PV market in Europe). Remedies are currently discussed among IEA Task 12 participants.

- A first draft of an LCA model has been completed by Elkem Solar with support from ECN. The LCA model's work aims at disseminating results on environmental impact and energy use for the Elkem Solar process to produce solar grade silicon (or Elkem Solar Silicon - ESS™). This includes entities like Energy Pay Back Time and CO_2 Pay Back Times. In addition, models for competing processes will be set up and compared to the ESS - process.
- An experts meeting was held in New York, November 2007, with the aim to establish guidelines that promote transparency and balance in conducting and communicating comparative life cycle assessments across different PV technologies and in comparing the environmental impacts of PV systems with those from other energy technologies.
- A number of papers related to life cycle assessments and other environmental aspects have been published during 2007 and can be found at:
  - http://www.ecn.nl/publicaties/default.aspx?au=44649
  - http://www.clca.columbia.edu/publications.html
  - http://www.chem.uu.nl/nws/www/research/e&e/e&e_rena.htm

SUBTASK 4: EH&S Information Dissemination

A set of Fact sheets have been developed under the EU PV technology platform and supported by EPIA. Some of the fact sheets deal with issues as the Energy Pay back Time for PV systems (Erik Alsema) or the external costs of electricity generation (Vasilis Fthenakis). Currently they are only in English but they will be translated to several European languages during 2008.

PLANS FOR 2008

A workshop on silane safety will be in conjunction with the next IEEE PVSC in San Diego, USA, May 2008

The "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" are currently under review among task members and they are expected to be published during 2008.

In the framework of PV CYCLE, a one year length study on the "development of a take back and recovery system for PV products in Europe" has been concluded and the results will be published within the following months. Therefore, the best option coming from the study will be discussed and implemented.

PUBLICATIONS AND DELIVERABLES

The following papers will be presented at different international events:

- *"Environmental Life cycle Assessment of the Elkem Solar Metallurgical Process Route to Solar Grade Silicon with Focus on Energy Consumption and Greenhouse Gas Emissions"* (Silicon for Chemical and Solar Industry IX", Oslo, Norway, June 2008.
- *"Comparison of the Energy Consumption in Different Production Processes for Solar Grade Silicon"* (The 23rd EU PVSEC, Valencia, Spain, September 2008.
- A most comprehensive LCA study "Emissions from Photovoltaic Life Cycles" will be published in Environmental Science & Technology in Feb. 2008.

AUSTRALIA

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Fig. 1 – PV Water Pumping (photo S. Troman).

GENERAL FRAMEWORK

Photovoltaics is an important renewable energy technology for Australia, with well established research groups and off-grid markets providing a good base for expanding grid and export markets. Public interest in climate change is now high and the new Government elected in late 2007 has ratified the Kyoto Protocol. Although PV remains a relatively high cost option, because of Australia's low electricity prices, its implementation is more straightforward than many other energy options, with few aesthetic, noise, water or emission issues arising. Hence, with Australia's excellent solar resources and continued rebates, the PV market is expected to grow more rapidly over the coming years.

The largest installed capacity of PV in Australia is for off-grid industrial and agricultural applications. These include power systems for telecommunications, signalling, cathodic protection, water pumping and lighting. Significant markets also exist for off grid residential and commercial power supplies and increasingly for fuel saving and peak load reduction on community diesel grid systems. The number of PV installations connected to central grids has increased steadily. The main grid applications are rooftop systems for private residences, schools and community buildings, with commercial interest now emerging, as a result of green building codes. There is also a growing market for recreational PV applications, for caravans, boats and off-road vehicles.

NATIONAL PROGRAMMES

In 2006 a total of 23,7 MAUD was spent on PV market support programmes, the largest portion of which was spent on off-grid PV applications to displace diesel fuel use.

The *Renewable Remote Power Generation Programme* (RRPGP) is an Australian Government programme, administered by State and Territory Governments which aims to increase the use of renewable energy for power generation in off-grid and fringe of grid areas, to reduce diesel use, to assist the Australian renewable energy industry and the infrastructure needs of indigenous communities, and to reduce long-term greenhouse gas emissions. The target groups are indigenous and other small communities, commercial operations, including pastoral properties, tourist facilities and mining operations, water pumping and isolated households that operate within diesel grids, use direct diesel generation or are at the end of long grid lines. Grants of up to 50 % of the capital cost of renewable generation and essential enabling equipment are available, with additional funding provided by some States.

The *Photovoltaic Rebate Programme* (PVRP) is funded by the Australian Government and provides PV rebates to householders and owners of community buildings, such as schools, to install photovoltaic systems in order to reduce greenhouse emissions, assist in the development of the Australian PV industry and increase public awareness of renewable energy. The householder rebates were doubled in 2007, to AUD8/Wp for the first kWp, with a corresponding increase in demand. School and community installations are eligible for a 50 % rebate, capped at 2 kWp. 1 230 systems were installed in 2006, amounting to 1,85 MWp, of which 75 % were on grid connected buildings. Since the start of the programme in 2000, more than 8 000 systems, using 10 MWp of PV, have been installed and rebates of over 40 MAUD have been provided. From 2007 an additional 150 MAUD over 5 years was allocated to the programme.

Fig. 2 – The Bushlight Energy Management Unit user interface.

1,64 MWp of PV was installed under RRPGP in 2006, bringing the total installed capacity to 7 MWp under this programme, of which 1,44 MWp is installed in large utility run diesel grid systems. The latter includes 0,72 MWp of solar concentrating dishes commissioned in the Northern Territory. The RRPGP also provides funding for industry support activities, such as test facilities, standards development, training, feasibility studies and demonstration projects, as well as support for the Bushlight programme to assist with deployment of renewable energy systems in small indigenous communities. More than 100 PV powered household systems have now been installed via Bushlight, with specifications developed in consultation with the end-users.

The *Low Emissions Technology and Abatement* (LETA) program has 26,9 MAUD to assist the uptake of low emission technologies by supporting development of PV-related standards, training of PV designers and installers, and of solar resource mapping.

75 MAUD have been allocated over 5 years to the *Solar Cities* programme, to demonstrate high penetration uptake of solar technologies, energy efficiency and smart metering and to improve the market for distributed generation and demand side energy solutions. Utility interest in PV has been rekindled by the Solar Cities Programme, after some years of low activity, with 5 electricity retailers now actively involved. Consortia, comprising a mix of PV companies, banks, local governments, utilities, building companies and research groups, were formed to bid for the Solar Cities funding. 5 Solar Cities have been announced – Adelaide, Townsville, Blacktown, Alice Springs and Central Victoria. The new Australian Government has indicated an interest in funding further Solar Cities.

R, D & D

Photovoltaics research and development is undertaken across a range of university, government and industry facilities. University research groups largely undertake fundamental device research, while industry-based and collaborative research involves PV manufacturing processes and PV systems. In 2006, 6,95 MAUD was spent on research at universities and research institutes and 0,59 MAUD on demonstration. The following describes some of the largest research programmes.

The *Photovoltaics Centre of Excellence, University of NSW* undertakes research in three interlinked strands aimed at near-term "first-generation" product based on silicon wafers, medium-term "second-generation" thin-film cell technology and long-term "third-generation" solar cells with both high-efficiency and thin-film.

The *Centre for Sustainable Energy Systems*, *Australian National* University undertakes research into solar thermal and photovoltaic technologies including cell performance, thin films, efficiency and processing, parabolic trough and paraboloidal dish PV concentrator systems, and associated concentrator cells, trackers, controllers and mirrors, as well as PV-thermal systems.

Murdoch University has an amorphous silicon research group, investigating cell designs which improve performance. New cell designs, using a combination of nanocrystalline and amorphous silicon alloys are being developed and improved methods of producing solar grade silicon directly from metallurgical grade material are being investigated.

Murdoch University also hosts the *Research Institute for Sustainable Energy* (RISE), which in turn runs ResLab, a renewable energy test and standards centre. RISE is actively involved in PV module testing, PV based remote area power supply system modelling and development and, as well as PV standards development and verification.

University of Melbourne, with partners Monash University, Securency, BP Solar, Merck, Blue Scope Steel, and NanoVic, is undertaking research into organic "plastic" PV cells with the possibility of producing flexible solar cells, or coatings that function as sunlight harvesting paints on roofs or as an integral part of fabrics. The research includes improved power conversion efficiencies, which are currently around 5 %.

The *Commonwealth Scientific and Industrial Research Organisation* also has a growing research programme in organic photovoltaics, with expertise in synthesis of light-harvesting molecular materials, organic device fabrication and characterisation of photovoltaic performance. It is working in collaboration with the Melbourne University based team described above, as well as with international partners, as part of the International Consortium for Organic Solar Cells.

IMPLEMENTATION

A number of Australian Government programmes support the PV market in Australia, as described above. Some support is also provided via the *Mandatory Renewable Energy Target* for the electricity sector, which is to be extended by the new Government. Most State Governments have also introduced Renewable Electricity Targets and while electricity retailers offer Green Power programmes, some PV specific.

Several State Governments are considering feed-in-tariffs for PV. To date only South Australia has implemented one: AUD 0,44/kWh (about twice the standard retail tariff in Adelaide) for 20 years, on exported electricity only. Similarly, electricity retailer *EnergyAustralia* offers an AUD 0,27/kWh buyback tariff (twice the typical Sydney tariff) for net export between 2 and 8pm. This may encourage west facing PV arrays.

Fig. 3 - Bushlight community RE System installed at Wanmarra outstation in Central Australia.

INDUSTRY STATUS

BP Solar is the largest commercial PV manufacturer in Australia with an installed cell capacity of 50 MW. In 2006 it produced 36 MW of cells and 7,6 MW of modules. The company is also active in the development of safe and efficient installation systems and procedures including new frame types, mounting systems, smart communications and modular pre-designed packaged systems. BP Solar and Dux have developed a combined PV / solar water heater kit, sold as the BP Solar Energizer Plus. It is available in several sizes and aims to streamline household solar conversion.

Bushlight was established under the RRPGP to provide sustainable energy services to remote aboriginal communities. It has developed a modular, scalable renewable energy power supply system which can supply loads between 2 and 32 kWh per day, with provision for a diesel generator to cater for higher loads if required. The systems are designed in conjunction with the community, which is also provided with appropriate educational material. For community systems, energy management units are installed at each house to ensure community supply is maintained.

CSG Solar commenced commercial module production in Germany during 2006 but continues its research in Australia on Crystalline Silicon on Glass, a thin film PV technology based on initial research at the University of NSW.

Dyesol is the industrial research hub for the world's network of researchers into Dye Solar Cell (DSC) technology. Dyesol researches, develops and manufactures DSC materials and components, including nanoparticulate pastes and dyes, as well as equipment specifically designed to research and manufacture DSC.

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. Trial 10 W and 70 W modules have been produced from a 5 MW Pilot Plant.

PV Solar Energy Pty Ltd has developed a 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 to allow warm air circulation into the building during winter months.

Solar Systems Ltd. has developed and commercialised a PV tracking concentrator dish system for off-grid community power supplies and end of grid applications. Current systems achieve 500 times concentration and use air or water cooling. The systems were initially based on silicon cells, but upgrading to higher efficiency non-silicon devices is now underway. The company has been granted 75 MAUD from the Australian Government and 50 MAUD from the Victorian Government towards a 154 MW heliostat PV concentrator power plant to be built in northern Victoria. Installation will commence in 2008.

MARKET DEVELOPMENT

PV installations in Australia in 2006 totalled 9,72 MWp, a 16 % growth since 2005. Of this, central grid installations accounted for 2,1 MW, off-grid residential 3,37 MW, off-grid industrial and agricultural 3,58 MWp and diesel grids 0,625 MWp. Grid installations grew at a rate of 31 % and now account for nearly 13 % of installed capacity. The recent doubling of PVRP rebates is likely to see a large increase in the grid market for PV over coming years, while continued increases in diesel fuel prices will also keep the off-grid market growing.

PV module and system prices increased by 4-10 % in 2006, with the flow through of earlier international silicon prices, as well as more stringent training and OH&S procedures. Module prices averaged AUD 8,50 and rooftop systems 12,50 AUD per Wp. Price competition for both modules and systems is likely to see prices stabilise and begin to drop in 2008.

FUTURE OUTLOOK

The Australian PV market has been growing steadily over the past decade, assisted by government grant programs, but began to increase markedly towards the end of 2006 when public awareness and discussion of climate change increased. From 2007 the PV market is expected to grow at a faster rate since Federal Government grant programs have been extended or increased and several State Governments have announced local renewable energy targets.
BP Solar is the only flat plate PV manufacturer in Australia at present, with a production capacity far in excess of current local use. There is interest in establishing other PV plants, so an increase in the local market may stimulate some proposals. It may also encourage local commercialisation of new PV technology, most of which currently goes overseas.

Solar Systems continues its development and installation of concentrator PV systems, with the market increasing both in Australia and internationally, particularly for use in diesel grids. Australia has more than 400 MW of diesel generation which will be impacted by both diesel price increases and any introduction of a carbon price, so that this market is also likely to grow strongly over the next five years.

State and Federal Governments are currently developing plans for a national Emissions Trading scheme, which will reduce the margin between renewable and fossil fuel based electricity supplies and provide another boost for the PV market.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
HUBERT FECHNER AND ROLAND BRÜNDLINGER, ARSENAL RESEARCH

Fig. 1 - Currently the largest PV system in Austria is at Fronius company/Sattledt, 603 kW (photo Fa. Fronius).

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

More and more stakeholders in the energy business in Austria recognize PV as an attractive and sustainable way to generate electricity. However, wide public support for PV installations as well as for other "new renewables" (Austria has about 60 % electricity from large hydro) will not be achieved within the upcoming year. The main reason for this is a revised green-electricity act (GEA) which is expected to be published in its third revision in 2008. An additional 700 MW wind energy as well as 700 MW new bio energy power plants are targeted for the period until 2015, which might cover about half of the expected increase in electricity demand.

These "new *RES*" are supported since the beginning of this act 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 about 4,5 Eurocent/kWh).
Starting with 2008 up to 2015, each year another 21 MEUR might be dedicated for covering the feed in tariffs for the newly installed energy systems. While the main part is dedicated to biomass and a smaller part for wind, now 12 % seems to be reserved for PV; which is little higher than in the former act, but still leading only to a few MW installed PV per year.
An annual maximum of 2,52 MEUR from the federal budget can be expected for PV. The regional parliaments are requested to double this federal subsidy specifically for PV support, which on the one hand adds some money, but on the other hand, makes the support system even more complex. This was already one of the main barriers in the former act, as well.
Photovoltaic feed-in-tariffs for 2008 are foreseen to be 44 EUR Cents (< 5kW), 38 EUR Cents (< 10 kW) as well as 28 EUR Cents (>10kW).

Compared to the former regulation, the feed-in-tariffs are slightly reduced and the time frame remains the same (100 % of the source/size specific tariff in year 1 to 10, 75 % in year 11, 50 % in year 12). A decrement factor will be implemented (to reduce the source/size specific maximum tariffs each year about a few %).

It can be expected that this new regulation will lead to about 5-8 MW annually installed systems in Austria. Furthermore, no definitions for supporting special PV applications (e.g. Building Integrated PV as proposed in the federal "Austrian PV Technology Roadmap") niche markets, where Austrian companies could maybe reach a leading position, had been made.

National PV stakeholders questions the effectiveness of the support system mainly because of the complexity of the support system and the modest financial limits, which might not be able to significantly foster the Austrian PV market. Although the new revision of the GEA is still in the negotiation phase, a significant market stimulation aiming at establishing competitive Austrian PV industry will not be achievable.

Another initiative might exceed the effect of PV support within the GEA: The national ministry of environment is promoting a so called "10 000 Roofs PV Programme," which might support only small systems (private households) but could lead to another about 3-5 MW PV installations in Austria per year. The realisation of this broadly discussed initiative is still open as well.

RESEARCH AND DEVELOPMENT

The national "PV Technology Roadmap," initiated by the Ministry of Innovation and Technology, mainly focusing on technology aspects was published and presented to the public by the Minister of State on the occasion of the National PV Congress in September 2007. This roadmap

was worked out in a wide discussion process amongst the main national PV stakeholders under the leadership of the mainly governmental research centre arsenal research. It aims at finding out the needs for establishing PV as significant source of electricity in Austria, as well as the possible future role of Austria's industry in the world wide PV market. Besides showing the potential for Austrian industry to contribute in many items to the value chain of the PV technology, significant employment in the short term perspective and considerable contribution to the national electricity demand (at least 20 % in 2050) are the main findings of this roadmap, which should attract decision makers.

Currently the Austrian PV research activities are mostly focused on national and international projects: The involved research organisations and companies are participating in various national and European projects, different tasks of the IEA-PVPS Programme, as well as in work concerning grid interconnection in the IEA ENARD Implementing Agreement. The RTD development and approach is widespread located and decentralised orientated.
The new national programme "Energy of Tomorrow," (http://www.energiederzukunft.at/) successfully launched in summer 2007, was initiated by the Ministry of Transport, Innovation and Technology and covers quite broad research items on energy technologies. Although PV research is addressed only in a small subpart of the programme, research in PV systems as well as in distributed generation with many aspects relevant for PV can be financed within this well designed activity.
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.

Research highlight of photovoltaics in Austria are:

- 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.
- Grid-interconnection, not exclusively related to PV but more to Distributed Generation from RES in general ("smart electricity networks"), is the main focus of several national and EU financed projects, which are jointly carried out by research institutions, industry and network operators.
- Research on PV inverter specification (MPP, islanding, efficiency aspects...) is done at arsenal research attracting worldwide inverter manufacturers for collaboration.
- Cost reduction and optimization of new solutions for building integrated PV are addressed within several EU projects.
- At the University of Salzburg, a new initiative was started in 2006 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.
- A large Austrian glass industry has intensified its 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 extended; arsenal research as an Austrian research and testing institution is officially accredited to qualify crystalline silicon PV modules according to the EN/IEC 61215 standard as well as PV inverters.
- A national PV Technology platform is currently under discussion to be established during 2008.

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 25 MW of PV power had been installed in Austria by the end of 2006. There are no figures available for 2007 yet, but it is expected that currently not more than 27 MW are totally installed in Austria.
The annual growth rate in 2006 totalled 1,5 MW; the lowest in many years.
Despite its weak home market, Austria has some internationally well positioned manufacturers nearly exclusively involved in foreign trade; mainly focusing on the neighbouring large German market.
The largest Austrian PV System was installed in 2007, on the premises of the inverter producer Fronius at its new headquarters in Sattledt/Upper Austria. The system size is about 600 kW and is part of a concept for a fully environmentally logistic system for Fronius International. It received the "Energy Globe Award" in 2007.

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 some remarkable installations were realised.
Beside on-grid applications off-grid systems are widely used to provide electricity to technical systems or for domestic use in Alpine shelters or households lying far away from the grid.
Some provincial governments have built PV-demonstration plants on municipal buildings in order to create public awareness for PV.

INDUSTRY STATUS

Despite the unclear and unsatisfactory situation with an insignificant national market for PV, the Austrian PV industry could still expand their activities during 2007 focussing on the export of their products predominately to the booming German and other International markets. In Austria, about 1 500 employees in the PV business seems to be a success, but rely heavily on the development outside the borders of the country.

SOLON-Hilber Technology: A subsidiary of the German SOLON manufacturer produces solar trackers and solar modules in Tyrol, close to Innsbruck; started in 2003. Currently more than 180 employees are working in this company.

Fig. 2 - PV at Roundabout Lustenau, Vorarlberg, Austria (photo Stromaufwärts).

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

Kioto Photovoltaic produces PV modules since 2004. 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 advantage of the German PV boom.

Blue Chip Energy GmbH will start production of silicon solar cells in the energy autarkic municipality of Güssing (Burgenland) in 2008, expected to finally employ 140.

Another thin film factory is about to start in early 2009 in Austria.

Besides PV-Module and cell production, various other companies are manufacturing components for modules and BOS-components like batteries, inverters, cell-wiring or mounting systems:

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

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

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.

PLANSEE-WERKE in Tyrol is manufacturing metallic base materials for thin film solar cells.

Altogether, the Austrian PV industry is expected to employ significantly more than 1 500 people in 2008.

MARKET DEVELOPMENT

The Ministry of Environment, engaged in climate protection started a large programme of initiatives to reduce CO_2 emissions ("klima:active") in 2004; through addressing and fostering various technology sectors like biomass-heating, solar thermal systems, heat-pumps, low energy buildings, environmental benign transport and others. It is currently preparing a programme for photovoltaics, concentrating on awareness raising, education and information about the potential and possible future contribution of PV to the general energy supply.

The National Photovoltaic Association has further expanded their activities by creating a national network for dissemination of PV information 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 framework conditions for PV by introducing stable and supportive PV market incentives preferably based on feed in tariffs.

At the end of 2007, more than 100 companies and persons involved into the PV business were Association members; which is about four times as much as of end 2005.

The annual National Photovoltaic Conference 2007 (a two days event) was jointly organised by arsenal research and the national PV association with support from the Ministry of Transport, Innovation and Technology and had again been a great success; with more than 200 experts participating. Besides technical presentations, an "industry forum" was part of the Conference where most relevant national market players (module producing companies, BOS producing companies, research experts etc.) informed the audience on their latest developments.

The Austrian research and testing centre "arsenal research" (known as an internationally accredited PV module test institute according IEC 61215 and testing of PV inverters) has continued in 2007 the "Certified PV Training" with another two trainings for installers and planners in order to improve the quality of the installed systems. The promising feedback and the growing interest will lead to a minimum of six courses in 2008.

FUTURE OUTLOOK

- Waiting for the effects on the new support scheme, the situation of PV remains unsatisfactory; mainly due to the complex and insignificant subsidies. 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.
- Potential PV niche markets, where Austria could take a lead position, have to be developed; in order not to fully lose the linkage to the booming international market. Some new initiatives and considerations at regional governments seem to be promising.
- 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 world-wide 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 (e.g. 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 continuously growing. Several renewable energy education courses are already implemented, some new are currently under development. All of them include PV as essential part of the future energy strategy. For example, at the technical University in Vienna, a post graduate education on renewable energy was introduced with PV as an important energy option included in the curriculum. The importance of proper education for installers and planners of PV systems will increase; depending on the market situation; the training is already available and can be extended easily.
- It can be expected that the National PV Association and other important PV stakeholders will further significantly promote the topic in Austria. The still quite 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 framework conditions.

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
JOSEF AYOUB AND LISA DIGNARD-BAILEY, CANMET ENERGY TECHNOLOGY CENTRE-VARENNES, NATURAL RESOURCES CANADA, (HTTP://CTEC-VARENNES.NRCAN.GC.CA)

GENERAL FRAMEWORK

In late 2006, the Government of Canada introduced Canada's Clean Air Act in Parliament. The Act represents a comprehensive and integrated approach in the regulation of air emissions in Canada. To complement introduction of the Act, the Government also released in to 2007 Canada's Action Plan to Reduce Greenhouse Gases and Air Pollution and it introduced a series of ecoENERGY initiatives to reduce smog and greenhouse gas (GHG) emissions that affect the environment and health to Canadians. These initiatives are a set of focused measures to help Canadians to use energy more efficiently; boost renewable energy supplies; and develop cleaner energy technologies. An important component of the ecoENERGY initiative is the ecoENERGY for Renewable Power[1] program which was announced in early 2007. This 14-year program will encourage the production of 14,3 terawatt-hours of electricity from low impact renewable energy sources, such as solar photovoltaic, wind, hydro, and biomass and ocean energy. It will provide an incentive of 1 cent Canadian per kilowatt-hour of production over 10 years. The objective of the program is to "position the low-impact renewable energy industries to make an increased contribution to Canada's energy supply thereby contributing to a more sustainable and diversified energy future."[2]

The Canadian Solar Buildings Research Network (SBRN)[3] continues to be in the centre of Canada's R&D into solar buildings by innovating solar energy production and efficiency of its use in commercial, institutional and residential buildings in Canada. Also in 2007, the SBRN held its second Conference in conjunction with the Annual Conference of the Solar Energy Society of Canada bringing together leading experts from Canada and around the world to discuss all aspects of solar housing, from solar electricity to design issues to finding ways to encourage Canadians to go solar. The SBRN is pooling the R&D resources of 10 universities and federal departments to develop the future generation of experts knowledgeable in solar buildings research. The R&D efforts of the SBRN 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 construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

In 2007, the Government of Canada announced the twelve Canadian homebuilder teams that were selected as winners of Canada Mortgage and Housing Corporation (CMHC) EQuilibrium sustainable housing competition[4]. The goal of CMHC's EQuilibrium initiative is to demonstrate the integrated design process as a new approach to housing in Canada. It supports the building of sustainable healthy houses that are also affordable and energy- and resource-efficient. EQuilibrium housing is designed to lower homeowner's energy bills by reducing energy consumption and by delivering electricity back to the grid. The houses will also promote water conservation, healthy indoor environments, durability, and reduced pollutant emissions. The EQuilibrium brand replaces the previous working name for this initiative, Net Zero Energy Healthy Housing, to better reflect the goals of balancing Canada's housing needs with those of the environment.

Fig. 1 - The ÉcoTerra' House, Alouette Homes, Eastman, Quebec (photo The Solar Buildings Research Network and Alouette Homes).

NATIONAL PROGRAMME RESEARCH AND DEVELOPMENT

The federal Photovoltaic Programme is managed by the Department of Natural Resources Canada (NRCan) and is funded by 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. The Programme's primary mandate has not changes since its inception - to help develop and deploy photovoltaic energy technologies in Canada. It does so by accelerating the deployment of this technology domestically, while supporting R&D activities that exploit the technology's potential, both nationally and internationally. NRCan through one of its technology science and technology centres located in Varennes, Quebec, promotes and facilitates the use of photovoltaic systems in off-grid and grid-connected applications, by carrying out research and demonstration projects, serving on international standards committees and developing information and training tools. The PV Programme also actively contributes its expertise to innovative partnerships with key players in the field. Most research projects are carried out on a cost-sharing basis with industry, universities, research groups, quasi-public agencies and other departments or governments.

On-going activities undertaken by the PV Programme in 2007 include:

- R&D for the integration of PV-thermal systems in buildings;
- Solar optimisation on Net-Zero Energy Homes;
- Implementing strategies to planning sustainable solar cities;
- Participating in the Canadian Solar Buildings Research Network;
- Solar potential forecast and analysis[5];
- Undertaking PV system performance, reliability and cost analysis;
- Facilitating R&D activities between universities and the private sector involved in fundamental solar cell research;
- Establishing standards and codes for the certification and installation of PV systems and their components;

- Establishing national guidelines for the connection of small, distributed power sources to the public power system[6];
- Simulation studies on the impact of utility interconnected PV systems within mini-grids and micro-grids;
- Representing Canada in the International Energy Agency Photovoltaic Power Systems Programme; and,
- Partnering with the solar power industry through the development of federally-funded demonstration projects.

DEMONSTRATION

ÉcoTerra‘ EQuilibrium - New housing for a Changing World, Alouette Homes, Eastman, Quebec

In 2007, Alouette Homes[7], a Canadian leader in the residential building industry, mainly as a manufacturer of modular and panel homes, built their first ÉcoTerra‘ home in the province of Quebec. Alouette’s ÉcoTerra‘ housing concept (Figure 1), one of the winning proposals in CMHCs EQuilibrium housing competition, is based on the principals of occupant health and comfort, energy efficiency, renewable energy production, resource conservation and reduced environment impact. The concept is an innovative way to create and build a home that combines the ideas of sustainable development, environmental harmony and personal health and well-being.

The ÉcoTerra‘ house consumes only 10 % of the energy used by a standard house with the same surface area. It uses a grid-tied 3 kW Unisolar PV laminates integrated into the roof that includes a Solar PV-thermal hybrid system.

The Jean Canfield Government of Canada Building, Charlottetown, Prince Edward Island

In 2007, the federal government through the Department of Public Works and Government Services Canada (PWGSC) installed a 108 kW grid-tie photovoltaic system on the newly constructed Jean Canfield Building (JCB) in downtown Charlottetown, in the Province of Prince Edward Island (Figure 2). The solar array, designed and installed by Carmanah Technologies Corporation is the largest building integrated in Canada and is comprised of 500 Sanyo solar modules connected to the grid. The JCB is one of the most environmentally friendly buildings ever constructed by PWGSC as it strives to attain a LEED Gold certification from the Canadian Green Buildings Council. The PV system is designed to supply an estimated 10 percent of the building power needs.

A Heavenly Light Shines on Regent College, University of British Columbia

In 2007, Canadian stained glass artist Sarah Hall[8] designed a unique art exhibit called “Lux Nova” (figure 3) which consists of solar cells encased between double layers of tempered glass installed on the façade of a 14-meter high ventilation tower for the underground theology library at Regent College. The college is a graduate school of Christian studies affiliated with the University of British Columbia in Vancouver. The photovoltaic cells power the installations shimmering blue, purple, and white flames produced by a rear column of color-changing LED lights. The Lord’s Prayer is etched into the painted and textured glass structure in its original Aramaic script.

IMPLEMENTATION

Update on the Provincial Government of Ontario’s Renewable Energy Standard Offer Program

The Province of Ontario’s Renewable Energy Standard Offer Program (RESOP)[9] launched in the fall of 2006 by the Ontario Power Authority (OPA) and the Ontario Energy Board (OEB) is designed to encourage and promote the greater use of renewable energy sources including solar photovoltaic. The targets is to help achieve Ontario’s renewable energy supply targets of 2,700 megawatt of electrical power generated by new renewable energy sources by 2010. At the end of calendar year 2007, contracted capacity reached over 900 MW of renewable power (Table 1).
The RESOP rules establish a “market-based pricing system for all technologies except solar photovoltaic that provides a Base Rate to be paid to Generators for each kilowatt-hour (kWh) of electricity delivered, plus a performance incentive for Generators who can control their output to meet peak demand requirements reliably over time. It also provides for price escalation to the Base Rate paid to some Generators, linked to the Consumer Price Index in Ontario. The rules also establish a cost-based price for solar PV production in order to conduct price discovery. A cost-based price recognizes that PV Projects cannot be successful at this time under a pricing regime suitable for other renewable generation sources. PV Projects will be paid $ 0,42 per kWh but will not be eligible for inflation indexation or the peak-hour premium.”

TABLE 1: SUMMARY OF THE PROVINCE OF ONTARIO RESOP CONTRACTS IN 2007 (JANUARY-DECEMBER)[10]

RE SOURCE	CONTRACTS	CAPACITY (KW)
Solar PV	145	252,140
Wind	65	572,827
Water Power	14	31,829
Bio-Energy	17	58,178
TOTAL	241	914,974

Solar programme strategic plan for the Province of British Columbia

In 2007, an independent technology advisory council in British Columbia (BC) reporting directly to the Premier of the province, has issued a report[11] on Greening BC Energy Purchasing Policies recommending that the province “support the development of feed-in-tariffs that decline over time to assist the commercialization of renewable emerging energy sources and their associated technologies”.

Fig. 2 - Newly installed 108 grid-tie solar power system on the Jean Canfield Government of Canada Building, Charlottetown, PEI (photo Carmanah Technologies Corp.).

The work of the Premier's Technology Council builds on the BC Hydro standing offer for small power generation and suggests for more aggressive options such as a feed-in-tariff system that "varies by the source of renewable energy and the maturity of the technology". The Technology Council's report opens the possibility for renewable tariffs in British Columbia. Further developments are expected in 2008. Also in 2007, the BC Ministry of Environment in partnership with federal and provincial energy departments, the provincial utility BC Hydro as well as the participation of public and private sector financial institutions convened a multi-stakeholder team to develop a plan that will help British Columbia achieve the goal of having 100,000 solar roofs in place province-wide. The target includes both solar photovoltaic and solar hot water systems. The solar roofs program supports the BC Energy Plan's goal for electricity self-sufficiency and 90 percent clean or renewable electricity generation. The plan is expected to be completed in 2008 and submitted to the provincial government for consideration.

Interconnection of Distributed Generation to the Electricity Grid

CANMET Energy Technology Centre – Varennes, in partnership with key industry players and associations, has undertaken a number of activities in the area of interconnection in order to avoid multiplication of regional requirements across the country. This included the development of harmonized national interconnection standards, the conduct of research and field-testing addressing concerns raised by electricity distributors, and the implementation of changes in the Canadian Electrical Code[12].

As for the installation of the distributed generators in Canada, PV Systems must be installed in accordance with all applicable general rules of the Canadian Electrical Code; to Part I for low voltage installations at load centers such as residences and commercial buildings, and to Part III for medium to high voltage on Part III of the electricity distribution and transmission systems. Continuing concern during the electricity network interconnection "impact assessments" by utilities delays projects and leads to additional costs to large scale PV projects planned in Ontario. Large inverter-based PV systems (up to 10 Megawatt) are compared to both induction and synchronous generators that are more commonly known to utility personnel. Improved simulations tools used by planning engineers, such as CYMDIST, now include examples for inverter, induction and synchronous generators. In 2007, specific case studies have been added to the CYMDIST tutorial material to promote and educate utility personnel that are tasked with conducting these interconnection "impact assessments" in Canada[13]. There is a need to support specialized courses designed under continuing education programs to support the training needs of the electricity industry in Canada.

Federal programmes in support of technology demonstration to market commercialization

Federal investment in technology transfer through strategic partnerships with the private sector continued to be provided through support to two key delivery programmes in 2007:

- *Technology Early Action Measures (TEAM)*[14], is a federal interdepartmental technology investment programme that in 2007 continued to provide financing for promising environmental technologies that have the greatest potential to reduce greenhouse gases (GHGs). TEAM plays a key strategic role in the technology innovation process. By supporting late-stage development and first demonstrations of GHG-reducing technologies, it enables the federal government to support a wide range of technology options and pathways towards the reduction of GHGs. Many Canadian-based solar companies that have been involved in TEAM projects have subsequently received further private and public financing or have commercially replicated their technology in the marketplace. Since 1998, TEAM has invested has invested 12 million CAD in eight photovoltaic technology early market-entry demonstration projects –the most recent ones being the development and demonstration of combined solar PV and thermal power generation technologies in collaboration with the Canadian Solar Buildings Research Network, and the development and demonstration of solar powered stand alone next generation LED lighting with Carmanah Technologies Corporation.
- *Sustainable Development Technology Canada (SDTC)*[15] is an arms-length foundation that operates as a not-for-profit corporation, established by the Government of Canada in 2001, has received to date 1,05 billion CAD from the Government to support the development and demonstration of innovative technological solutions. SDTC works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian entrepreneurs, helping them form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada.

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[16] and Énergie Solaire Québec[17]. The Canadian PV manufacturing sector has grown significantly in the last five years to serve both the domestic and export markets.

Canadian-based Timminco Limited18, a leader in the production of silicon metal for the electronics, chemical and aluminum industries has commenced production of solar grade silicon through its wholly-owned subsidiary, Bécancour Silicon Inc. (BSI) in its new facility in Bécancour, Québec. The facility will be comprised of three production lines, each with an annual capacity of 1,200 metric tons. The production lines are being brought into production in series with the first starting in fourth quarter 2007, with the second and third lines anticipated to be coming on stream in the first quarter of 2008. In 2007 BSI also announced that it has entered into several long-

Fig. 3 - Sarah Hall's Lux Nova exhibit of stained glass embedded with solar cells and LED lighting grace the wind tower of Regent College, British Columbia (photos Sarah Hall).

term commercial agreements for the sale of approximately 6,000 metric tons of solar grade silicon to solar cell manufacturers beginning in 2009.

In 2007 witnessed several growth-developments of Canadian solar manufacturers. Burnaby-based Xantrex Technology Inc.[19], a world leader in the development, manufacturing and marketing of advanced power electronic products and systems for the renewable, portable, mobile and programmable power markets, expanded its programmable power business by acquiring California-based Elgar Electronic Corporation. This acquisition will enable Xantrex to become a leading player in the global programmable power market with a significantly expanded product line and customer base. Also Day4Energy Inc.[20] formed in 2001 in Burnaby, British Columbia, as a manufacturer of PV modules announced in 2007 that it has raised over 115 million CAD in public investment into the company to enable to expand its production. It was also the lead PV modules supplier to the 1 MW solar energy project in the German county of Sigmaringen with EnBW one of Germany's largest energy suppliers. EnBW has extended its contract with Day4Energy for two additional large-scale projects set for construction in 2009 and 2010. The province of Ontario's Renewable Energy Standard Offer Program (RESOP offer PV $ 0,42 kilowatt-hour) has attracted several large energy developers in 2007. For example Skypower Corporation[21], a subsidiary of Lehman Brothers, a US-based private equity business, and one of Canada's leading independent renewable energy developer, entered into a joint venture with SunEdison Canada LLC, a subsidiary of SunEdison LLC the largest solar energy service provider in North America, on two 10 MW RESOP solar projects in Ontario.

MARKET

Growth in the Canadian sector has been strong over the past 15 years, with capacity growing by more than 20 % percent annually between 1993 and 2007. Whereas, the worldwide trend has been moving towards grid-integrated application supported by market stimulation measures mainly in selected European countries, Japan and the U.S.A., in Canada, the market is mainly for off-grid applications and represents 90 % percent of total installed PV power capacity. The Ontario RESOP offering 0,42 CAD per kilowatt-hour for PV electricity production is paving the way for a strong uptake for grid-connected PV – once the contracted projects are implemented. The numbers of grid-connected systems in Canada in 2007 continue to grow because the barriers to interconnection of "micropower" systems have been addressed through the adoption of harmonized standards and codes. In addition provincial policies supporting "net-metering" of PV power have encouraged a number of building integrated PV applications throughout Canada during this period.

The PV market and industry in Canada is continuing to grow, despite the low price for conventional energy. A sustainable market for remote and off-grid applications has developed over the last 15 years in Canada and continues to accounts for about 90 % 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.

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. The Solar Buildings Research Network 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. Technology demonstration funding opportunities in support for climate change mitigation will continue to generate private sector interest in demonstration projects and collaborative joint ventures.

Footnotes with relevant websites:
(Endnotes)

1 *Natural Resources Canada - ecoENERGY for Renewable Power: http://www.ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/conditions-eng.odf*
2 *Natural Resources Canada: http://www.ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/conditions-eng.odf*
3 *Solar Buildings Research network website: http://www.solarbuildings.ca*
4 *EQuilbrium replaces the working name of this initiative, Net Zero Energy Healthy Housing: http://www.cmhc-schl.gc.ca/en/inpr/su/neze/*
5 *Photovoltaic (PV) potential and insolation web-based maps: https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php*
6 *Micropower Connect: http://www.powerconnect.ca/mpc/index.htm*
7 *Alouette homes: http://maisonalouette.com*
8 *Sarah Hall: http://www.sarahhallstudio.ca*
9 *Renewable Energy Standard Offer Program: http://www.powerauthority.on.ca/sop/*
10 *Information extracted from OPA, "A Progress Report on Renewable Energy Standard Offer Program, December 2007".*
11 *"Premier's Technology Council 10th Report, September 2007": http://www.gov.bc.ca/premier/attachments/ptc_10th_report.pdf*
12 *S. Martel and D. Turcotte, Review of Distributed Generation Product and Interconnection Standards for Canada: http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2007-172/2007-172e.pdf*
13 *Cyme T&D technical engineering courses: http://www.cyme.com*
14 *Technology Early Action Measure: http://www.climatechange.gc.ca/english/team_2004/*
15 *Sustainable Technology development Canada: http://www.sdtc.ca/en/index.htm*
16 *Canadian Solar Industries Association: http://www.cansia.ca*
17 *Énergie Solaire Québec: http://www.esq.gc.ca*
18 *Timminco Ltd.: http://www.timminco.com*
19 *Xantrex Technology Inc.: http://www.xantrex.com*
20 *Day4 Energy Technology Inc.: http://www.day4energy.com/*
21 *Skypower Corporation: http://www.skypower.com*

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS

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

Fig. 1 - Reflections in the dark modules which are customized to be a natural part of the roof in colour and shape.

GENERAL FRAMEWORK

The Danish government proposed a new energy plan, early in 2007, called Energy Vision 2025. However, this plan has not yet been politically accepted, as general elections in the fall of 2007 interrupted the political negotiations, which are now only expected to be completed during the first quarter of 2008. Until then Denmark follows the energy plan launched in March 2005.
This 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 on 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 the base year 1990. The market for CO_2 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 end of 2007 more than 25 % of the national electricity consumption was generated by renewable energy sources including incineration of waste. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the present 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; both at favourable cost to the consumers.

Photovoltaic technology (PV) is not specifically mentioned in the government's energy plan, but 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 envisaged to be developed in the coming years and an overall framework for the coordination of PV development and deployment in Denmark is thus envisaged to be in place inside a few years. The PV strategy was updated mid 2006 by the way of an annex outlining the need of long term operational targets and support mechanisms for demonstration. A full update is expected early 2008.

Key actors have been identified as: utilities – carrying out small and large R&D and in particular demonstration projects; transmission system 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 a steady interest in and willingness to buy PVs, if conditions can be established resulting in a simple pay-back time of 20 years or less.

Fig. 2 - The customized PV modules from the Danish module manufacturer GAIA Solar are made especially to fit with the roof in the PV-Danmark project.

NATIONAL PROGRAM

Denmark has no unified national PV programme, but a number of projects supported mainly by the Danish Energy Authority and via the Public Service Obligation (PSO) of Danish transmission system operator, Energinet.dk. In late 2006, a new support mechanism, the Energy Development and Demonstration Programme (EUDP), to be administered by an independent board and with the Energy Authority as secretariat was announced. A first call for proposals was closed in September 2007, and a few PV projects received support by end of 2007, but the extent to which PV really can benefit from this new instrument is not yet known.

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.

By the end of 2007 about 3 MW has been installed in the context of various projects and demonstrations plants supported by various instruments. A 1 000 roof-top programme was launched late 2001; this programme targeted 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 1000, 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 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 2006 about 700 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 1000 programme was extended until end of 2006. The average system size in the project is for the private households 1,8 kWp. Since end of 2006 there are no longer any instruments in Denmark to bring down investment cost of PV systems in general, only the distribution utility EnergiMidt supports PV installations inside its concessionary area.

A special support programme for PV applications in the commercial sector, funded by the CO_2 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. The programme was not been very successful, as the commercial sector seem to regard an incentive of 40 % as inadequate.

Net-metering for privately owned PV systems was established mid 1998 for a pilot-period of four years. 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; however net-metering alone appears not on its own to be able to stimulate private PV installations.

RESEARCH & DEVELOPMENT, DEMONSTRATION

During 2003, the government has announced additional financial support to the new R&D programme started in 2002. Over a 5 year period more than 150 MDKK was allocated to renewables; however, as the focus of the programme is on university research activities, it is so far only to a limited extend PVs have benefited from the programme. In 2004, the government increased the PSO allocation for R&D into environmentally benign electricity generating technologies from 100 MDKK per year to 130 MDKK per year. Since then the government has pledged itself to increase the funding for R&D in new energy technologies up to 2010 and a few R&D PV projects have indeed benefited from support during 2007 with most of the funding going to basic R&D at universities.

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. Denmark has in the context of the PSO system in 2007 decided to enter the first

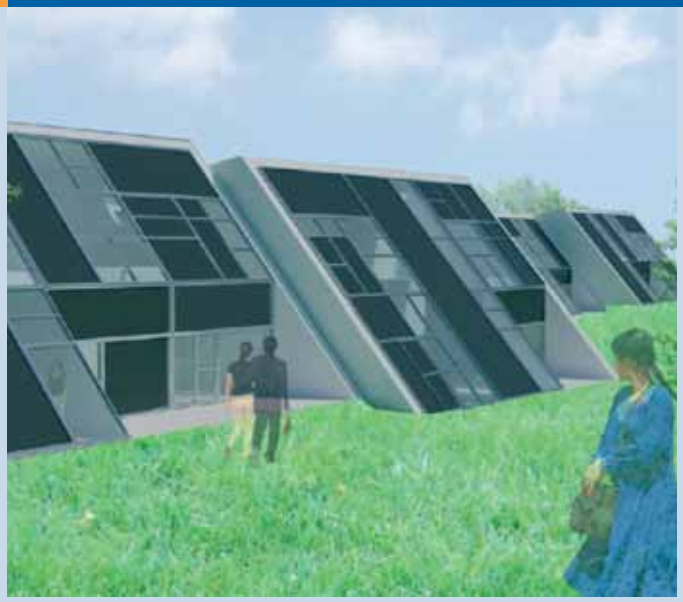

Fig. 3 - One of many ideas to make a house optimized for PV generated by students from Aarhus School of Architecture.

Fig. 4 - Different ways to integrate PV in a prefabricated building are demonstrated in the SOL-IND project, led by EnergiMidt.

Joint Call on PV R&D in the framework of the PV-ERA-NET, and is considering joining a second Joint Call now under preparation.

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 support has been granted from 2007 and onwards for continued R&D activities in this field. 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.

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 including certification of installers 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; in particular 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. Several more publications have followed and the Aarhus School of Architecture has included BIPV in its curriculum.

Municipal-based PV interest groups have been formed in two municipalities: Solar City Copenhagen and Solar City Horsen. These groups are quite active and more similar groups are expected.

IMPLEMENTATION

The potential for large scale deployment of PVs in Denmark has been identified as building integrated systems.
The SOL 1000 programme ran by the utility EnergiMidt, which as mentioned above intended to demonstrate low cost and architectural acceptable integration of PV technology primarily on existing single family houses, has by end of project ultimo 2006 implemented a bit more than 700 kW in total. There was a focus on the gradual increase of end-user payment, this way paving the way to a commercial market with no investment subsidy; the highest acceptable end-user payment appeared to correspond to a simple pay-back time for the owner of about 20 years. A third objective was 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 your self” PV plants were also introduced with a size of 250Wp, and since 2005 about 150 of these system have been sold and installed; a major weakness in this context is the requirement to use a professional electrician for the grid hook-up, which increases the cost of the system considerably.

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 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 success.

Also in Copenhagen the so called Valby Initiative has progressed. Valby is region of Copenhagen undergoing extension changes and refurbishment, and a PV initiative targeting about 300 MW has long been in preparation. The initiative has been integrated into actions in the EU Concerto Programme. The Carlsberg brewery in the centre of Copenhagen is moving out of town leaving a large area for new urban development. BIPV are reported to be strongly represented in this development.

INDUSTRY STATUS

R&D efforts are beginning to exhibit commercial results in terms of export. The company Topsil, which using 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. It was in 2004 seeing 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 break through was also announced in 2003 by the Danfoss related company Powerlynx, which reports in 2007 to have underpinned and significantly strengthened the commercial breakthrough announced in 2003. Powerlynx, which now employs more than 200 people, was fully acquired by Danfoss in 2007, and is now called Danfoss Solar Inverters.

PV Si cell production stopped in Denmark in 1996. A single Danish module manufacturer (Gaia Solar) with an annual capacity of about 0,5 MW per shift has existed since 1996. A few other companies producing tailor-made modules such as window-integrated PV cells can be found.

Some medium to large scale industrial corporations long established in the building industry 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 PV's 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 PV's entering the curricula. The objective of integrating PV's in industrialized building processes has been continued in 2007 via a new project.

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 2007 is very difficult to estimate with any degree of accuracy primo 2007 due to the commercial secrecy surrounding the above mentioned new business developments in the fields of Si feed stock and inverters. However, an increase from 40 MEUR in 2006 to 45 MEUR in 2007 is a "best guess" mostly due to exports.

The cumulative installed PV capacity in Denmark (including Greenland) is by end of 2007 estimated to about 3 MW; an increase of about 3 % compared to 2006.

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 and up-date a national PV strategy and consequent deployment schemes may succeed in creating a more coordinated and unified approach to PV in Denmark. 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. In 2007, the newly introduced EUPD programme, which focus on technology development and large scale demonstrations, does not specifically mention PV as a target technology, and the benefit of this programme to the PV sector is not yet clear.

It is regarded as obvious that without funding and clear public support to large scale demonstration of PVs for yet some years to come, the sector risks to go on diminishing 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 completed during 2007 indicates, that with the continued global technical and economic development of the PV technology, with now a 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 2014-15; given that the necessary demonstration activities can be continued in the period up to 2013. The source of funding for such a demonstration effort has still to be found, and the ongoing political energy negotiations exhibit some hope for the PV sector.

EUROPEAN COMMISSION

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

PIETRO MENNA, RESPONSIBLE FOR THE SOLAR ELECTRICITY SECTOR, EUROPEAN COMMISSION, DG ENERGY AND TRANSPORT
DAVID ANDERSON, SCIENTIFIC OFFICER, EUROPEAN COMMISSION, DG RESEARCH

POLICY

As a milestone in the creation of an Energy Policy for Europe, and a springboard for further action, in March 2007 the European Council adopted a comprehensive energy Action Plan [1], based on the Commission's Communication "An Energy Policy for Europe" [2]. Today, for the first time, the European Union has a genuine energy policy backed by commitments at the highest political level. The European Council adopted targets for 2020 that include achieving an increase of 20 % in energy efficiency, increasing renewable energy to 20 % of overall consumption and having 10 % of gasoline and diesel oil used for transport supplied from bio-fuels. For the first time ever, these renewable targets are binding and mandatory.

Concerns about global warming have been a strong motivation for this shift in policy – a further target set in March was a commitment to reduce greenhouse gas emission by 20 % relative to the 1990 levels by 2020, independent of international agreements. But the other motivation is the deepening concern about Europe's energy security, and a perception that energy technology has been an area of competitive advantage for the EU that requires accelerated investment and market stimulation if this leadership is to be preserved. This is why a key element in the package is the work to develop a European Strategic Energy Technology (SET) Plan, which has been adopted on 22 November 2007, for a more integrated and targeted approach to achieve the technological improvements required to meet our energy and associated environmental challenges over the longer term and strengthen the European leadership. The leitmotif of the SET-Plan is to turn technology opportunities into business realities that can deliver the policy targets. To achieve this, the energy research and innovation system in Europe must be transformed into a more powerful, efficient and competitive one.

In addition, an action plan for energy efficiency was adopted already in October 2006. Higher energy efficiency would contribute to tackling the challenge of decoupling energy consumption from economic growth. With regard to this point, the 2005 Green Paper on energy efficiency explains how it is feasible to reach 20 % energy savings by 2020 in a cost effective way [3] and a Framework Directive on renewable energy resources which is due to be published at the beginning of 2008 will propose a framework for national targets and national action plans to achieve the targets.

DEPLOYMENT

According to the provisional estimates published in 2007, the cumulated installed photovoltaic capacity in Europe had largely surpassed 3 000 MW by the end of the year 2006 [4]. This means that the White Paper target has been achieved four years ahead of time. Grid-connected applications represent by far the majority of all the installations.

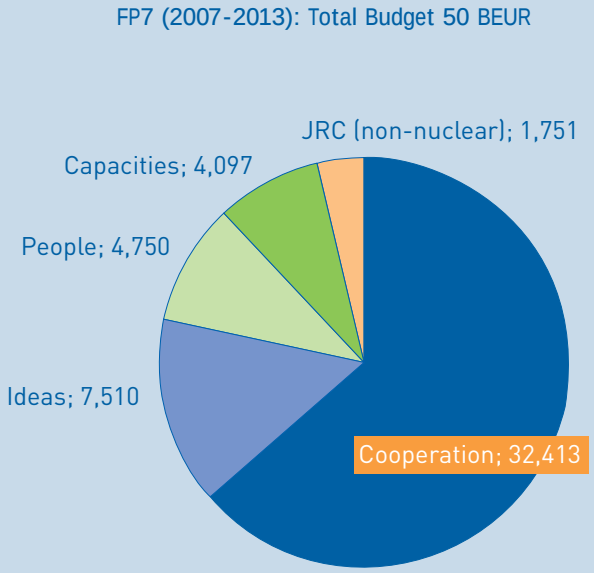

Fig. 1 - The broad objectives of FP7 have been grouped into four categories: Cooperation, Ideas, People and Capacities. For each type of objective, there is a specific programme corresponding to the main areas of EU research policy. The non-nuclear research activities of the Joint Research Centre (JRC) are grouped under a specific programme with individual budget allocation. Fusion, fission & JRC nuclear activities are covered in separate Euratom treaty for 2,7 BEUR.

Although care has to be exercised when comparing the different estimates of production, capacity and installation, it would appear that in 2006, Europe accounted for about 50 % of the global market, but European manufacturing represented only 30 % of global cell production [5]. Europe, therefore, remains a net importer of cells – a trend which may worsen if its production growth is less than that of global counterparts in the future years. In fact, the estimated production capacity increases for 2007 for Japan, Germany and China are 8 %, 37 % and 53% respectively [6].
The European market remains very heterogeneous. It is characterized by a largely dominant German market while that of the other European countries is still limited. According to BSW (the German Solar Industry Association), in 2006, the German PV industry had a turnover of 3,7 BEUR and employed 35 000 people, including manufacture, R&D, installation and distribution. It has been estimated that the employment figure for the whole EU ranges between 50 000 and 55 000. Because solar photovoltaics, like many of the renewable energy sources, is still relatively new to the market, there is a need for a targeted legislative and commercial infrastructure to encourage rapid market growth. At the same time, there is still a need for high profile demonstration and promotional activities to raise the confidence of investors. The Commission is therefore active in both these areas, with the clear purpose of increasing the share of renewable energy sources in the energy portfolios of the EU Member States.

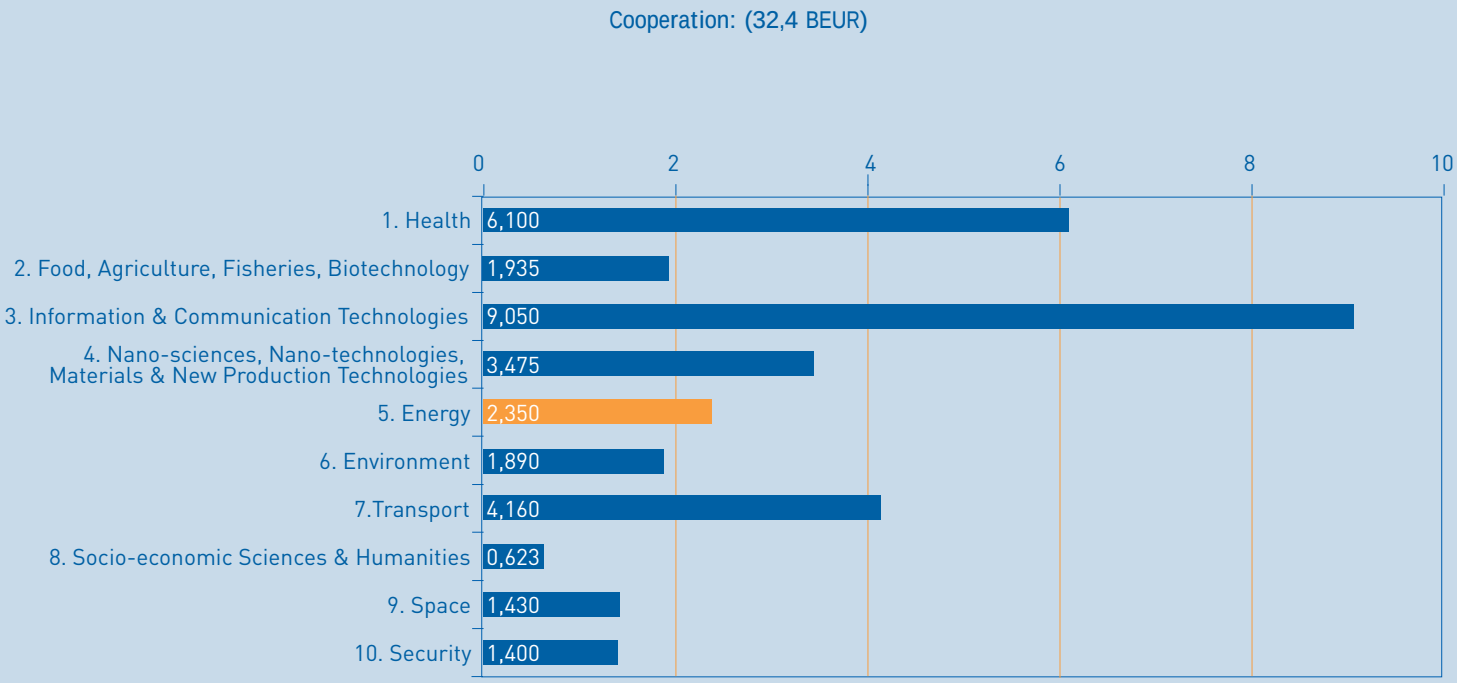

Fig. 2 - The specific programme on 'Cooperation' supports all types of research activities carried out by different research bodies in transnational cooperation and aims to gain or consolidate leadership in key scientific and technology areas. The Cooperation programme is sub-divided into ten distinct themes.

EUROPEAN PV TECHNOLOGY PLATFORM

The EU Photovoltaic Technology Platform is an initiative which aims at mobilising all the actors sharing a long-term European vision for photovoltaics; realising the European Strategic Research Agenda for PV for the next decade(s) and give recommendations for implementation; ensuring that Europe maintains industrial leadership. For further information, see http://www.eupvplatform.org.

The EU Photovoltaic Technology Platform is one of over 30 platforms which bring together researchers, industry and other stakeholders across Europe in key technological fields. For more info: http://cordis.europa.eu/technology-platforms.

In June 2007, the EU Photovoltaic Technology Platform published the finalised Strategic Research Agenda (SRA). The document sets out the short, medium and long-term R&D issues deemed necessary for continued cost-reduction of photovoltaic systems, with the aim of reaching grid-parity in the south of Europe by 2015. The SRA aims to serve as a common framework for decision makers at national and European level, in order to increase the coordination of research programmes throughout Europe.

RTD & DEMONSTRATION

The year 2007 also marked the first year of the new 7-year European Framework Programme for research, technological development and demonstration. Photovoltaics is supported mainly under the energy theme [7] – which is jointly implemented by the Directorates General for Research and for Energy & Transport. Two calls for proposals in the energy theme in 2007 led to seven successful proposals on photovoltaics being selected for contract negotiation. The selected projects address challenges ranging from near-to-market to longer-term technologies, namely ultra-thin silicon wafers & processing, improved production equipment, thin-film crystalline silicon on glass, heterojunctions (a-Si, c-Si), concentrator photovoltaics technologies, intermediate bandgap cells and dye-sensitised solar cells. Support for photovoltaics under the previous (sixth) Framework Programme has been reported previously [8].

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION (EPIA) MISSION AND ACTIVITIES
ELENI DESPOTOU, POLICY OFFICER
DANIEL FRAILE MONTORO, EPIA SCIENTIFIC OFFICER, POLICY DEPT
MARIE LATOUR, COMMUNICATION OFFICER

With over 150 Members drawn from across the entire solar electricity sector, the EPIA represents over 95 % of the European photovoltaic cells production and 80 % on the global scale. EPIA membership is spread along the whole value-chain of the photovoltaic industry from silicon producers, cells and module manufacturers to system providers.

EPIA 2006-2010 STRATEGY

The successful result of the 2003-2006 strategy lead to propose a new and more ambitious market oriented action plan for the years 2006-2010.

EPIA's Mission Statement

EPIA exists to deliver a distinct and valuable service driven by the strength of a single European photovoltaic voice.

Objective

Its objective is that 7 million Europeans may produce clean and sustainable solar electricity by 2010. This represents a global objective of 7 GWp global annual market and a European market of 3,6 GWp in 2010.

EPIA's CIPQ® Strategy

Four main pillars are driving EPIA activities to reach this objective:

- Competitiveness – The challenge for the industry is to reach competitiveness. Cost reduction can be only obtained with mass production and technological research.
- Innovation – Promoting research activities and stimulating technological transfer from laboratories to the industry with particular focus of financing the industry priorities through the European Framework programs for research and development (FP7).
- Quality – Standards, certification and performance of devises are of extreme importance for the PV products. The PV industry can demonstrate that can deliver quality products and having social responsibility too.
- Promotion –Improving EPIA's visibility to all relevant stakeholders by maintaining and reinforcing its credibility.

As part of its activities at European and Global level EPIA is member of the following organizations:

- EREC – European Renewable Energy Council
- CEFIC – European Chemical Industry Council
- EUFORES – European Forum for Renewable Energy Sources
- IEA-PVPS – International Energy Agency Photovoltaic Power System
- ARE – Alliance for Rural Electrification

EPIA Implication in the activities of the IEA-PVPS

In the year 2007 EPIA has participated in two IEA PVPS ExCo meetings:

- Athens (April 2007), represented by Eleni Despotou
- Ebeltoft, Denmark (October 2007), represented by Eleni Despotou

Fig. 1 - The Second PV MED Conference gathered stakeholders from the PV sector in the Mediterranean region.

EPIA's main task as member of the IEA-PVPS is to disseminate and promote the results of the different tasks, stimulate and initiate subjects of particular interest for the industry and in general terms bring the voice of the industry amongst the countries members.

Task 1: Exchange and Dissemination of Information on Photovoltaic Power Systems

EPIA was represented in both IEA-PVPS Task 1 Meetings in 2007. The meetings were held in Zacatecas, Mexico and Tokyo, Japan. During the meetings important developments concerning PV markets, data collection methodologies and data processing were discussed. This discussion proved to be very useful for all products of IEA-PVPS Task 1 (Trends Report, etc). Due to its competence in PV markets, the contribution of EPIA was appreciated. The constant information flow on national PV markets was also very useful for EPIA. During the meeting in Zacatecas, EPIA also presented at a national PV conference. Furthermore EPIA contributed to IEA-PVPS Task 1 Workshop with a presentation during PV-SEC in Milan.

Task 2: Performance, Reliability and Analysis of Photovoltaic Systems

In the last meeting of Task 2 in Erlenbach, on September 2007, EPIA represented by Daniel Fraile, committed to contribute to the follow-up activities of this task. The integrated project, "Performance," was presented there as it has complementary added value for the Task. EPIA will support the new Task, providing a reliable communication channel between industry and participants of the Task.

Fig. 2 – The European Parliament, Brussels: EPIA represents the European Photovoltaic Industry towards European and International Institutions.

Task 8: Very Large Scale Photovoltaic Power Generation Systems

During the 2nd PV Mediterranean Conference organized in Athens, 20th April 2007, EPIA held a workshop called, "Energy from the Desert," dedicated to present the work carried out under the Task 8. Over 150 people participated. Further information can be found here: www.pvmed.org

Task 10: Urban Scale Photovoltaic Applications

EPIA supported Task 10 by offering the opportunity to launch the 2nd Lisbon Ideas Challenge at an event organized by EPIA for the European PV Technology Platform on 2nd February 2007 in Brussels. This event, entitled "New Rising Era for Photovoltaic Integration in Buildings" took place in the frame of the Sustainable Energy Week. It was jointly organized with the European Construction Technology Platform. It gathered over 120 participants from all over Europe, targeting at architects, developers, installers, PV and the construction industry. The results of the competition were also presented on the occasion of the event, "Boosting Solar Electricity in Portugal," on 31st May 2007, in Lisbon.

Task 12: PV ENVIRONMENTAL HEALTH AND SAFETY (EH&S) ACTIVITIES

This new Task launched successfully in March 2007 in Brussels, and co-coordinated by EPIA and the Brookhaven laboratories has started its work during 2007 with important involvement from the PV industry. Activities in the field of PV component recycling and environmental life cycle assessments LCA are the main activities of this Task which counts representatives of several European countries and USA.

Experts meetings and a workshop have already been held during 2007 in order to develop Guidelines for a Common Approach in Life Cycle Inventory and Life Cycle Assessment for Photovoltaics.

Technical and cost feasibility of collection and recycling are being analyzed for both crystalline and thin-films technologies under the recently founded association PV CYCLE.

Fig. 3 - The EPIA Secretariat team (2007).

GENERAL SUPPORT TO THE IEA PVPS

Organization of the 29th IEA PVPS ExCo Meeting, Athens, Greece, 16-18 April 2007

As part of its general support to the activities of the IEA-PVPS, EPIA hosted the 29th IEA PVPS Executive Committee Meeting in Athens from 16 to 18 April 2007 prior to the 2nd PV MED conference. This meeting gave the opportunity to bring IEA PVPS closer to the Greek authorities and the possibility of Greece to become an official member is still open.

The Second PV MED gathered stakeholders of the PV sector from the Mediterranean and enabled discussion on the latest market trends.

Furthermore, Eleni Despotou chaired the Operating Agents meeting on 24th October 2007, at the 30th IEA PVPS Ex-Co meeting in Ebeltoft, Denmark.

FRANCE

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
ANDRÉ CLAVERIE AND FABRICE JUQUOIS
FRENCH AGENCY FOR ENVIRONMENT AND ENERGY MANAGEMENT (ADEME)

Fig. 1 – Cité de la voile Éric Tabarly, 19 kW (photo Tenesol).

GENERAL FRAMEWORK

In 2006, the French government has implemented measures to promote the use of solar photovoltaic (PV) energy systems:

- The feed-in tariffs for PV-generated electricity are set at 0,30 EUR the kWh for the traditional photovoltaic installations and 0,55 EUR the kWh when photovoltaic modules are integrated into the architecture of the buildings.
- The tax credit deductible from the private individuals' income is set at 50 % of the costs of the equipment with a ceiling at 8 000 EUR per fiscal home.

The measures designed for boosting the market are aimed at creating industrial dynamics and diversification of primary energy sources that have low greenhouse gas emissions.

In parallel, since 2005, the government has extended national sources for funding research and technological development (RTD) in the photovoltaic field. ADEME, the historic backer, is now sharing its research interventions with two other agencies: The National Research Agency (ANR) and the Agency for Industrial Innovation associated with OSEO Agency (Innovation in the SMEs).

2007 has seen two important initiatives. In October 2007, in his conclusion speech on the *"Grenelle de l'environnement"* – (a series of public meetings involving stakeholders from the environment field), the President of the Republic has stressed his willingness to promote the development of renewable energies. On its part, the European Commission has launched a fresh strategic plan covering the new energy technologies in March 2007. One of the objectives of the said plan is to achieve a contribution of 20 % of renewable energies to the energy package by 2020. This would represent a total operational photovoltaic power of 4 to 5 GW in France.

In order to implement its policy for market opening in conjunction with the regional councils, ADEME is sharing the investment subsidies and acting in some operations in cooperation with the structural funds of the European Commission. Some regional councils are very active, and they have implemented a policy involving calls for projects in the tertiary and collective construction industry while stressing architectural integration and energy performance in the buildings as well as the demonstrative aspect (Languedoc-Roussillon, Provence – Alpes – Côte d'Azur, Poitou-Charentes, etc.).

PHOTOVOLTAIC PROGRAMME

The French Agency for Environment and Energy Management (www.ademe.fr) is the public organization to which the French government has entrusted the implementation of the national policy on sustainable development in the four following fields: energy management, waste management, preservation of soils and air quality. The area of energy management includes energy efficiency and the use of renewable energy sources among which, solar photovoltaics. ADEME's policy is to promote initiatives involving energy efficiency and the use of solar energy in the construction industry.

The ADEME's *Photovoltaic Solar Electricity* programme includes five types of activities that call for different divisions and departments:

- Support in industrial R&D on the PV components and systems. Note that the funds are complementary to those provided by the National Research Agency (ANR) and by the OSEO/AII;
- Market stimulation (with the help of the regional delegations of ADEME and often in collaboration with the regional councils);
- Training of the electricians and project sponsors (professional training course) and training through research (doctorate grants);
- International collaborations forged with similar agencies for specific study projects;
- Dissemination of information (colloquia, publications of proceedings, technical guides, fact sheets for the general public, etc.).

These activities match the four tasks of ADEME as specified in the contract of objectives ADEME-STATE (2007-2010): Know, convince and mobilize, advise and help to realize.
ADEME is funding research and technological development projects undertaken by the industrialists from the photovoltaic industry

Fig. 2 – Examples of applications eligible for the feed-in tariff bonus.

in cooperation with the public laboratories. The aim is to reduce the manufacturing costs for the photovoltaic materials and components, to optimize the systems performance as well as their impact on the environment and to ensure the quality of the products and services.

The ANR (agence-nationale-recherche.fr) is responsible for providing support to the projects of fundamental and industrial research. Similarly to ADEME, ANR favours the public-private partnership and contributes to the transfer of the results of public research towards the industrial world.

The first two types of activities featured in ADEME's PV programme, R&D support and market stimulation, are described in the subsequent sections 3 to 6. The three other types of activities involve several actions that are detailed hereafter. ADEME is running a dozen of training sessions meant for the installers and those developing PV projects at the Sophia-Antipolis headquarters, in Lyon and the overseas departments (DOM). Some 150 professionals (engineering offices, owners, architects, financial people, entrepreneurs, etc.) benefited from such training sessions. ADEME also contributes to training given to young engineers through doctorate grants (closing date for the yearly applications: 31 March). A dozen doctoral students are currently participating in the research projects funded by ADEME or ANR in the public or private research laboratories.

ADEME is also involved in several types of cooperation projects with European and international partners. With the support of the European Commission, ADEME participates in the European network PV-ERA-NET (www.pv-era.net). This network pools together the heads of the R&D PV programmes from the Member and associated States with the objective of achieving enhanced coordination of their respective research efforts. ADEME also participates in the works of the European Photovoltaic Technology Platform (www.eupvplatform.org). The platform brings together all the players from European PV. It has published the PV strategic research agenda in May 2007. This document serves as a reference for ADEME's policy. ADEME is also participating actively in International Energy Agency Photovoltaic Power Systems Programme (IEA/AIE, www.iea-pvps.org) which involves direct or subcontracted participation in the working groups T1, T2, T9, T10 and T11. Regarding the International Standards, ADEME contributes together with its partners to the International Electrotechnical Commission (CEI/IEC, Technical committee 82, www.iec.ch) work. In the framework of the bilateral partnerships, ADEME provides support to some French-speaking African countries for the projects of decentralised rural electrification.

RESEARCH AND TECHNOLOGICAL DEVELOPMENT

For the research and technological development (RTD) projects, the public-private partnership is recommended by the funding agencies. The large public research organizations such as the CNRS and the CEA have forged close cooperation with the photovoltaic industry. In order to gather the research teams in solar energy in the same place, the CEA, the CNRS and the CSTB have pooled together their personnel by creating the research platform of the National Institute of Solar Energy (INES).

In 2007, the funding agencies ADEME and ANR have renewed their partnership to launch a call for PV RTD projects (photovoltaic solar programme). Nine research projects have been selected. In the frame of this call for projects, ADEME is funding a project concerning the silicon nitride deposition plasma process at atmospheric pressure, and the pre-normative studies on the connection of PV systems to the electricity grid. For its part, ANR is funding seven projects: layer deposition of crystalline silicon on glass substrate; type N multi-crystalline silicon wafers and cells; hybrid cells combining silicon nanowires and polymers; photonic structures; recrystallization of silicon layers; impurity segregation by electromagnetic mixing, and the seventh project: detection of the defects in a photovoltaic installation.

Altogether there are forty RTD projects, lasting three years, which are under way since 2005. These projects are described in other reports and databases. The developments of PV components specific to building applications are included in the programme called Prébat, jointly launched by ADEME and the ANR. In 2007, four PV projects were selected under this programme. The intervention budget allocated by ADEME and ANR for PV RTD amounts to approximately 10 MEUR a year since 2005.

A new initiative launched by the regional councils, has allowed reactivating the R&D, notably in the SMEs through the *Competitiveness Poles* in which the renewable energies hold a place. Photovoltaics is present in the projects of the *"Tenerrdis"* pole in Rhône-Alpes region, in *"Derbi"* in Languedoc-Roussillon region, and in *"Capenergies"* in Provence – Alpes – Côte d'Azur region. The funds are provided by the national funding agencies or the regional councils.

The electricity utility, Électricité de France (EDF), has been granted subsidies from ADEME and the ANR for research on the CIS processes and the development of International Standards (IEC 62257). The R&D division of EDF has created a joint research institute, the IRDEP jointly with the CNRS and the École de chimie de Paris. The national colloquium on photovoltaic research organized by

TABLE 1 – FEED-IN TARIFF FOR PHOTOVOLTAIC ELECTRICITY IN FRANCE

FEED-IN TARIFF	CONTINENTAL FRANCE	OVERSEAS DEPARTMENTS AND CORSICA
Basic Tariff	0,30 EUR/kWh	0,40 EUR/kWh
Building Integration Premium	0,25 EUR/kWh	0,15 EUR/kWh
Building integrated application	0,55 EUR/kWh	0,55 EUR/kWh

ADEME and the ANR with the participation of the INES was held in Aix-les-Bains on 20-22 March 2007. The colloquium was held as the same time as the Prébat programme meeting that brought together the researchers and industrialists from the energy and construction areas. Common sessions have allowed the two communities – professionals from the construction industry and photovoltaic specialists – to communicate on the concept of integration of the photovoltaic modules into the building. The CD-ROM that includes the proceedings of these two events is available upon request.

IMPLEMENTATION

The French government and ADEME consider that photovoltaics is a construction component that generates electricity.

Table 1 summarizes the feed-in tariffs for PV electricity that were in force as of the 10 July 2006. In continental France, these prices offer high premium to the integration of the photovoltaics modules into the built environment and should allow sustainable growth of the French market in this segment.

This choice of development for the French market in continental France should allow in the short term:

- Subtract from the investment costs in a photovoltaic generator, the cost of the construction component that it replaces, and therefore increase the profitability of this investment whilst reducing its ecological impact;
- Position industrialists and installers from the photovoltaic field on a more innovative sector that generates more added value;
- Enable a better and faster penetration of photovoltaics into the French landscape thanks to the improved aesthetics of the PV modules;
- Make the incorporation of PV modules into the construction industry commonplace in order to meet the logic of the buildings with positive energy and to be able to meet the objectives set in the "Factor 4" plan by 2050.

In the overseas departments, the financial incentive to building integration is lower. There are long periods of sunshine and the production costs of fossil fuel electricity are high. Photovoltaic electricity is therefore more economically competitive that in continental France. The priority in these departments is thus to implement important capacities for the generation of photovoltaic electricity as soon as possible.

In addition to the PV feed-in tariff, the finance act that came in force early 2006, has implemented a reimbursement covering 50 % of the costs of the materials (the installations costs are excluded) for the private individuals that are installing a photovoltaic system on the roof of their home. Some regional councils still allocate subsidies to private individuals in the form of buyback rates or direct grants.

Concerning the private or public operators which are not liable to taxation on income, the amount of the subsidies is granted on a case-by-case basis in the frame of call for projects. In this case, ADEME and the regional councils insist on three criteria to define the subsidies winner: the quality of the architectural integration of photovoltaics, the energy performance of the building and the demonstrative character vis-à-vis the general public (see Fig. 1).

The Ministry of Industry has issued a document showing the examples of applications integrated into a building. Figure 2 shows examples eligible for the building integration bonus. Given the potential for innovation in this industry, this document should not be considered as exhaustive and new examples can be incorporated in the future.

Two colloquia concerning photovoltaics were organized by ADEME in 2007. The first one, "Sustainable Construction with Photovoltaics" was held in Lyon on 15 February 2007 and brought together about 150 people. Approximately 500 people attended the second one entitled, "Solar Energy and Construction," organized over a three day period (5, 6 and 7 November 2007) at the Palais de la Bourse in Paris. This colloquium, common to solar photovoltaics and solar thermal was meant to attract the professionals from the construction industry (some 30 % of the attendees). It will be held again in 2008 under the name "Renewable Energies and Construction" with the introduction of biomass and heat pumps.

ADEME has published two brochures in 2007: "Guide de rédaction des cahiers de charges techniques (*Guide for writing the technical specifications*)" and "Photovoltaïque intégré au bâti (Building integrated photovoltaics", downloadable from www.ademe.fr) and has contributed to the new edition of the Guide Perseus (How to manage a private individual photovoltaic project).

INDUSTRY STATUS

The main industrial players develop, manufacture and put on the market all the components of the photovoltaics systems.

The company Photowatt International from Bourgoin-Jallieu (subsidiary of ATS) is specialised in the manufacturing of multi-crystalline silicon ingots, wafers, cells and modules. The annual production capacity stands at 60 MW. The company works on an ambitious project of RTD called RÉDUCOP (ADEME 2004/2008 funding). The project is aimed at the reduction of the production costs while increasing the PV cell/module conversion efficiency in cooperation with the research teams of the CEA and the CNRS. Photowatt is installing photovoltaics systems with the components that it has approved. In the field of BIPV modules, Photowatt is working on new products of its own conception or together with Imerys and Clipsol companies.

The company Emix is developing multicrystalline silicon ingots using a method of electromagnetic continuous casting in a cold crucible. Emix, based at La Souterraine, is leading a RTD project called TWIN (funded by ANR).

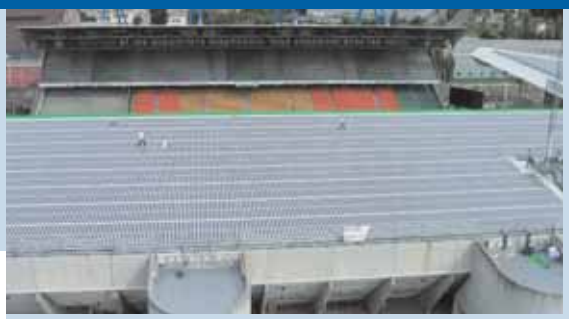

Fig. 3 – Saint-Etienne Stadium, 216 kW (solar steel; photo Arcelor/Tenesol).

The company Tenesol Technologies, a subsidiary of Tenesol, is manufacturing photovoltaic modules at Saint-Martin-du-Touch from crystalline silicon cells purchased outside of France. The production capacity is 17 MW per year. Tenesol's headquarters is based in the suburbs of Lyon and it is the first French company for the design and installation of the photovoltaics systems.

The companies Invensil/Ferropem and Apollon Solar have completed the construction of a manufacturing pilot of feedstock silicon (metallurgical route, annual capacity of 200 tonnes) in 2007. This project, called PHOTOSIL, in which CEA and CNRS are collaborating, has received funds from ADEME and the local communities. Based in Bourget-du-Lac, the pilot is located near the INES institute (National Institute of Solar Energy).

The consortium Silicium de Provence (SILPRO) has decided in 2007 to build a plant for the production of feedstock silicon (chemical route) in Saint-Auban in the Alpes-de-Haute-Provence, dedicated to the photovoltaic industry. The site has been chosen because of the presence of a plant producing chlorine for a chemical company undergoing restructuring. The plant will be commissioned in 2008 and has an annual capacity ranging from 2 000 to 3 000 tonnes.

Regarding thin film amorphous silicon technology, the industrial players Free Energy and Solems are continuing their production of photovoltaic modules and have not announced any new developments in 2007.

All the companies described above have involved industrialists who manufacture materials and equipment in their projects: Saint-Gobain, ECM, Vésuvius, Semco, etc., storage batteries of which SAFT or manufacturers of construction components: Imerys-Toiture, Lafarge Couverture, Sunland21, Kawneer Europe, Arcelor, etc.

Concerning the area of design and installation of photovoltaic systems, the companies Apex BPSolar and Tenesol are the pioneers of photovoltaics in France, but new companies have recently been created. For example, Solaire Direct, which installs and operates all size of systems from 3 kW dwelling to 4 MW ground mounted. The French electricity utility EDF, is active in material development and its subsidiary, EDF Énergies Nouvelles has recently extended its photovoltaic activities in Europe and has acquired interests in several companies.

MARKET DEVELOPMENT

The total power of the systems installed in France during the year 2007, is estimated at approximately 30 MW, i.e. tripling of the volume of the installations relative to the previous year. However, these data will have to be confirmed in coming months through investigations carried out by ADEME and the figures for the grid connection communicated by EDF.

According to a recent survey made by a private consultancy office and based on a questionnaire sent to the French installers, BIPV accounts for over 80 % of the market in continental France in 2007; primarily in the residential sector. Conversely, in the overseas departments (DOM) where the basic PV feed-in tariff is higher, the installations on large surface areas of roofing account for the majority of the market (building added-on applications). Several projects of PV power plants (between 1 MW and 15 MW) are being finalized in these departments. The operational photovoltaic capacity in France[1] was estimated at 73 MW, in late 2007. This accounts for an annual production of 70 GWh of electric power.

The regional councils have launched calls for exemplary projects based on 3 main criteria (architectural integration, energy performance of the building and demonstrative aspect). All these subsidy-winning installations account for approximately 4 MW.

A roof of 216 kW (see Figure 3) has been realized on the Geoffroy Guichard stadium in Saint-Étienne. This stadium has hosted the World Rugby Cup. The product used is an innovation developed through a RTD project partially funded by ADEME.

CONCLUSION AND OUTLOOK

There has been an important growth in the photovoltaic installations fuelled by the new feed-in tariffs and fiscal measures. A first estimation at the beginning of 2008 shows that during 2007, the volume of the installations has tripled relative to the previous year. Since it is becoming difficult to calculate this growth, ADEME and its partners such as the Renewable Energies Federation (SER) and EDF, are trying to rationalize the collection of information. The strategy of building integration of photovoltaics seems to pay off since new integration products have been commercialized and that over 80 % of the operations in continental France are building integrated.

Concerning the materials, the silicon sector is the most dynamic for its R&D projects as well as for the investments made in new production equipment. Among others, one should recall two new projects involving the manufacture of feedstock solar photovoltaic grade silicon.

The French government has announced its commitment to the environment and the development of renewable energies. The European Commission is also preparing an ambitious policy in this field. Such a favourable context may enable France to regain a place more in keeping with its historic involvement in the photovoltaic industry.

1 *France means continental France and Corsica and the four overseas departments: Guadeloupe, Martinique, Guyane and Réunion that are important users of photovoltaics.*

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY – STATUS AND PROSPECTS

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GENERAL FRAMEWORK

The support of renewable energies by the German Federal Government follows the general guiding principles for energy policy; namely security of supply, economic efficiency and environmental protection. Concerning climate protection, the aim is to ensure that all measures are affordable and keep pace with the economic development. For this reason, the German government adopted in December 2007 a package implementing an integrated energy and climate programme which comprises a number of proposals dealing with, for example, energy efficiency and renewable energies in the electricity and heat sectors, as well as transportation [1].

Moreover, the integrated energy and climate programme also promotes Germany as an industrial and investment location. Through improved efficiency and the use of renewable energies, a lower consumption of coal, oil and gas in the transport, heating, hot water and electricity sectors and thus a reduction of Germany's dependence on energy imports will be accomplished.

For the electricity sector, the Federal Government set a national target for renewable energies of 12,5 % by 2010 and 20 % by 2020. While in 2000, a share of 6,3 % for renewable energies was assessed; in 2006 already 11,5 % were reached [2]. For 2007 a share of around 14 % is expected which means exceeding the 2010 target already now.

Photovoltaic (PV) adds to this development. From the currently installed PV capacity one can estimate a share for PV of roughly 3 % of the renewable power generated in Germany. Driven by the Renewable Energy Sources Act (EEG), PV still shows an impressive development. Additionally, PV has become a real business with noticeable employment and turnover.

NATIONAL PROGRAMMES

In Germany, the Federal Ministry for the Environment, Nature, Conservation and Nuclear Safety (BMU) is responsible for renewable energies within the Federal Government. In 2007 Research and Development (R&D) was conducted under the 5th Programme on Energy Research and Energy Technology called “Innovation and New Energy Technologies” [3]. The main parts of this programme are administrated by the Project Management Organisation PtJ in Jülich. Aditionally, there are other sources for the support of PV R&D: The Federal Ministry of Education and Research (BMBF) is currently preparing a concept on basic research funding called “Energy 2020+” 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. This support scheme is now continued by a soft loan programme called “Solarstrom Erzeugen - Solar Power Generation” [4].

Fig. 1 - Different kinds of PV Systems in Germany (photos upper left: BSWSolar / Viessmann lower left: BSWSolar / S.A.G. Solarstrom AG upper right: BSWSolar / Sun Technics lower right: BSWSolar / Conergy)

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, see Figure 1.

RESEARCH AND DEVELOPMENT

Overview

The new 5th Energy Research Programme is designed to be valid for the period from 2006 to 2008. Under this programme an open call for tender was released in 2006. Concerning PV, the call addresses five focal points:

- Silicon feedstock and wafer technology, especially the production of solar silicon, reduced material consumption and the development of new cell and module concepts.
- Thin film technologies, especially transfer of concepts and processes into an industrial environment, optimisation of processes considering reduction of costs and investigation of degradation processes aiming for long term stable structures.
- System technology, especially for decentralised grid structures, adaptation to future module generations and standardisation of island systems for global applications.
- Alternative concepts which are both suitable for power applications and feasible for industrial production.
- Cross-cutting issues like enhancement of the lifetime of all system components, avoidance of materials which are harmful to the environment, reduction of energy usage in the production and recycling.

In order to provide these targets with concrete goals, a R&D roadmap was developed by representatives from industry and research institutes. The roadmap 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 [5].

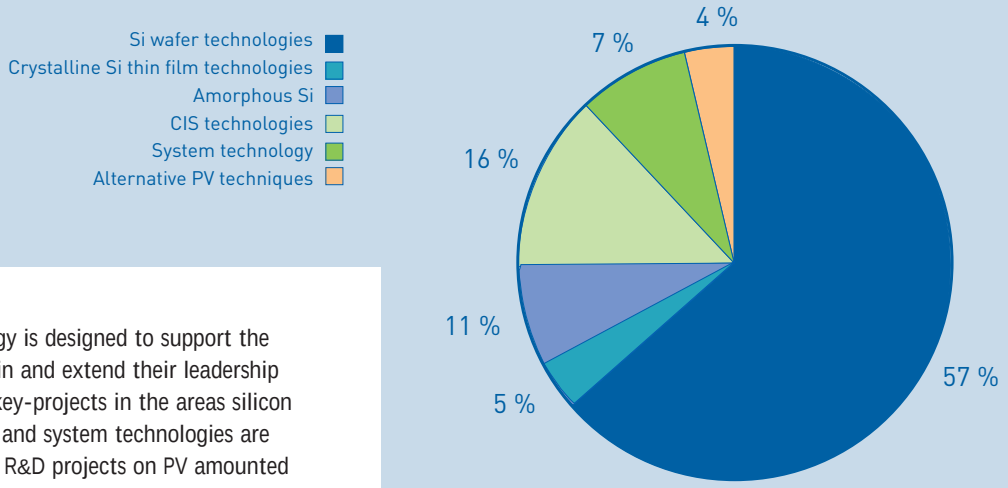

Fig. 2 - BMU funding of R&D in 2007 (organic and concentrating PV).*

In general, the federal PV R&D strategy is designed to support the German PV industry to reach, maintain and extend their leadership in all relevant disciplines. Therefore, key-projects in the areas silicon wafer technology, thin-film concepts and system technologies are funded. In 2007 the BMU support for R&D projects on PV amounted to about 32,1 MEUR shared by 140 projects in total. The distribution of the budget shows that one focal point still is on wafer based silicon technologies (57 % of the budget). The second centre of attention lies on thin-film technologies (32 %). The development of system technology (7 %) and alternative technologies like organic PV and concentrating PV (4 %) are funded as well, see fig. 2.

In addition to the BMU grants, the BMBF provides funds for the development of PV technologies as well; currently 5 network projects with 29 participants are supported with a total amount of 12,4 MEUR.

Funding Activities of the BMU

In accordance with the PV R&D strategy outlined above, 49 new grants were contracted by the BMU in 2007. The funding for these projects amounts to 41,7 MEUR in total (after 43,4 MEUR in 2006, 32,3 MEUR in 2005 and 29,5 MEUR in 2004).

In 2007 the highlights of R&D were as follows:

- The supply with Silicon is still an important topic for the PV industry. Two German companies, namely Wacker Chemie AG and Joint Solar Silicon, are currently developing alternative production methods for solar silicon. Both processes promise a more efficient manufacturing route and thus energetic and economic advantages.
- A co-operative research project between industry and research institutes aims for a minimisation of the kerf-loss of the wafering process. By reducing both the wafer thickness and the sawing gap to 100 µm a cost reduction of 20 % to 50 % is expected. The projects results will be transferred into production from 2012 on.
- Recent developments from the semiconductor industry will be applied to solar cell manufacturing processes in a project of the Fraunhofer ISE. Higher cell efficiencies are within reach when new concepts for light trapping and the conversion of photons into charge carriers are used.
- The focus of R&D on thin film technologies lays currently on silicon and CIS technologies. Especially the transfer of results from different laboratories to an industry relevant scale is funded. It is expected that in addition to the PV industry, the equipment manufacturers will benefit from these projects as well. Concerning amorphous / microcrystalline silicon films in 2007 a co-operative project on the improvement of TCO lavers (Transparent Conductive Oxides) was started. Four research institutes and five PV companies are participating. Additionally, four running activities in the field of CIS technologies address different production routes of different industrial partners.
- The next generations of PV inverters will not only allow a secure connection of PV systems to the grid but also offer additional items such as improvement of power quality and advanced supply security. The background of higher numbers of PV systems on the grid concepts dealing with fault ride through capabilities and cost of ownership receives higher weight. On the background of higher numbers of PV systems on the grid, concepts dealing with fault ride through capabilities and cost of ownership receive higher weight. The BMU funds a number of industrial projects dealing with these issues.

Funding Activities of the BMBF

In addition to the BMU grants, the BMBF provides funds for the development of PV technologies as well. In summer 2007, the BMBF launched two calls:

- A joint initiative of BMBF and industry is addressing the development of organic solar cells. From 2008 on, 360 MEUR will be available for this type of solar cells.
- Networks aiming for the development of thin-film solar cells are dealt with by the second call. Emphasis will be put on topics like material sciences including nanotechnology, new experimental or analytical methods and the usage of synergies with other fields of research, such as microelectronics or bionics.

In both cases decisions on funding will be taken early in 2008.

IMPLEMENTATION

Since 2004, Germany is the country with the highest annual PV installation world-wide. This remarkable development is based on the following measures in the area of market introduction:

The “Renewable Energy Sources Act (EEG)” rules the input and favourable payment of electricity from renewable energies by the utilities. In order to stimulate price reduction, the tariffs for new installed PV systems currently drop year to year by 5 %. Table 1 shows the development of the basic PV tariff. The rates are guaranteed for an operation period of 20 years.

TABLE 1 – DEVELOPMENT OF THE BASIC PV FEED-IN TARIFF OF THE EEG

	2003	2004	2005	2006	2007	2008
Tariff* (Ct/kWh)	46,0	57,4	54,5	51,8	49,2	46,75

** For rooftop- systems smaller than 30 kW; for bigger systems there are lower tariffs; façade integrated systems get a bonus of 5 Ct/kWh.*

For 2009, an amendment of the EEG is under discussion. Current plans foresee the introduction of another system class, namely rooftop systems bigger than 1 MW. The feed-in-tariff may be lowered in 2009 by 1 Ct/kWh generally and the depression rate may rise from 5 % to 7 %. The Federal Parliament will take a decision on the EEG in the first half of the 2008.

At the end of 2003, the "100 000 Rooftops Solar Electricity Programme" terminated. The support of PV systems by soft loans is maintained by the programme "Solar Power Generation" [4]. Under this programme in total 43 000 loans representing a total volume of 338,1 MW equivalents to 1 335 MEUR investments were granted since 2005. In 2007 alone, 101,3 MW were supported.

Other measures, such as 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 measures described above, the German PV industry experienced a period of strong growth over the last years. Despite the fact that some investments are delayed, the range of companies dealing with PV is expanding along the whole value chain. Especially the capacity of thin film production facilities is expected to grow significantly in the near future; taking advantage of the current global silicon supply shortage. The production figures given below are based on an analysis of the PV magazine "Photon" [6] and the initiative "Invest in Germany" [7].

Silicon Feedstock: Wacker, one of the world's largest suppliers of silicon for the semiconductor and PV industry, again enhanced its silicon production to 8 000 t in 2007. This is equal to a PV production of approximately 660 MW. An extension to 10 000 t until 2008 has already been decided on.

Along with Joint Solar Silicon, PV Silicon, Scheuten SolarWorld Silizium and Schmid Silicon Technology, additional producers will enter the market in 2008/9 introducing new ways for the production of solar silicon. In total, for 2008 a production of 11 750 t equal to almost 1 000 MW is expected.

Wafer Production: The total production of wafer amounted to 415 MW in 2007. The main supplier of silicon wafers is still Deutsche Solar AG in Freiberg. The company produced approximately 250 MW of mono- and multi crystalline wafers. 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 125 MW in 2007. Silicon ribbons are produced by Wacker Schott Solar (EFG-ribbon) in Alzenau and EverQ (String-ribbon) in Thalheim.

From 2008/9 on two other companies will start production; namely Conergy in Frankfurt (Oder) and Q-Cells in Thalheim. It is estimated that at the end of 2008, a total wafer production capacity of around 1 300 MW will be accomplished.

Solar Cell Production: The cell production in Germany shows a steady growth. Starting from 58 MW in 2002 the production achieved 700 MW in 2007. Currently, nine companies are engaged. These are Deutsche Cell in Freiberg, ErSol Solar Energy in Erfurt, EverQ and Q-Cells in Thalheim, Scheuten Solar in Gelsenkirchen, Schott Solar in Alzenau, Solarwatt Cells in Heilbronn, Solland Solar Cells in Aachen/Heerlen (NL) and Sunways in Konstanz and Arnstadt.

With Conergy and Arise Technologies Corp. (Bischofswerda), a Canadian based company, ready to start production in 2008, an increase in production capacities to 1 250 MW in 2008 seems possible.

The production of solar modules grew again. After assembling 40 MW in 2002, the output of modules reached 680 MW in 2007. Because of the ongoing strong demand for modules many manufacturers are aiming for further production extensions. The biggest module manufacturers are planning to end up with a production of around 1 000 MW in 2008 alone.

Thin-film Technologies: In addition to the silicon wafer activities, there is an increasing number of companies investing in thin-film production lines.

In 2007 there was a production of around 92 MW, namely of silicon technologies (6 MW from CSG Solar, Brilliant 234 and SCHOTT Solar), CIS (16 MW mainly from Odersun, Sulfurcell and Würth Solar) and CdTe (70 MW from First Solar and Calyxo). This is a remarkable increase of thin film production when compared to the activities in previous years which were on the level of 10 MW. For the coming years further growth is expected. For 2008, based on a production of more than 250 MW, it seems likely:

- CSG Solar is going to double its production capacity to 20 MW.
- Sontor (formely Brilliant 234), Ersol Solar Energy, Inventux Technologies, Malibu, Schott Solar, Signet Solar and Sunfilm AG announced to establish (additional) production capacities of amorphous / mircomorphous silicon modules until the end of 2008.
- Avancis (former Shell Solar), Global Solar Energy, Johanna Solar Technologies, Nanosolar Inc., Odersun, Sulfurcell Solartechnik and Würth Solar are going to invest in CIS technologies. Together, a production of around 50 MW could be possible during 2007.
- First Solar and Calyxo will increase the production of CdTe modules aiming for a production of 150 MW and 5 MW respectively.

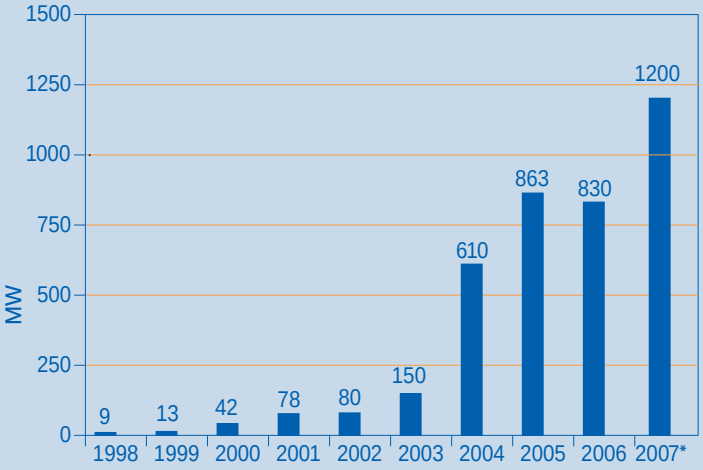

*Fig. 3 – Development of grid connected PV capacity in Germany after [2] and [6], * first estimate; as of January 2008.*

Besides the manufacturing of wafers, cells and modules, the production of inverter technology shows impressive growth rates and keeps pace with the market expansion.

In addition to the PV industry PV equipment manufacturers supply tools for every step of the PV value chain. The initiative "Invest in Germany" lists 44 companies covering the range from equipment for ingot/wafer production to module turnkey lines [7].

In Conclusion, the German PV industry is not only a fast growing industry but is also offering innovative products along the whole value chain. During the last years, equipment and production companies became the most experienced ones world-wide. More and more companies are entering into the business making PV to a real opportunity for employment and business in general: Today, around 10 000 companies employing 40 000 workers are producing a turnover of 5,5 billion Euros annually [8].

MARKET DEVELOPMENT

The programmes described above have accelerated the installation of grid-connected PV-systems in Germany significantly. The capacity installed in recent years is still a topic of discussion. The dilemma is based on the fact that the high number of installations makes it difficult to track each single system. The current data on the development of the German market since 1998 is shown in Figure 3.

For 2006 the statistics of the grid operators suggest an additional installed capacity of 830 MW, showing a temporary stagnation of the market. The cumulated installations amount to 2,7 GW at the end of 2006 [2, 6].

A first approximation for 2007 is based on a new capacity on the grid amounting to 1 200 MW resulting in a cumulated capacity of 3,9 GW at the end of the year.

In addition to the market of grid connected systems, there is a stable and steadily growing request for stand alone systems. First estimates indicate that in 2007 around 4 MW were installed mainly for industrial applications, such as the automotive sector, traffic signals etc.

FUTURE OUTLOOK

The temporary stagnation in the German PV market which was observed in 2006 was overcome in 2007. Further market growth seems to be possible in the next years.

The currently running amendment of the EEG will be completed in 2008. For PV one expects slightly lower feed-in tariffs and higher depression rates in order to stimulate additional price reductions.

The German PV industry intends to extend their production capacities further. From 2010 on, an increasing share of the turnover will be earned from export activities. In an environment of competition it is therefore important to offer high quality state of the art products. The current technical and economical status does not allow any standstill. Enhancement of production efficiency and at the same time lowered costs remain on the agenda. For that reason, high-level R&D together with sustainable market supporting mechanisms such as the EEG are still needed.

The current situation in Germany and in Europe, in general, feeds the conviction that PV will continue its way successfully.

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[1] *see "The Integrated Energy and Climate Programme of the German Government", http://www.erneuerbare-energien.de/inhalt/40589/36356/*

[2] *"Renewable energy sources in figures - national and international development", November 2007, http://www.erneuerbare-energien.de/inhalt/5996/*

[3] *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*

[4] *For information on the soft loan programme "Solar Power Generation" of KfW see http://www.kfw-foerderbank.de/EN_Home/Housing_Construction/SolarPower.jsp*

[5] *Christoph F. Hünnekes, Joachim Nick-Leptin - "THE GERMAN FEDERAL PV R&D PROGRAMME – STATUS AND OUTLOOK" in Proceedings of the 21st European Photovoltaic Solar Energy Conference, Dresden, September 2006*

[6] *Photon Magazine, December 2007, p. 44 ff and January 2008, p. 28 ff.*

[7] *Invest in Germany – Industry overview Photovoltaics, Winter 2007/8, see http://www.invest-in-germany.de/en/*

[8] *BSW Fact sheet "Statistische Zahlen der deutschen Solarwirtschaft", June 2007, and "Statistische Zahlen der deutschen Photovoltaikbranche", January 2008 see http://www.solarwirtschaft.de*

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 http://www.solarwirtschaft.de

ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE
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Fig. 1- Prototype dust-removing device Kinnor-2; one of the consequent stages of widening of the dust-free zone from the central to the peripheral region of a 400-mm wide PV panel (in the laboratory).

GENERAL FRAMEWORK

At present, 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.

About 1,3 MW of peak power has been installed so far; 275 kW were installed in 2006. Nearly all the applications are off-grid remote electrification systems (remote homes, agriculture, security and alarm systems, communications and exterior lighting). Most installations were justified on an economic basis, the PV system being the most economically viable alternative (because of the project's distance from the electric grid).

Things appear to be moving as a result of intensive Government activity during the last years:

- The Ministry of National Infrastructures has recently set a target of 10 % of electricity supply from renewable energy by 2020 (today just 0,1 % of the country's electricity supply comes from all sources of renewable energy).
- The Government will publish international tenders for a number of solar power plants in the Negev desert, up to a total of 250 MW, during 2008. It is expected that at least one of the tenders will mandate use of PV technology.
- The Public Utility Authority (PUA) plans to introduce tariffs for distributed PV systems in 2008. The tariff is expected to be about 0,52 USD/kWh. The total installed power will be limited to 50 MW over a period of seven years. The tariffs will be guaranteed for 20 years, and it is expected that they will influence strongly the local PV market. In 2006, the PUA published feed-in tariffs for solar power plants, ranging between 0,23 and 0,18 USD/kWh for systems between 100 kW and 100 MW. However no solar power systems have so far taken advantage of these tariffs, chiefly because of land acquisition problems.

There is a growing interest among the general public, as well as among investors, in clean and local energy sources. In view of the worldwide increase of energy prices and with the new measures planned, an increase in PV implementation is expected.

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 are 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 economic 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 are 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).

Fig. 2 - A pilot project in the city of Ariel, providing free wireless LAN (photo SolarPower).

Fig. 3 – 1,5 kW PV system at a large water control station (photo Interdan).

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

- 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 1 m-diameter concentrating dish and a high-efficiency CPV module. The heat can be provided at temperatures suitable for steam generation, cooling, space and water heating, and process heat.
- An innovative inverter topology developed at Ben-Gurion University of the Negev's Blaustein Institutes for Desert Research (BIDR) overcomes the main deficiencies of present day solutions: the hard switching operation and the problem of connecting a voltage source to the grid. The new approach is designed around a current source rather than a voltage source. This implies that connection of the inverter to the power line is inherently safe since the current source will automatically adjust itself to the voltage of the grid. Consequently, there is no need for extra monitoring, controlling, protecting and current shaping circuitry, improving thereby the reliability of the system. Another important feature of the invention is the soft-switched operation that is possible with the new power stage design. The soft switching operation reduces losses, enables economic utilization of the switching transistors and allows the increase of the switching frequency. Consequently, the size and weight of the inverter are reduced; the efficiency and reliability are increased while the cost is in fact reduced, due to better utilization of the components.
- Researchers from Ben-Gurion University of the Negev's Blaustein Institutes for Desert Research (BIDR) designed and participated in the development of the two generations of high-flux photovoltaic concentrating systems being produced, researched and commercialized by the SolFocus Corporation of San Jose, California. They were also co-inventors on the patents for the two concentrator generations (the first being air-filled, 31 cm in linear dimension, and the second being all-glass, 3,1 cm in linear dimension). These are currently 500-sun units (about 625X) with triple-junction ultra-efficient solar cells and completely passive cooling within miniature and ultra-miniature devices. SolFocus has recently announced the installation of the first solar array in the 3 MW Spanish CPV project.
- During 2006, Ben-Gurion University's BIDR embarked upon a 3-year project in collaboration with two German research institutes (Fraunhofer ISE and TUV), in which it will use its extreme desert conditions and unique AM 1,5 natural sky spectrum to quantify the rate of degradation of PV modules in the power rating range 150-200 W_p. This project is an extension of the EU 6th Framework PERFORMANCE project in which all three research institutes are also involved. In the project, module temperatures and relevant meteorological data are recorded at 5-minute intervals. In addition, I-V curves will be measured at noontime on clear days, at approximate intervals of one month throughout the 3-year test period.
- Another EU-funded project, HiConPV, in which BIDR was involved, finished at the end of 2006. Its giant solar dish PETAL achieved a world record by subjecting a 10 cm x 10 cm concentrator photovoltaic (CPV) "module" - i.e. the size of a conventional small solar cell - fabricated by partners at the Fraunhofer ISE, to a flux intensity of 1 000 X, and producing more than 1 500 W of electric power. This result helps raise the credibility of a thesis argued in the IEA Task 8 book "Energy from the Desert II - Practical Proposals for Very Large Scale Photovoltaic Systems," that CPV can provide cost-effective, country-scale solutions for electricity production throughout the Middle East and other sunrich regions.
- Cleaning of light-collecting surfaces constitutes a significant component of the O&M budget of a commercial solar power plant. The search for effective and economical cleaning methods, as an alternative to conventional washing with large amounts of de-ionized water, is an important direction in scientific program of the BIDR. The investigation into the possible application of an electric field to the surface has led to creation of a number of prototypes. Testing of one of them (Kinnor-2) in the spring of 2007, under various meteorological conditions, including severe dust storms, confirmed its high cleaning efficiency, which is typically higher than 90% (Figure 1). This research continues now in several directions; one of them started in late 2007, in collaboration with the Fraunhofer ISE.
- The Solar Energy Laboratory of the Jerusalem College of Technology (JCT), Jerusalem, is pursuing the development of Si solar cell fabrication technology based on the combination of thermal and ion implantation processes. Solar cells under

Fig. 4 - 520 W tracking system (photo SolarPower).

Fig. 5 - Home system at Drijat (photo Beit-Hazavdi).

development are thin, have improved optical properties and are suitable for use as bifacial PV converters. High conversion efficiency and decreased fabrication costs are the goals of the JCT activity. Another area of the JCT Solar Energy Laboratory activity is the development of a low cost anti-reflective (AR) glass coating for PV modules. The AR layer deposited by dip-coating provides more than 3 % relative improvement of module energy generation. The coated glass samples are undergoing special tempering treatment for improved resistance to environmental conditions. This program is progressing with an industrial partner.

DEMONSTRATION AND APPLICATION

The higher fuel prices have caused increased installation of off-grid systems, replacing diesel generators (Figure 2). PV in water supply and irrigation control are widespread applications (Figure 3). In addition, there is growing interest in grid-connected applications, including tracking systems (Figure 4).

A large PV project, aimed at electrifying an Arab 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 had been 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 5) 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.

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

It is expected that the Government activity described above (solar power plant tenders and tariffs for distributed PV) 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 75 000 USD in 2006; however, additional funding is available in this area from other research foundations.
- Partial funding of innovative demonstration projects.

ITALY

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

GENERAL FRAMEWORK

Although in Italy during 2007 a doubling of the total installed capacity up to the end of the previous year has been recorded, this result has not been adequate to the very high public demand and to the real availability of prosperous feed-in tariffs of the "conto energia" Programme first phase, nor to the ambitiuos target of the last feed-in decree. The licence trade effect that has negatively characterized the first phase of the programme, some bureaucratic issues related to installation permission as well as a tariff reduction for large free standing plants introduced by the last decree, seems to be the main causes of the present Italian context.

NATIONAL PROGRAMME

The Italian feed-in programme has been deployed through three governmental decrees. The first two, emanated in July 2005 and in February 2006, have defined the criteria for promoting the production of electricity from photovoltaics, providing a strong expectation in the Italian PV market. The support scheme foreseen by these decrees was composed by a feed-in tariff for the whole electric energy produced by the PV plant (ranging from 0,445 EUR/kWh to 0,490 EUR/kWh depending on plant size), and by the value of the electricity which can be partially or totally sold to the local electric Utility.

In the framework of these two decrees, projects for a total power of about 388 MWp have been positively evaluated, but only a small fraction of the admitted projects (corresponding to about 50 MWp) has been effectively realised and put in operation by the end of 2007 while a total power of about 200 MWp (only 1/2 of the admitted projects) is expected to be installed within 2008. The reasons that have strongly limited the realization of the approved projects can be essentially ascribed to administrative barriers, problems or delays with the Utilities for the connection of plants to the grid and, above all, to the so called "licence trade" effect consisting of the admissions to benefit feed-in tariff.

In order to overcome such obstacles, in February 2007 a new edition of the feed-in decree was established:

- an increase of the national objective from 1 GW to 3 GW by 2016;
- an increase of the supported capacity from 500 MW to 1 200 MW to which must be added the power of plants that will be built within 14 months after the supported capacity has been reached;
- the elimination of the annual limit (85 MW) and of the plant upper size limit (1 MW);
- simplified procedure: applications for admission to feed in tariffs must be submitted only after the start of plant operation;
- no permission necessary for plant installation, at least in areas without environmental constrains;
- Utilities compelled to pay penalties for delays in regard to grid connection of PV systems.

Fig. 1 – Italian Feed-in Programme: 40 kW PV plant in Narni, Terni (photo GSE).

The new tariffs result increased in values, if compared with the previous decrees; accordingly the PV integration in buildings (up to 49 cEUR/kWh), higher for small size plants and reduced for large plants (especially free standing 36 cEUR/kWh). Tariffs remain valid for a period of 20 years at constant remuneration and decreased by 2 % each calendar year, for applications submitted after 2007.

A further novelty regards the energy efficiency in buildings: in these cases tariffs are increased up to 30 %, depending on the energy saving level achieved. Finally, a 5 % tariff increase is instead allowed to self-producers, public schools and hospitals, small Municipalities or in case of asbestos roofs substitution. In the framework of this last decree, since May 2007, about 2 000 plants have been put in operation, corresponding to a total power of 10 MW.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Research, development and demonstration activities on photovoltaic devices and systems are mainly conducted by ENEA (the Italian Agency for New Technology, Energy and the Environment), CESI RICERCA (a research company owned by ENEA and CESI, the Institute for Research and Certification of Electric Components and Systems), some Universities, CNR (the National Council for Scientific Research) and private Laboratories.
As far as ENEA activities, the most significant ones concern the setup and optimization of fabrication processes of several kinds of innovative cells through laser assisted processes, buried contact, selective emitter technology and advanced screen-printing. Other important activities concern the optimisation of high efficiency crystalline silicon cells (EU Project), the development of thin film cells for BIPV as well as Cu2O solar cells research. As far as thin

Fig. 2 – Italian Feed-in Programme: 50 kW PV plant in Brentonico, Trento (photo GSE).

films, microcrystalline Si devices are still a main line of activity with the aim of improving the stabilized efficiency of integrated large area modules. Last, but not least, ENEA is working on the PhoCUS (Photovoltaic Concentrators to Utility Scale) Project, aimed at investigating concentrators technologies and to assess the technical and economical feasibility of this application.

In the field of photovoltaics, CESI RICERCA is carrying out activities in the development of concentrating system (CPV) based on III-V compounds solar cells. In this frame, CESI RICERCA is supporting ENEL (the Italian main Electric Utility) in a pre-feasibility study for the realisation of a concentration photovoltaic power plant to be installed in the south of Italy. Moreover, CESI RICERCA is involved with ENEA in a Photovoltaic National Platform (Fotoenergia Project), supported by MIUR (the Italian Minister for University and Research), for the development of photovoltaic devices to be transferred to the industry. CESI RICERCA has just concluded the negotiation phase of a large integrated project with the European Commission, which concerns the development of "point focus" and "dense array" solar concentrating systems (known as the Apollon project).

Industrial manufacturing of high efficiency solar cells both for space and terrestrial applications is carried out by CESI, while CPower is manufacturing CPV system based on silicon cells and it is developing CPV systems based on solar radiation splitting, supported by Ferrara University.

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

IMPLEMENTATION OF SYSTEMS

At the end of 2007, a total capacity of about 100 MWp was installed and operating in Italy. Taking into account that during this year about 50 MWp have been installed, the growth recorded has been about 100 %.

This increase has been driven by the support mechanism of on-grid distributed systems markets, that now account for about 75 % of the total photovoltaic installed. In particular, four significant sectors of PV power system applications can be identified in Italy:

- 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 (25 MW), installed at the beginning of 1990's and expected to be increased due to the feed-in tariffs;
- on-grid distributed systems, growing to over 63 MWp over the last years and dominating Italy's cumulative installed photovoltaic power.

INDUSTRY STATUS

At present, four producers of cells and modules and some companies assembling finished PV products can be identified in Italy. The two historical producers of cells and modules are Enipower (formerly Enitecnologie), owned by ENI Italian oil company and Helios Technology (Kerself group). Their manufacturing facilities have a production capability of about 10 MWp/year each.

Both single-crystalline and multi-crystalline silicon cells are currently produced from wafers imported from the international market. Two other emerging producers of cells are now operating: namely Ominia Solar and Xgroup; both strongly determined to expand their production facilities in the next years.

Further companies assembling and encapsulating standard or tailor-made and especially designed modules can be found in Italy. During last year, the module production capacity of such companies totalled to be about 45 MWp per year.

Furthermore, a new initiative has been announced regarding the production of multi-crystalline silicon. The line will produce about 250 t/year and will be powered by means of green electricity. As far as thin films, the Ministry of Environment has promoted a project aimed at developing a pilot plant for CdTe modules fabrication with a production capacity of about 18 MW/year. On the whole, counting on a market growth of about 150 MW/year, Italian firms are planning to extend their capacities up to 200 MW/year while foreign companies are establishing on-site settlements.

FUTURE OUTLOOK

Photovoltaic is becoming more and more important in Italy as also proved by a government call for ideas, launched last year in order to contribute to the definition of the future strategic lines for the development of the Italian productive system in the field of renewables and energy saving. The financial support of innovative industrial projects is foreseen, with the aim to increase the competitiveness of Italian industry and create new enterprises and employment. Within the more than 1 000 submitted ideas, PV technology has been one of the most considered; with 125 proposals and an increase in research activities is expected.

Moreover, with the new feed-in decree, the largest obstacles for the growing market seem to have been overcome and the tariffs introduced seem to be adequate for small plants, as well as for large plants, but only in the sunny southern region of Italy.

In this contest, Counting on a growth up to 50 MW in 2007 and of about 150 MW in the following years Italian firms are planning to extend their capacities in the next years up to 200 MW/year; while foreign companies are establishing on-site settlements.

JAPAN

PV TECHNOLOGY AND PROSPECTS

KOJI MATSUBARA, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)
OSAMU IKKI, RTS CORPORATION

Fig. 1 – Mitsubishi Heavy Industries (MHI) Nagasaki Research and Development Center, 20 kW, Nagasaki City, Nagasaki Prefecture (photo RTS Corporation).

GENERAL FRAMEWORK

Japan's policy and measures on energy including PV power generation is based on the Basic Act on Energy Policy (Energy Policy Law) enforced in 2002, that stipulates 3 principles; securing a stable supply, environmental suitability and utilization of market mechanisms. Promotion of use of solar energy is listed in the "environmental suitability". In addition, the Basic Energy Plan was established in order to materialize these basic directions of the energy policy. Dissemination of PV Systems is defined in the "New Energy Innovation Plan" under "New National Energy Strategy" that is the foundation of Japan's energy strategy, laid out in 2006.

The "New National Energy Strategy" was established based on the basic recognition of the current status of energy, such as structural change in energy demand and supply. Numerical targets to be achieved by 2030 were set for achieving the "Establishment of energy security measures that people can trust and rely on the "Establishment of the foundation for sustainable development through a comprehensive approach for energy issues and environmental issues all together," and "Commitment to assist Asian and world nations in addressing energy problems." Specific activities are comprised of the four items:

1) Realizing the state-of-the art energy supply-demand structure,
2) Comprehensive strengthening of resource diplomacy and energy and environment cooperation,
3) Enhancement of emergency response measures and
4) Common challenges. New Energy is considered as one of the four major pillars of the structure in the "Realizing the state-of-the art energy supply-demand structure;" significantly contributing to the New Energy Innovation Plan.

The New Energy Innovation Plan clearly specifies the targets for year 2030 based on the following concepts:

1) "Specify renewable energy sources which particularly need to be promoted, such as PV, wind power and biomass, and give them strong support,"
2) "Development and enhancement of use of innovative technology for high-level utilization of energy,"
3) "Promotion of "demand" and "supply" expansion measures in response to dissemination stages,"
4) "To broaden thickness of industrial structure of new energy, etc. and improve economic efficiency of the entire new energy industry." As for the PV Systems, it is targeted to reduce the PV power generation cost to the level of thermal power generation by 2030. Promotional measures for the expansion of "demand" and "supply" through implementation support measures such as subsidies and taxation systems by stages of growth will continue. Also targeted is the creation of a group of PV-related industries.

Toward the dissemination of new energy, the "New Energy Law," established in 1997, defines the responsibility of the government and local authorities, energy consumers, energy suppliers and manufacturers of energy equipment. In addition, "Special Measures Law Concerning the Use of New Energy by Electric Utilities, the Renewables Portfolio Standard (RPS) Law" established in 2002, obliges energy suppliers to use a certain amount of electricity generated from new and renewable energy sources. The obligatory usage amount of new and renewable energy has been increased every year.

For technological development of PV Systems, technological targets for solar cell and PV Systems from the long-term perspective towards

Fig. 2 - Matsumoto Station, 30 kW, Matsumoto City, Nagano Prefecture (photo: RTS Corporation).

2030 were established based on "PV Roadmap toward 2030 (PV2030)", a roadmap for technological development of PV Systems established in 2004.
Moreover, utilization and introduction of new and renewable energy are implemented as one of the measures to reduce greenhouse gas emissions toward 2010 under the "Kyoto Protocol Target Achievement Plan" endorsed by the cabinet in 2005.

NATIONAL PROGRAM

Government has implemented research and development (R&D), demonstrative research, model projects and dissemination measures toward further deployment of PV Systems, mainly through the efforts of the Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment (MoE).
METI has been promoting the technological development of PV Systems for cost reduction and acceleration of introduction. As for demonstrative researches, the Field Test Project on New Photovoltaic Power Generation Technology under the Field Test Project on New Energy Technology and Verification of Grid Stabilization with Large-scale PV Power Generation Systems have been conducted to demonstrate the effectiveness of PV systems employing novel PV modules, new components, advanced system technology and newly developed installation methods, etc. and enlarge the application area of PV systems. Projects for promoting the introduction of PV Systems are implemented to support local governments and private businesses.

MoE continuously promotes projects for the introduction of new energy and technological development to support local governments and private enterprises through establishing business model projects in local areas utilizing PV power generation technologies as model projects of countermeasures against global warming.
The budgets for major national PV programs implemented in FY2007 are as follows;

1 New Energy Technology Development: 4 580 MJPY
2) Field Test Project on New Photovoltaic Power Generation Technology: 10 800 MJPY
3) Verification of Grid Stabilization with Large-scale PV Power Generation Systems: 3 500 MJPY
4) Project for Supporting New Energy Operators: 31 600 MJPY
5) Project for Promoting the Local Introduction of New Energy: 4 500 MJPY
6) Project for Establishing New Energy/Energy Conservation Visions at the Local Level: 1 300 MJPY
7) Project for Promotion of Non-profit Activities on New Energy: 70 MJPY
8) Demonstrative Project of Regional Power Grids with Various New Energies: 500 MJPY
9) Model Project of Promotion of PV Power Generation for Global Warming Countermeasures (Solar Promotion Program): 4 800 MJPY
10) Project for Developing Technology to Prevent Global Warming: 3 300 MJPY

The budgets for items 1), 4), 5), 6), 7), 8), 9) and 10) include ones for PV and other new and renewable energy.

R, D & D

R&D

Two Projects started in FY2006 under "4-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY2006 - FY2009)" have been continued in 2007; 1) R&D for Next Generation PV systems and 2) Development of PV Systems Technology for Mass Deployment, Phase II. Interim assessment of these projects will be conducted in the end of FY2007. In addition, Technological development of each issue has also been continued under PV Systems Advanced Practical Technology following FY2006.

1. R&D for Next Generation PV Systems

This project aims at establishing elemental technologies to achieve the target PV power generation cost set in PV2030: 14 JPY/kWh in 2020, 7 JPY/kWh in 2030. Based on the outcome of the "Development of Advanced Solar Cells and Modules" in the previous term (FY2001 - FY2005), technological development of 5 types of solar cells as elemental technologies of next generation photovoltaics have been conducted aiming at higher conversion efficiency, further cost reduction and improvement of durability. Types of solar cells include thin-film CIS solar cells, thin-film silicon solar cells, dye-sensitized solar cells (DSCs), next-generation ultra-thin crystalline silicon solar cells and organic thin-film solar cells. In parallel with these topics, fundamental research projects to develop ultra-high efficiency solar cells using quantum dot nanostructure and other technologies have been underway.

2. Development of PV Systems Technology for Mass Deployment, Phase II

This project is a successor of Development of PV Systems Technology for Mass Deployment in the previous term, aiming at developing

technological infrastructure for supporting extensive utilization and mass deployment of PV Systems. Under this project, research studies to develop evaluation technologies for performance and reliability of PV cell/ module and evaluation technologies of electricity output from PV Systems were continued. In addition, as environmental technologies for manufacturing processes of PV Systems and disposal of used PV modules, studies on life cycle assessment (LCA) and development of recycle technology of solar cell were also continued.

3. PV systems Advanced Practical Technology

This project aims at developing industrial technology to accelerate practical application of outcomes of preceding technological developments. In FY2007, the following technological developments were continued: recycling technology of silicon feedstock for solar cell, manufacturing technology of spherical silicon solar cell, high-performance inverter, demonstration of autonomous PV Systems technology, etc. FY2007 is the final year for this project so that new proposals were not solicited.

DEMONSTRATION

7 major demonstration programs were implemented in FY2007:

1) Field Test Project on New Photovoltaic Power Generation Technology,
2) Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems,
3) Demonstrative Project of Regional Power Grids with Various New Energies,
4) Verification of Grid Stabilization with Large-scale PV Power Generation Systems,
5) Development of an Electric Energy Storage System for Grid-Connection with New Energy Resources,
6) International Cooperative Demonstration Projects for Stabilized and Advanced Grid-connection PV Systems and
7) International Cooperative Demonstration Projects Utilizing Photovoltaic Power Generation System

1. Field Test Project on New Photovoltaic Power Generation Technology

Since FY2007, "Field Test Project on New Photovoltaic Power Generation Technology" has been implemented under the New Energy Technology Field Test Project. This program aims at leading dissemination of medium-scale PV systems by installation of PV systems employing advanced technologies on a trial basis and promoting further improvement of performance and cost reduction of those PV systems. This program is positioned as a successor of Field Test Project on Photovoltaic Power Generation Systems for Industrial and Other Applications. Under the program, the following 4 model technologies are defined:

1) PV Systems with new modules,
2) PV Systems with building material integrated modules,
3) PV Systems with new control systems and
4) PV Systems aiming at higher efficiency. Introduction of PV systems for public facilities and industrial uses are promoted under this program. 262 projects were selected and PV systems totaling 7 161 kW were installed in FY2004. In FY2005, as METI enhanced this application area as a prioritized area for PV power dissemination, the number of the selected projects significantly increased to 457; totaling 17 709 kW. In FY2006, 675 projects, totaling 19 454 kW were selected. In FY2007, 374 projects, totaling 21,058 kW were selected. Cumulative installed capacity of field tests conducted from FY1992 - to FY2007 is expected to exceed 90 000 kW.

2. 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 of a large-scale and intensive introduction of on-grid PV systems. The program aims at establishing grid connection technologies for grid-connected PV systems intensively installed to one area, seeking establishment of environment for mass deployment of PV systems. The specific research objectives are 1) development of technology to avoid restriction of PV Systems output by using storage batteries, 2) analysis and evaluation of higher harmonics, 3) analysis and evaluation of existing devices for mis-actuation function to prevent islanding operation as well as development and evaluation of novel devices to detect islanding, 4) development of applied simulations and 5) evaluation of characteristics of power generation and economical efficiency. Installation of 553 residential PV systems totaling 2,129 kW was completed by the beginning of FY2006. In FY2007, operation test of output control, evaluation of new devices for mis-actuation function to prevent islanding operation and so on have been continued and final reports have been compiled. This project is scheduled to be completed in FY2007.

3. 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, wind power systems and fuel cells, etc. in one area, aiming at demonstrating various issues such as ensuring quality of electricity, balance between supply and demand of electricity, stability and economical performance of distributed power sources. In FY2003, 3 demonstrative sites were selected across the country: Aichi Prefecture (total 2 225 kW of distributed power generation systems including PV systems totaling 330 kW), Aomori Prefecture (total 714 kW of distributed power generation systems including PV systems totaling 130 kW and Kyoto Prefecture (total 850 kW of distributed power generation systems including a 50-kW PV system). Demonstrative operation of the power generation systems was started in FY2005. The power generation systems installed on the premises of the 2005 World

Exposition (EXPO 2005), Aichi, Japan, were relocated to Central Japan Airport City in Tokoname City of Aichi Prefecture and the demonstrative research was resumed from August 2006. This project is scheduled to be completed in FY2007.

4. Verification of Grid Stabilization with Large-scale PV Power Generation Systems

This demonstrative research aims at establishing a system to stabilize power output of MW-scale PV systems without giving negative impact on the quality of grid electricity and validating its effectiveness and usefulness. In addition to these objects, the final goal of this research is the development of technologies to make the business using future MW-scale PV plants feasible. A 5-MW scale project in Wakkanai City of Hokkaido Prefecture and a 2-MW scale project in Hokuto City of Yamanashi Prefecture were selected and construction was launched in both sites. By the end of FY2007, 2 MW part of the 5-MW PV plant in Wakkanai City and 0,6 MW part of the 2-MW PV plant in Hokuto City will start operation.

5. Development of an Electric Energy Storage System for Grid-Connection with New Energy Resources

This project is a 5-year project between FY2006 and FY2010 on development of electricity storage technologies with the aim of minimizing output fluctuation of power generation using new energy. Technological development covers 4 issues as follows:

1) development of technologies for practical application,
2) development of elemental technologies,
3) development of next-generation technologies and
4) research of common fundamental technologies. Under these themes, development of large-capacity lithium ion battery and nickel hydride battery has been conducted.

6. International Cooperative Demonstration Projects for Stabilized and Advanced Grid-connection PV Systems

This program is an international program of demonstration and technological development using PV power generation, aiming at stable electricity supply by mainly constructing micro-grid with higher share of capacity of the PV Systems within entire capacity. Collaborative projects on demonstration and technological development has been conducted in China, Thailand, Indonesia, Malaysia, etc.

7. International Cooperative Demonstration Projects Utilizing Photovoltaic Power Generation Systems

This is an international program of demonstration and technological development using PV power generation. Under this program, cooperative demonstrative research project is underway in China mainly aiming at improvement of reliability of the PV Systems and other issues through cooperation with developing countries whose natural conditions and distinctive social systems are rarely seen in Japan.

IMPLEMENTATION

The Ministry of Economy, Trade and Industry (METI)

1. Residential PV Systems Dissemination Program

"Residential PV Systems Monitor Program" initiated in FY1994 was renamed "Residential PV Systems Dissemination Program" in FY1997 to develop the initial market of residential PV Systems. The program was terminated in FY2005. The subsidy amount was 20 000 JPY/kW and 36 754 residential PV systems, totaling 136,3 MW were installed in FY2005. During the 12 years (FY1994 to FY2005), the total number of PV systems installed under this support measure reached 253 754, totaling 931 575 kW in total. The program highly contributed to the creation of the initial market of residential PV Systems in Japan.

2. Project for Promoting the Local Introduction of New Energy

This program aims at accelerating the introduction of new and renewable energy in local areas by supporting projects for installation of facilities as well as projects for awareness towards dissemination, which are implemented based on plans for introduction of new and renewable energy in areas designated by local government and nonprofit private institutions. Subsidy is provided for facilities 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 cell, biomass, utilization of snow and ice and clean energy vehicles. In FY2007, subsidy for waste power generation, use of waste thermal energy and production of wastes fuel was discontinued. Instead, small- and medium-sized hydroelectric power generation (with a capacity of 1,000 kW) and geothermal generation (only for binary cycle power generation) became qualified for subsidy. PV systems with 10 kW of output capacity and over are qualified under the program. Recipients can receive the subsidy, the lower amount of either half of installation cost or 340 000 JPY/kW (in case of specific public body, supported by the local government, one third of installation cost or 220 000 JPY/kW). Projects for awareness towards dissemination are subsidized with a fixed amount (or within half of installation cost). 572 systems in total were subsidized between FY1997 to FY2006, of which 254 systems were PV systems. Total capacity installed was 23 012 kW. In FY2007, 119 systems in total were newly qualified, of which 49 systems were PV systems. Total capacity installed was 945 kW. Local governments or nonprofit institutions understand the benefit of introduction of new and renewable energy through this program and introduce PV systems to school buildings and public facilities, etc. over several fiscal years.

3. Project for Supporting New Energy Operators

This program aims at accelerating the introduction of new and renewable energy by supporting private institutions who install facilities 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 cell, biomass, utilization of snow and ice, etc. In FY2007, subsidy for

Fig. 3 - Wakkanai Photovoltaic Demonstration Facility (Under Constructed), 2 MW (end of FY2007), 5 MW (end of FY2010), Wakkanai-City, Hokkaido Prefecture (photo RTS Corporation).

waste-related facilities was discontinued. Instead, small- and medium-sized hydroelectric power generation (with a capacity of 1 000 kW) and geothermal generation (only for binary cycle power generation) became qualified for subsidy. The subsidy is one third of installation cost or below, 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 combined installation with other facilities). 277 systems in total were qualified from FY1998 to FY2005, of which 12 systems were PV systems, 826 kW in total. In FY2006, 54 systems were selected, of which 2 systems were PV systems, and the total installed capacity was 160 kW. Recipients of FY2007 subsidy have not been announced yet.
Besides these programs, METI has been supporting local governments for their projects to develop their own visions for the introduction of new and renewable energy and to nonprofit organizations (NPOs) for their awareness activities to introduce new and renewable energy.

The Ministry of the Environment (MoE)

The Ministry of the Environment (MoE) is promoting projects to reduce CO_2 emissions by use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming," enforced in FY1998. MoE established the "Solar Promotion Program," a package program for the introduction of PV Systems; to implement measures to reduce CO_2 emission by PV technology in FY2005 and continued the program in FY2007 as the 2nd phase. The major subprograms for dissemination of PV Systems under the "Solar Promotion Program" are 1) the Town-wide CO_2 20 % reduction projects, 2) Model project for shared use of MW-scale solar (3 areas were selected for 3-year projects from FY2006. PV system installation projects with total capacity of 3 MW was implemented), 3) Model project for advanced introduction of renewable energy (MoE and METI jointly support regional projects for CO_2 reduction), 4) Project of environment-friendly renovation of schools, 5) Project for pioneering introduction of PV Systems by local governments, 6) Solar Mileage Club Program and 7) CDM/JI project survey which was newly established in FY2007 to roll out in the Asian region. In addition, MoE implements "Model Project for a Virtuous Circle for Environment and Economy" aiming at achieving city planning including introduction of PV Systems, developed by local communities and the "Project for developing technology to prevent global warming" to develop practical technology for introduction of renewable energy, etc.

The Ministry of Land, Infrastructure and Transport (MLIT)

Under the "Guideline for Planning Environmentally-Friendly Government Buildings (Green Building)" as well as the Kyoto Protocol Target Achievement Plan, construction of green government buildings, buildings for central ministries and agencies and local government offices equipped with PV Systems and other new and renewable energy systems has been promoted. In addition, MLIT started to utilize PV systems under several measures: promotion of environment-friendly houses and buildings for global environment conservation, introduction of navigation aids using clean energy and a program to reduce CO_2 emissions in road projects.

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

MEXT continues "Eco-school Promotion Pilot Model Project" initiated in partnership with the former Ministry of International Trade and Industry (currently known as METI) in FY1997 and has been promoting the introduction of PV systems to elementary schools, junior high schools and kindergartens. 611 schools all over Japan were designated as the Eco-school pilot model schools by the end of FY2006 (March 2007); of which 388 schools installed PV systems with output capacities of 10 kW and over each. In FY2007, 77 schools were newly selected as the pilot model schools and PV systems are to be installed at 51 schools of them. METI, MoE and the Ministry of Agriculture, Forestry and Fisheries (MAFF) has been jointly working on this project in promoting model projects of environment-friendly schools.

Local Governments and Municipalities

The movement to actively work on environmental issues has been spreading among local governments and municipalities year by year. Prefectures and other local governments began to set their own target for the introduction volume of new energy following the national target for PV Systems introduction (4 820 MW) one after another. More than that, local authorities have started their own programs for dissemination of PV Systems. Support activities for dissemination of PV systems have also been promoted on the municipality level and over 300 municipalities continue to provide their own subsidy or preferential loan programs for residential PV systems even though the national support program for residential PV systems was terminated. In the Saga Prefecture, the amount

Fig. 4 - GG Solar Building,10 kW, Chuo-ku, Fukuoka City (photo RTS Corporation).

of electricity generated from residential PV systems for home consumption is certified as green power and the prefectural government purchases the certificate. In the Shiga Prefecture, the prefectural government provides additional support on the amount of electricity sold from residential PV systems to utilities. The Metropolis of Tokyo set a target to reduce CO_2 emissions by 25 % in 2020 compared to that of 2000, under a plan called "Tokyo towards 10 years later" and announced a plan to introduce 1000 MW of solar energy.

Utilities

Electric utilities in Japan continue the introduction of PV Systems to their own facilities and net-billing to buy-back surplus PV electricity at the same rate as the retail price of electricity.
They also 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 FY2006, 752 public facilities including schools across Japan were subsidized by the fund and the total capacity installed was 15 112 kW. In FY2007, 122 sites were selected, and installation of PV systems totaling 1 716,9 kW are underway.
Electric utilities achieved to purchase required amounts of electricity generated from new and renewable energy for FY2006 designated under the RPS Law that was enforced in FY2003. Usage amount of electricity generated by new and renewable energy by utilities for FY2006 was 6 507 TWh in total, including 541 TWh from PV power generation. The accredited facilities for power generation using new energy under the RPS Law was 333 898 systems totaling 4 756 MW. Among them, PV systems are 332 852, accounting for 1 232 MW of generation capacity.

Financial Institutions

Some banks and other financial institutions provide preferential financing at a low interest rate for introduction of residential PV systems and houses equipped with PV systems. The number of such financial institutions has been increasing year by year. In addition, financial institutions themselves started to introduce PV systems to their own branch offices and other facilities, which is an increasing trend. Moreover, there is an increasing trend of expanding environmental financing for business activities working on environmental issues.

INDUSTRY STATUS

In 2007, a series of activities to strengthen a group of PV related-industries were observed in Japan's PV industry; 1) capacity expansion and new entries by raw material and silicon wafer manufacturers, 2) large scale production capacity increase and extension of overseas production sites, in addition to improvement of PV cell/ module performance by early-started solar cell manufacturers, 3) start of production and production capacity increase by new entrants of thin-film PV module manufacturers, 4) burgeoning of system integrators, 5) production capacity increase and new entrants in components of PV cell/ module, 6) emergence of manufacturers who produce full turn-key manufacturing equipment for solar cell production lines.

PV cell/module manufacturers continued actively working on their business. Highlights of PV cell/module manufacturers in 2007 are as follows.

Sharp announced a plan to first increase its solar cell production capacity at Katsuragi Plant from 600 MW/year to 710 MW/year and then to construct a thin-film silicon PV module plant with capacity of 1 000 MW/year in Sakai City, Osaka Prefecture, annexed to a plant

for large-sized liquid crystal display (LCD) panels. First, capacity of a thin-film PV module production line at Katsuragi Plant will be increased to 160 MW/year; then the technology cultivated there will be introduced to the new Sakai Plant. Furthermore, Sharp announced a plan to double the production capacity of the PV module factory in the UK to 220 MW/year.

Kyocera will increase domestic production capacity to 500 MW/year by 2010. Production capacity of PV module plant in Mexico will be increased to 150 MW/year.

Sanyo Electric announced a plan to launch a new PV module plant in Shiga Prefecture with the capacity of 40 MW/year, in response to the growing demand. Sanyo also plans to establish the "Advanced Photovoltaic Development Center" in the aim of commercialization of next-generation thin-film silicon PV module.
Mitsubishi Electric plans to enhance its solar cell production line towards establishing a production framework with the capacity of 250 MW/year.

Kaneka completed the construction of a new thin-film silicon PV module production line with the capacity of 55 MW/year, with a plan to further increase the production capacity to 130 MW/year.
Fuji Electric Systems plans to increase production capacity of flexible thin-film silicon PV module from 15 MW/year to 150 MW/year.
Showa Shell Sekiyu decided to construct the second plant for CIGS PV module with the production capacity of 60 MW/year and announced a plan to increase production capacity to 80 MW/year in total.

Honda Motor started a full-scale production of CIGS PV module entered into the residential PV Systems market.
Clean Venture 21 established a commercial plant of spherical silicon solar cell.

Fujipream established a plant to exclusively produce concentration-type spherical silicon solar cell.

MSK's Fukuoka Plant was acquired by its employees and started operation as a new company "YOCASOL".
In the area of the silicon feedstock/ wafer, manufacturers have been increasing production capacities and many new players are entering the market.

Mitsubishi Materials, one of the major polysilicon manufacturers, announced a plan to increase manufacturing at production plants both in Japan and the USA.

Japan Solar Silicon, one of the group companies of Chisso achieved polysilicon for solar cells with 6N purity by SiCl4 zinc reduction process.

M. Setek entered into the business of polysilicon for solar cell and started production.
With the metallurgical process of polysilicon production, Nippon Steel entered into the business and other companies have been active in this area.

JFE Steel plans to construct a 300-t/year plant of polysilicon for solar cell.

Dow Corning Toray expanded sales of polysilicon for solar cells, in which the US headquarters is engaged, to a full-scale operation.

SUMCO decided to supply multicrystalline silicon wafer for solar cells, in addition to that for semiconductors, and announced a plan to construct a new plant of silicon wafer aiming to achieve 1 GW/year production.

Sumitomo Corporation formed a business alliance with a Chinese company for single crystalline silicon ingots for solar cells.

Osaka Fuji Corporation decided to establish a new plant to process wafers for solar cells.

Not only in the area of silicon ingot and wafer but also in the area of BOS (Balance of System) and production equipment for solar cells, a number of companies are entering into the business and aggressively expanding production as well as establishing business partnerships.

Denal Silane plans to increase production capacity of monosilane gas.

Jemco plans to double the production capacity of columnar crystalline silicon ingot.

Ferrotec decided to produce quartz crucibles in Norway and strengthen production of single crystalline silicon ingot puller.

Covalent Materials decided to increase production of quartz crucible for solar cells.

Other manufacturers are also active in the area of BOS and production equipment, as follows:
EVA: Bridgestone, connector for PV modules: SMK, Honda Tsushin Kogyo, wiring units: Onamba, solar cell production line: SES, PV cell/ module production equipment: NPC (listed on TSE MOTHERS of the Tokyo Stock Exchange), PV cell/ module testing equipment: Iwasaki Electric, Yamashita Denso, crystalline silicon solar cell production equipment: Noritake.

Ulvac entered into the business of thin-film silicon PV module production equipment, receiving a series of orders from PV manufac-

Fig. 5 - Intensively installed PV system for houses, Pal Town Jyosai-no-Mori, Total 2 130 kW, 553 houses (Average: 3,85 kW per house, Ota City, Gunmma Prefecture (photo Otacity Land Development Corporation).

turers in Taiwan and China. Accordingly, Ulvac established a PV module line for evaluation and plans to expand its production sites.
In the PV Systems distribution industry, residential PV Systemss have been selling well, despite completion of the government's subsidy program.

Sekisui Chemical achieved sales of 58 000 PV systems by the end of 2007.

Daiwa House, PanaHome and Sumitomo Forestry have started the sales of all-electrified housing one after another, with PV Systems as standard equipment.

NTT Facilities has been promoting the construction of large-scale PV systems as part of national projects.

Itochu acquired Solar Depot, a US company selling PV systems and entered into the PV business.

As systematic introduction of PV systems has started on the user side, movements towards full-scale PV dissemination will be continuously pursued.

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 is underway.
The size of the residential PV market grew to the level of 50 000 systems/year through government support programs for introducing residential PV systems implemented for 12 years. Cumulative installed capacity at the end of FY2006 was 1 277 MW installed at approximately 350 000 houses. Even after the program was completed, the PV market in Japan didn't shrink but leveled off.
PV manufacturers are working on expansion of the market for residential PV Systems for both newly built and existing houses by minimizing the price increase of PV Systems despite the soaring price of silicon feedstock due to the polysilicon shortage. In the newly built residential house market, pre-fabricated house manufacturers enhance efforts for energy conservation and reduction of CO_2 emissions. Accordingly, some housing manufacturers adopted PV Systems as standard equipment and this trend has expanded to major housing companies, who are advertising PV-equipped housing on TV commercials to increase sales across the country. In particular, the new concept of zero-utility charge house equipped with PV system contributes to the expansion of purchasers who recognize economical efficiency in running cost of the house as well as the environmental value. In the PV market for existing houses, PV manufacturers are developing and establishing a distribution channel consisting of local builders, electric contractors, electric appliances stores and roofers, etc., while seeking purchasers of residential PV systems all over Japan.
Through the long-term field test projects, PV systems for non-residential use, such as for public and industrial facilities, have been making 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 PV Systems and the market development of non-residential area is in progress. As for the installation sites, PV Systems have been added to a wider variety of places: 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 (greenhouses), 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.). The size of a PV Systems has been increased to as large as 5-MW. The range of those who installed PV systems are widely varied, from large companies to individual owners in the private sector and from public-interest organizations to nonprofit organizations (NPOs). Some companies have been introducing PV systems to their factories and offices nationwide and installing additional PV systems to existing PV-equipped facilities. Installation of large-sized PV systems is also on the rise. The number of such companies has been increasing year by year. In NEDO's Field Test Project on New Photovoltaic Power Generation Technology in FY2007, total capacity exceeded 20 MW, of which 2 007 kW was installed by Toyota Motor Corporation and 1 000 kW by Electric Power Development.

FUTURE OUTLOOK

The government of Japan revised the Basic Energy Plan foreseeing around 10 years ahead in 2007. The Plan emphasizes the importance of energy security reflecting recent global circumstances such as the tight situation of energy demand and supply, soaring prices of energy and countermeasures against global warming. The main pillars of the Plan include the following:

1) promotion of nuclear power generation and expanded installation of new and renewable energy,
2) aggressive development of diplomacy on resources toward the stable supply of fossil fuels such as oil,
3) enhancement of energy conservation strategy and initiative for forming an international frameworks to work on measures against global warming and 4) strengthening of technological capabilities.

New and renewable energy is positioned as "the complementary energy for the time being; which the government will promote measures aiming at making new and renewable energy one of the key energy sources in the long run." For that, the government announced the creation of strategic efforts for implementing technological development to reduce costs, to stabilize the grids and to improve performance in collaboration among industrial, academic and governmental circles. Furthermore, in order to expand introduction of new energy, the following measures are included, depending on different stages of market growth:

1) take-off support (technological development, demonstration tests),
2) creation of initial demands (model projects, support for installation of facilities),
3) initiative in installations (at public institutions-related facilities),
4) support for market expansion (legal actions such as the RPS Law),
5) formation of industrial structure (promotion of venture businesses to enter into the market, fostering peripheral and related industries),
6) maintenance of promoting environment for dissemination (awareness for dissemination, public relations and information service).

In addition, the government reviewed the RPS Law which obliges utilities to use a certain amount of new energy, and set the target for the period between FY2011 and FY2014. In the revision, final target for FY2014 was set based on the former target of 12,2 billion kWh by FY2010 as a benchmark, by increasing 950 million kWh every year, to reach the ultimate goal of 16 billion kWh. The revision adopted a special preferred measure to double-count the RPS equivalent volume for PV power generation in order to improve the system management of the RPS Law. It is expected this measure would be a new tailwind for the dissemination of PV Systems.
Moreover, the government proposed a long-term target of countermeasures against global warming; cutting global greenhouse gas (GHG) emissions by half from the current level by 2050, announced "Cool Earth 50 - Energy Innovative Technology Plan" to achieve the target and selected 20 research topics to be promoted as priorities. "Innovative PV Technology" was selected as one of the research topics aiming to improve conversion efficiency of solar cells from current 10 - 15 % to over 40 % and reduce power generation cost of solar cells from current 46 Yen/kWh to 7 Yen/kWh. The efforts for "innovative PV technology" will start from FY2008.

Meanwhile, it is assumed that the PV manufacturers will enhance their efforts for full-scale dissemination of PV Systems by working on 1) further cost reduction of the PV system, 2) detailed product development suitable for each application area, and 3) development of new application area, through technological development, enhancement of production capacity and collaboration with other industries using PV Systems.
Thus, in addition to these efforts by the national government and industry, and with support from users of PV Systems, including other ministries, agencies, local authorities, private companies and individuals, further deployment of PV Systems in Japan will continue into the future.

KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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Fig. 1 - The 13 kW grid-connected BIPV systems installed on the KIER research building in 2007.

Fig. 2 - 3 ~ 5kW grid-connected PV systems on residential houses under the 100 000 roof-top program.

GENERAL FRAMEWORK

Korea has been making a strong effort to increase the new and renewable energy (NRE) portion of "energy mix" to achieve the goal that was announced in December 2003. Korea's renewable energy is targeting to take 5 % of the total energy consumption by 2012. Currently the renewable energy is estimated to be about 2,1 % of total energy. The Korean government increased the renewable energy budget steadily from 196 BKRW in 2004, 324 BKRW in 2005 and 409,5 BKRW in 2006. In 2006, budget was allocated as 124,4 BKRW for R&D, 137,5 BKRW for deployment, 121,3 BKRW for long-term loan and 2,3 BKRW for Feed-in Tariff program. As of the third year of implementing the 10-year Plan, the Korean Photovoltaic Program has made great progress in the areas of system installation, R&D investment, standards and accreditation. The Feed-in Tariff (FIT) rate per kW-hr changed from 716,40 to 677,38 KRW for systems larger than 30 kW with a ceiling of cumulative 100 MW since Oct. 2006. Korean PV industry attracted international attention when DCC announced to jump into the poly-silicon feedstock manufacturing business in order to tackle the silicon shortage issue.

NATIONAL PROGRAM

The Ministry of Commerce, Industry and Energy (MOCIE) has been implementing, via KEMCO (Korea Energy Management Corporation), demonstration and field test of various renewable energy technologies. In 2003, the 2nd 10-year basic plan for NRE R, D&D was established to enhance the level of self-sufficiency in energy supply; to meet the challenging of climate change and to consolidate infrastructure of NRE industry. The goal of the plan is to achieve 3,0 % share of total primary energy supply with NRE by 2006 and 5,0 % by 2012. PV was selected as one three major areas as well as wind power and hydrogen & fuel cell. The government appointed Korea University as an organization for planning and managing PV R&D programs and established the Korea Photovoltaic Development Organization (KPVDO) in 2004. Korea plans to secure 7 % of world PV market share through utilizing the infrastructure and the resources of semiconductor and display industries where Korea has a world-class leadership and also has plans to install 1,3 GW of PV by 2012.

RESEARCH AND DEVELOPMENT

The government budget in 2006 for PV R&D was 124,4 billion KRW, which is a 25 % increase from previous year. Korea's PV R&D Program is led by the KPVDO since 2004. The program mostly consists of industry-oriented research works. The 25 projects have been running with participation from 35 companies, 8 national institutes and 21 universities. The projects implemented in 2005 and 2006 included various categories. For the short- term commercialization, 9 projects have been implemented with the subjects of 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 goal, three projects have been implemented in the area of a-Si and CIGS thin-film and dye-sensitized solar cells. Especially two new important projects have been initiated for poly-Si feedstock production and 130 μm wafer-based silicon solar cell development in 2006 to counteract the Si shortage issue. In addition, for demonstration and infrastructure areas, 11 programs have been carried out. The main subjects are the Road Map for Standardization and Certification, the 1 MW PV Power Plant Demonstration, the Solar Cell Evaluation Facility, a PV demonstration site infrastructure and a public building demonstration, etc.

DISSEMINATION PROGRAMS

General Deployment Program: The government supports 70 % of the installation cost. In 2006, 77 PV systems with a total of 2,255 kW were installed. The installed capacity was not much changed compared to 71 PV systems with a total capacity of 2,025 kW in

2005. Various grid-connected PV systems with a power capacity of 5-200 kW were installed in schools, public facilities, welfare facilities and universities.

Rooftop Program: In 2006, under the 100 000 roof-top program, 2 452 systems with a total capacity of 6,469 kW were for single-family houses; the average capacity being 2,47 kW. In addition, 120 kW systems for apartment buildings with 550 households and 3 kW for public rental apartment buildings with 2 962 households were installed. PV system applications for multi-family apartment buildings were new in 2006 and this kind of installation will be more encouraged by the Korean residential situation. The beneficiary paid only 30 % of total system price of 8,55 MKRW per kW.

The Public Building Obligation Program: This program was implemented in 2004 and was applied to newly installed public buildings larger than 3 000 sq. meter and obliged to invest renewable energy equipments such as PV more than 5 % of the total building construction cost. Up to November 2006, a total of 349,1 kW PV systems were installed under the program. As the central government pursues the “New Administration-Oriented City Plan” and “Plan for Public Enterprise Relocation,” new public buildings are planned all over Korea and thus the Program should contribute a great deal to the expansion of the Korea PV market.

Feed-in Tariff Program: The Feed-in Tariff (FIT) rate per kW-hr changed from 716,40 KRW to 677,38 KRW for systems larger than 30 kW with a ceiling of cumulative 100 MW since Oct. 2006 guaranteed for 15 years for the PV system over 3 KW. 52 commercial PV power plants of 9,157 kW in total ranging 3 kW~1 MW were newly installed and operating. Four 1 MW PV plants were installed such as Donghae PV Power owned by the Dongseo Utility; Youngheung PV Power owned by the Namdong Utility; Kangjin PV Power owned by Namhae Energy; and Hanra PV Power owned by the Hanra Electric Co., LTD. Several projects of multi-MW scale are in the planning stage with local government and local utilities or foreign companies. Annual spending for the PV Feed-in-Tariff program was 3,478 MKRW and the annual PV Power generation was 5,474 MWh in 2006.

Local Deployment Program: Under the local energy development project, a wide variety of PV systems including off-grid domestic, non-domestic and grid-connected systems were constructed. In 2006, 27 PV systems of 1,831 kW were installed; a two-fold increase compared to 24 PV systems of 883,7 kW in 2005. This program aims at increasing public awareness on PV and developing PV as an indigenous renewable energy source for their region. It is worthy to note that several local authorities finished 9 “Green Village” projects which were mainly composed of PV, solar thermal, geothermal and wind power until the end of 2006. In 2006, two new green village projects were accomplished, which are Buyeo of Chungchung nam-do province and Suncheon of Chunla nam-do province.

Fig.3 - The 310kW PV power plant installed at water purification sites from Seoul Metropolis in 2007.

Fig. 4 - The 2,2 MW PV power plant installed at Munkyung, Kyungpook Province in 2007.

DISSEMINATION PROGRAM OUTCOME

The total cumulative installed PV power for each sub-market as of the 31 December of each year, from 1992 to 2006 is shown in Figure 3. The total installed power of PV systems in Korea was 34,733 kW at the end of 2006. The total PV power installed during the year 2006 was 21,209 kW, which is over four times higher than that achieved in the previous year (4,990 kW). The major increase came from PV power plants supported by the Feed-in-Tariff Program and 3 kW residential roof-top applications under the 100 000 solar roof program. The share of grid-connected distributed system increased to 83 % of the total cumulative installed power from 58 % in the previous year. The annual installed power of this sector in 2006 reached 20,930 kW; representing over 98 % of the total Korean PV market. Following rapid increase of commercial PV power and residential roof-top installations, off-grid non-domestic and domestic sectors are not interested by Korea PV industry and the cumulative share decreased year by year; occupying only 17 % of total cumulative installed power.

INDUSTRY STATUS

Production of Feedstock and Wafers: There was no production of feedstocks but single crystalline wafers were produced by Siltron Corp. which has 10MW pilot production line using electronic-grade ingot off-spec. In 2006, Dongyang Chemical Co., (DCC) announced to invest for 3,000 ton annual production facility of poly-silicon feedstock; scheduled for commercial production in 2008. In the wafer area, Woongjin established a joint venture, Woongjin Energy, with US-based Sunpower for single crystalline silicon ingot production.

Fig. 5 - The PV gardening systems: PV Tree.

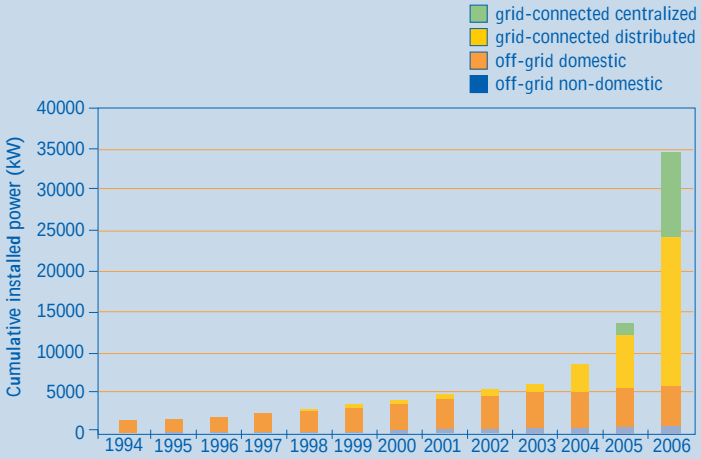

Fig. 6 - The Cumulative Installed PV Power in Korea.

Production of Photovoltaic Cells and Modules: In 2006, KPE completed the second manufacturing line of 30 MW which has a capability of handling both single and multi crystalline Si wafer at the size of 125 mm and 156 mm and had a total production capacity of 35 MW, as of May 2006. As a new company, Millinet Solar, is constructing 30MW solar cell line scheduled for operation in middle of 2007. Sinseong ENG and Hyundai Heavy Industry Co. Ltd., are constructing a production line with capacity ranging from 30 to 50MW with a target for production within 2008. Eight companies produced only 16,9 MW of PV modules with total annual production capability of 130 MW, due to the PV cell supply problem. In spite of limited operation of the production line, Symphony Energy and Hyundai Heavy Industries successfully entered into the European module market in 2006 and these two companies are expected to increase their production in 2007. Korean module manufacturers plan to produce more than 60 MW in 2007. The module price was in the range of 4,200 to 4,600 KRW/W depending on the manufacturing company and the order volume. The average PV module price of 4,400 KRW/W in 2006 was a little less than that in the previous year. Manufacturers and Suppliers of other Components: In 2006, several new companies entered the grid-connected inverter market with the leading company - Hex Power Systems. Active new companies were Willings, Hanyang Electric, Hyundai Heavy Industries and Dathtech. Due to new suppliers and imported products from SMA and Fronius, the price of PV inverters decreased very sharply in 2006. These trends expect to continue in 2007. Domestic manufacturers supplied mainly for residential PV systems less than 10kW and foreign companies were actively supplying over 100 kW for PV power systems for the Feed-in-Tariff program. SMA was a leading supplier for larger inverters in the Korean market.

FUTURE OUTLOOK

The year 2006 was a year that the annual installed PV capacity in Korea exceeded 20 MW. In 2007, the annual PV market will increase to about 50 MW based on the government dissemination budget and PV power plant under feed-in Tariff program. Under the new Korea's national PV plan, the goal increased to 100 000 roofs and 70 000 buildings for a total capacity of 1,3 GW by the year 2012. An explosive market growth is expected between 2006 and 2012. The foundation for mass deployment was set into place in the year 2006 especially for roof-top and feed-in tariff market. In the future, the BIPV market is expected to play an important role due to the "New Administration-Oriented City" and "Many Innovation Cities" programs under which the Korean government will construct public buildings throughout Korea until 2012. The Korean government recognizes that the PV industry will grow and take up to 10 % of the world market by 2012, with exports amounting to 3 BUSD and employing 50 000 people. The strategies for promoting the distribution of PV systems are described below. The whole program will be managed and monitored by the experts group organized solely for PV technology distribution.

- Establish the foundation for mass distribution through developing PV systems for the 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 more "green villages" throughout Korea starting from Daegu and Gwangju. For new buildings, encourage the installation of 10 kWPV systems and multi-hundreds kW PV systems for factory buildings with removal of administrative and legal barriers.
- Maximize the subsidy program 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 have to spend about 2,3 BUSD during 2004-2012. The fund will be provided by the Government. As the PV world market rapidly grows, investment from industry is expected to increase accordingly.

MEXICO

PV TECHNOLOGY STATUS AND PROSPECTS IN MEXICO

JAIME AGREDANO, J. M. HUACUZ
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Fig. 1 - 5,6 kW PV array of a PV-Wind-Diesel hybrid system installed at the Biodiversity Reserve on Contoy Island, near Cancun (photo Conergy Mexico).

GENERAL FRAMEWORK

New PV capacity installed in Mexico during 2007 was substantially the same as that installed in 2006; i.e., 1,1 MW. Similarly, rural electrification remains as the major application area as well as the main motor of the PV industry in this country. New programs of the Central and State Governments for poverty alleviation and rural development are expected to provide further incentive for further implementation of off -grid PV systems. Grid-connected roof tops represent an emerging market segment, which is anticipated to grow substantially in the coming years. This type of applications is motivated by the "Contract Model for Small Grid-Connected PV Systems," a piece of regulation emitted in mid 2007 by the Energy Regulatory Commission (CRE). Such resolution allows domestic and commercial electricity users to install PV systems of up to 10 and 30 kW, respectively, interconnected to the national electricity grid, in the modality of net metering. Installation of roof tops under this resolution becomes attractive for large electricity consumers due to the step-wise structure of the electricity tariff system in Mexico. Further regulatory measures and support incentives are under consideration.

NATIONAL PROGRAMME

The bill to foster the use of renewable energy resources in Mexico, mentioned in earlier reports, is awaiting approval by Congress. No prognosis could be made as to when this bill could be finally approved. After a long period of planning and negotiations, a new program of rural electrification with renewable energy has been launched and co-funded by the GEF, the World Bank and the Mexican Government. 40 rural communities have already been selected as candidates for the implementation of pilot projects. These communities are located in four target states in southern Mexico, namely: Oaxaca, Chiapas, Veracruz, and Guerrero. Field activities are in progress, and it is expected that pilot projects could be concluded before the end of 2008. PV continues to show in the analyses as the best technical and economic alternative in providing basic electricity services to the approximately 50,000 households to be covered by the program.

RESEARCH AND DEVELOPMENT

Draft technical guidelines for the interconnection of PV systems to the grid have been developed and submitted to the national electric utility, the Federal Commission of Electricity (CFE), for review and subsequent adoption as a national code. Guidelines apply to individual systems of up to 30 kWp of PV capacity. Japanese and US module manufacturers located in Mexico, continue their production of PV modules but only for export. Operation start-up of the first module assembly factory for the local market took place in December this year and full production of 15 MW annually is planned for the coming months.

PV R&D at academic institutions continues its normal trend; which is mostly basic research on cell materials for higher efficiency thin films. At the Electrical Research Institute (IIE), engineering research focuses on grid connected applications and rural electrification issues. IIE has been awarded a grant by the Global Environment Facility, through the United Nations Development Programme, to co-fund a 3-year program to identify and remove barriers to the large-scale deployment of grid-connected PV in Mexico.

IMPLEMENTATION

Construction of the first PV neighbourhood, comprising 220 low-income houses, with 1 kWp grid-connected PV roof top each, was concluded early this year. This is the first stage of a project to reach 500 installations in the modality of net metering. The project is being carried out by the State Government of Baja California, in collaboration with CFE and IIE. Technical performance of the PV systems in this project, as well as their benefits to both, the user and the grid, along with other social factors related to the use of solar electricity, will be studied as part of the GEF-UNDP-IIE project mentioned earlier. It is expected to gain deeper understanding on the effects PV systems have for midday peak shaving during summer time at the micro-distribution side of the grid in this sunny region through this activity.

The First Colloquium aimed specifically at Fostering PV Energy in Mexico was held in the northern city of Zacatecas. It was jointly organized by the Mexican Energy Secretariat, the State Government of Zacatecas, and IIE. One important purpose of the meeting was to

promote the dialog between public and private entities in order to create a common vision on the role PV is bound to play in the future of the Mexican electricity sector. Topics covered in the colloquium included a review of the current situation of PV in Mexico in terms of policies, applications and industrial infrastructure, as well as presentations by representatives of international organizations, PV companies and PVPS Task I experts, on the experience in their respective institutions, companies and countries. The audience of around 100 people included investors, industry leaders, project developers, officials from international agencies and representatives from federal, state and local governments.

MARKET DEVELOPMENT

According to information provided by the Mexican Association for Renewable Energy Suppliers (AMPER), in 2007 the size of the Mexican PV market was slightly above 1 MWp which shows no substantial growth as compare to previous years. No detailed information could be obtained about market segmentation. Hence, cumulative PV capacity installed in Mexico by the end of 2007 is estimated at around 20,8 MWp. According to estimates by companies established close to the Mexico-US border, at least 100 kW of PV capacity were installed within the duty-free zone this year. However, no official information could be found to back this estimates.

FUTURE OUTLOOK

Grid-connected PV is attracting the attention of the national electric utility, government officials, and private investors, as an area of new applications and business. For instance, preliminary studies on the implications of interconnecting 100 MW of distributed PV systems to the regional electricity grid in northern Baja California have been carried out by CFE in an initiative known as FOTORED 100. New housing developers are also assessing commercial opportunities for putting in the market mid- and high-income residences with PV incorporated in the design. Innovative financial mechanisms are being explored as part of the GEF-UNDP-IIE project, and workshops on the subject are being planned for the coming future. The new rural electrification program mentioned earlier is set to start in early 2008.

Fig. 2 - 15,2 kW PV array of a water pumping system used for water supply in a rural community in Northern Chihuahua State (photo Conergy Mexico).

Fig. 3 - 7,5 kW PV to power a SCADA and telecommunication system for a non- manned offshore oil platform (photo: Conergy Mexico).

Fig. 4 - 6 kW PV system in a commercial building in Tijuana, Mexico (photo: Atlantis Solar).

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS
JOB SWENS, SENTERNOVEM, WILLEM VAN DER HEUL,
MINISTRY OF ECONOMIC AFFAIRS

GENERAL FRAMEWORK

At the start of 2007 the new centre – left government announced an ambitious sustainability plan aiming at an annual energy consumption reduction of 2 %, a reduction, of CO_2 emission of 30 % by 2020 (compared to 1990) and a contribution of 20 % of renewable energy to the energy needs in 2020. With these targets the Dutch government surpasses the already ambitious targets of the European Commission. Following these ambitions the government initiated the set up of a new market implementation programme, called SDE (Stimulation Sustainable Energy Production), which will be launched in early 2008.

The new political direction also resulted in extra attention for the Energy Transition plan initiated in 2006. Within this programme the Dutch government collaborates directly with market players through a number of Energy Transition Platforms, which advise the government on desired and required legislation, and support schemes to realise the above mentioned targets.

NATIONAL PROGRAMME

In 2007, as in 2006, the main objective was still to implement proven renewable energy technologies (wind and biomass) and to support R&D activities in future renewable energy technologies (PV, fuel cells, etc.). Support for future energy technologies is organised in four EOS (Energy Research Subsidy) programmes, and one Transition programme, which together cover the full spectrum from fundamental new ideas and fundamental research to demonstration (Figure 1):

- EOS NEO: New Energy Research, focussing on new, unconven tional ideas. This programme is mainly intended for inventors. The programme covers all new energy options.
- EOS LT: Long term energy research, focussing on a selected range of promising energy saving or renewable energy technologies; with expected serious impact between 2020 and 2050.
- EOS ES: Collaboration projects, focussing on technology transfer from research to industry; in order to convert technologies into products. This programme replaces the energy part of the IS (Innovation Subsidy for Collaboration Projects) programme, which appeared ineffective for energy technologies.
- EOS Demo: Projects, focussing on testing and demonstrating new energy saving - or renewable energy applications in a realistic user environment.
- Transition UKR: “Unique Opportunities Scheme,” focussing on improvement of material - and energy use and on the application of renewables, in general and biomass, in particular.

EOS NEO and EOS LT are still the most interesting sub-programmes for PV, which resulted in 4 new EOS-NEO projects and 1 new EOS-LT project in 2007. The research activities in the past however have led to results which are now ready for transfer to the industry or even for demonstration resulting in 1 EOS ES project in 2006 already and 1 EOS- ES plus one EOS Demo project in 2007. The total budget going towards PV RTD activities in 2007 was around 9,4 MEUR of the total EOS / UKR budget of around 100 MEUR.

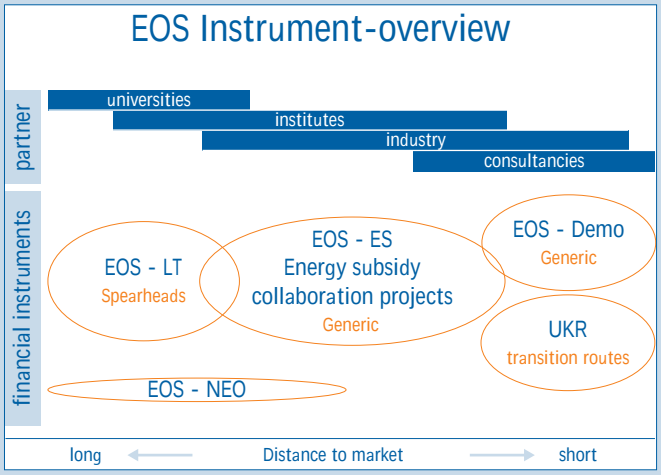


Fig. 1 - Position of the EOS and Transition sub-programmes SenterNovem.

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2007 the RTD activities continued along the three existing main lines for PV RTD in the Netherlands:

- Solving the silicon shortage problem by reducing the silicon consumption per Wp and developing production processes for SoG (solar grade silicon):
  NUON Heliantos continued on the path towards roll-to-roll tf-Si cell production, expecting to realise a commercial pilot production line in 2008, ECN, Solland Solar, ECN, Tempress and Mallinckrodt Baker started new activities in the field of high throughput emit ter processing.
- Improving cell production processes, using new cell concepts and new or improved production technologies. Here two projects stand out: 1) continuation of the development of CIS cells based on 0,2 mm CIS coated glass spheres, homogeneously distributed over a grid-shaped substrate at Scheuten Solar and 2) Further optimisation of the spray deposition process for CIS cells.
- Improving the efficiency of future generation cells through hetero-junctions and up- and down conversion of photons.
  In this field several projects, running or initiated in 2005, were still ongoing in 2007. A good example of these projects is the project on photon management for solar cells from the university of Utrecht (Figure 2)

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

As the programme's focus for PV was still on (long term) RTD, very little RTD work was done in the field of BOS. A change is foreseen for 2008, when the installation of the market stimulation scheme is expected to generate new RTD activities in the field of PV building integration.

At the international level, Dutch PV RTD centres and industries collaborate in several networks, amongst which is the CrystalClear project; that is co-ordinated by ECN and started early 2004. Other significant ongoing PV RTD or PV RTD related projects with Dutch participation are PV Upscale, Flexellence, Full Spectrum, cRRescendo, PV-ERA-NET and the PV Policy Group.

PV-ERA-NET opened a special PV dedicated Joint Call, allowing international teams from the participating countries to submit projects for funding in the field of polymer and molecular PV solar cells. The pre-proposal phase was closed successfully with 9 pre-proposals with Dutch participation in six of these. The final proposals are due for 7 March 2008.

INDUSTRY STATUS

In spite of the still low level of implementation, the PV industry sector continued to grow. Besides the existing plants of Solland Solar, Scheuten Solar NUON Heliantos, Ubbink Solar and RGS Development, three new initiatives should be mentioned: Solland Solar started the construction of a second production line, tripling its annual production capacity 60 MW. Scheuten Solar decided to bring the new CIS factory to Venlo, and expects to have a 250 MW CIS factory running at the end of 2009. APA started the preparation for a small initial CIS factory, based on the spray deposition technique developed by AST.

DEMONSTRATION PROJECTS, IMPLEMENTATION AND MARKET DEVELOPMENT

Though final numbers are not yet available, the implementation of PV is expected to have stabilised at 1,5 MW per year. The only significant implementation was generated by some larger projects profiting from both the EIA support mechanism, which allows companies to deduct the cost of sustainable energy systems from the company profit, and local or regional investment subsidies (Figure 2).

FUTURE OUTLOOK

The new SDE (Subsidy for Renewable Energy), which is expected to be opened early 2008 will generate a new impulse for investment in renewable energy systems. Though mainly targeted at large scale implementation of proven renewable energy technologies, a specified budget is allocated to PV. The goal of the PV subsidy is to prepare the Dutch market for the large scale implementation in the near future, when the price per kWh for PV reaches grid parity. The scheme is expected to initiate a market of somewhere between 10 and 20 MW in 2008.

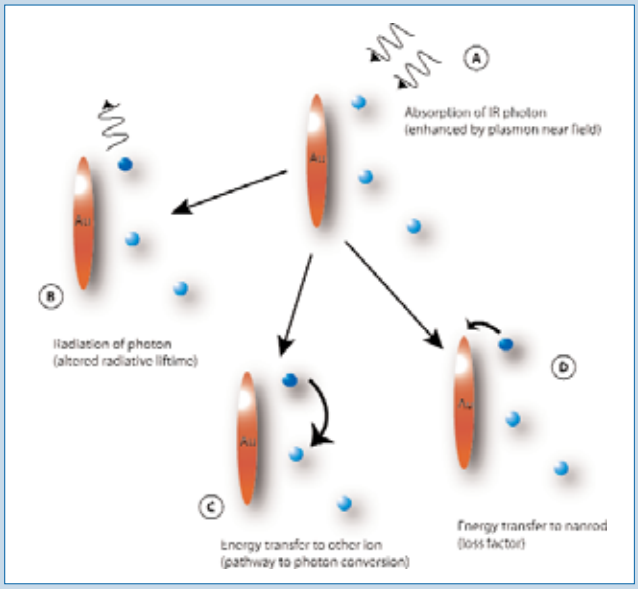


Fig. 2 - Interaction between the optically active ions and the plasma resonance in metal nano-rods . A.M. Vredenberg en J.T. van Wijngaarden, University of Utrecht.

Fig. 3 - 42 kWp flat roof – top PV installation in Groningen, The Netherlands Oskomera.

NORWAY

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

Fig. 1 - The 17,6 kWp installation on the roof of Oslo Innovation Centre in Oslo (photo Norsk Solkraft as).

GENERAL FRAMEWORK

The Norwegian electricity system is mainly supplied by hydropower. Increased consumption and limited increase in production, i.e. new power plants, has lead to growing import. *Focus on environmental issues, security of supply* etc. has lead to an increased interest in renewable electricity production, such as wind and small hydro, but also in bioenergy as a substitute to electric space heating.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001. With an annual budget of nearly 200 00 MEUR, Enova is the main instrument with regard to improve energy system efficiency and increase renewable energy production.

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. Enova SF has, however, supported some PV installations.

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 approx. 8 MNOK for 2007. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells. Other programmes in the Research Council also fund solar research, e.g. fundamental material research and production processes. The total funding for solar cell research was 37 MNOK.

RESEARCH AND DEVELOPMENT

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

- NTNU (Norwegian University of Science and Technology) Trondheim: Focusing on silicon feedstock, refining and crystallisation.
- SINTEF Trondheim and Oslo: Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.
- Agder University: Research on silicon feedstock with Elkem. *Renewable Energy demonstration facility* with PV, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.
- IFE (Institute for Energy Technology): Focus on silicon solar cell design, production and characterization and investigations of the effect of material quality upon solar cell performance. The IFE solar cell laboratory contains a R&D pilot line dedicated to the production of crystalline silicon solar cells and solar cell and material characterization laboratories. PV-systems activity is linked to research on distributed renewable energy hydrogen systems.

At SINTEF Architecture and Buildings, PV research has been done on building integration and PV in urban planning. 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 frame-work 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 enviroment.

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.

Agder University has a 20 kW photovoltaic array at its facility in Grimstad in southern Norway. It is used for demonstration of an integrated energy system and long term measurements of different PV modules (amorphous, monocrystalline and multicrystalline) in order to compare their relative performance, and to assess their total energy yield. Results have been presented at recent European Photovoltaic Solar Energy Conferences.

A PhD-programme in End Use of Photovoltaic Technology is planned in partnership with Elkem Solar. The programme will also be financed by The Research Council of Norway and the City of Kristiansand. In addition, an activity in computer modelling and simulation of solar cells and systems has been initiated, in order to do both theoretical studies of such concepts as tandem cells and spectrum splitting schemes, and in order to better understand system behaviour.

Recently, Agder University has also created a very strong link between our PV research activities and our educational programmes, through the introduction of a new engineering bachelor programme named Renewable Energy (start-up 2008), where photovoltaic technology is also included; both from a systems perspective and from the materials side.

Institute for Energy Technology (IFE) is an autonomous research foundation with about 550 employees. IFE's activity on solar electricity is comprehensive, stretching from basic research on the production of silicon feedstock, through solar cell modelling and design, solar cell process development and optimisation, characterisation of silicon solar cells to modelling and analysis of integrated PV-systems. IFE has a full inline solar cell processing line for crystalline silicon solar cells. In addition, advanced characterisation laboratories for solar cells, as well as material, electrical and optical properties are also present. IFE has been doing both theoretical (modelling) and experimental work on RE/H2-systems since 1995.

IMPLEMENTATION

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

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. During 1982-2001, the Norwegian Coastal Administration made approximately 1 840 installations with a total of 3 600 PV-modules. The smallest are equipped with one single module of 60 W, the largest with arrays counting up to 88 modules. The average is 135 W per installation. In 2007, the cumulative installed PV power capacity is 223 kW.

Norway does not have any incentive schemes supporting the installation of PV systems. In addition, the Norwegian power market was at a relatively low level during 2007. Consequently, no large grid-connected PV-system was built this year.

Norway's two largest PV projects were, however, finished in 2006/07, namely at the new opera house in Oslo, and at the Oslo Innovation Centre (Forskningsparken). The opera project consists of transparent double glass modules covering a 300 m^2 surface. The system capacity is 35 kWp, yielding about 20 000 kWh/year. The Innovation Centre project covers an area of 120 m^2. With a system capacity of 17,6 kWp, it is expected to yield about 17 000 kWh/year. The grid-connected PV system consists of a total of 94 modules arranged in three strings of 31-32 modules each. The total output is 17,6 kWp.

INDUSTRY STATUS

Elkem Solar Through the developed metallurgical route, ES has the potential to be an important player in this market. During the last years 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. From being a research organisation, ES is now building up production capabilities. 2,7 BNOK is now being invested in a industrial production plant. The plant will start up in 2008; produce about 5 000 tons Si and have 140-150 employees.

Renewable Energy Corporation (REC) REC is uniquely positioned as the most integrated company in the solar energy industry. REC Silicon and REC Wafer are the world's largest producers of polysilicon and wafers for solar applications. REC Solar produces solar cells and solar modules. REC Group had revenues in 2006 of 4,334 MNOK and an operating profit of 1,574 MNOK. In December 2007, REC entered into a long-term agreement for supply of multi-crystalline silicon wafers to Solland Solar Cells BV. Under the agreement, REC will until 2015 deliver wafers worth around EUR 500 MEUR (approximately 4BNOK).

NorSun AS The vision of the wafer producer NorSun AS, is to become the leading and most cost effective producer of high efficiency mono-crystalline silicon wafers. NorSun will build

Fig. 2 - Production facility of Elkem Solar in Kristiansand under construction (photo Elkem Solar).

its first wafer production facility in Aardal, in the western Norway. The construction commenced at the beginning of 2007 and production is planned to start at the beginning of 2008. With a 'phase one' capacity of approximately 130MW, the plant will be one of the largest of its kind in the world. Through an agreement with the Finnish company Okmetic, NorSun has secured access to key tech-nology and expertise in mono-crystalline silicon ingot pulling, which will be utilized at the Aardal plant.

Metallkraft AS The wafer cutting process requires large amounts of cutting slurry. The slurry consists of abrasive silicon carbide particles and glycol, and is quickly polluted during the cutting process by silicon shavings, metal particles from the saw wires and water. Metallkraft AS has developed a technology that turns the spent slurry into commercially interesting products. Metallkraft has signed a contract with an annual value of 20 mill USD with Jiangsu Shunda Semiconductor Development Co., Ltd. for SiC slurry recovery. On this background, Metallkraft is planning a factory in the Yangzhou Economic Development Zone, reaching a capacity of 80,000 mt spent slurry within a few years.

Metallkraft will also supply services to the new NorSun facility in Aardal, Norway.

PORTUGAL

PV TECHNOLOGY STATUS AND PROSPECTS

PEDRO SASSETTI PAES, EDP S.A.

Fig. 1 - Hercules power plant (Serpa) – 11 MWp single-axis tracking system.

GENERAL FRAMEWORK

Photovoltaics is part of the general framework for promoting Renewable Energies in Portugal, as stated in the government's National Strategy for Energy, established by the Cabinet Resolution 169/2005.

Improving energy efficiency, reducing CO_2 emissions and increasing the use of renewable energy sources (RES) are some of the core objectives of this strategy. The promotion of market deployment of renewable energy (RE) technologies can thus be regarded as a major policy objective, contributing to increasing security of supply, through the diversification of energy sources, while reducing the environmental impact associated with the energy system.

NATIONAL PROGRAMME

The government established ambitious goals for renewable electricity (RES-E) to be reached by 2010, increasing the targets agreed to under the 2001/77/CE Directive – 39 % of the gross electricity consumption from RES – to 45 %. This target will be reached mainly through wind power (about 5 000 MW by 2010, currently 2 000 MW) and hydropower plants (about 5 600 MW by 2010, currently 4 800 MW), while PV remains with a small contribution (about 200 MW by 2010).

The main instrument for promoting renewable electricity is a feed-in tariff mechanism, differentiated by technology, guaranteed for a fixed timeframe (typically 15 years) and applicable until a certain capacity target is attained – Independent Power Producer law. The corresponding legal framework, in force since1988, was once again revised in 2007 by the Decree-law 225/2007. Among all eligible technologies, PV benefits from the highest feed-in tariffs, which depends on the power at the interconnection point and whether systems are building integrated or not, as shown in Table 1.

TABLE 1- PV FEED-IN-TARIFF (cEUR/kWh)

	P< 5 KW	P> 5 KW
BIPV	46,9	35,4
Non-BIPV	44,7	31,7

In November 2007, a new framework for the promotion of micro-generation systems was approved, known as "Renewables on Demand." While the IPP law involves mainly private companies, the micro-generation scheme is oriented to electricity consumers, provided they have a commercial contract with any electricity supplier. Two regimes are defined:

- The general regime, applicable to any type of micro-generation (or co-generation) source, where the maximum interconnection power by application is limited to 5,75 kW (25 A single-phase). The feed-in tariff equals the regulated tariff (true net metering).
- The special regime applies exclusively to renewable sources – solar PV, wind, hydro, biomass and fuel cells (provided hydrogen is produced from RES) – but the maximum interconnection power by application is limited to 3,68 kW (16 A single-phase). A reference feed-in tariff, generally established for RE micro-generation technologies, is initially set at 65 cEUR/kWh and is revised to 95 % of its previous value every time an additional 10 MW capacity is attained (overall micro-generation installations, not exclusively PV). Under this regime, PV systems benefit from 100 % of the reference feed-in tariff, wind benefit from 70 %, hydro and biomass from 30 %. The feed-in tariff is guaranteed for 5 to 6 years (5 years plus the months left in the installation year) after which, during the 10 following years, the applicable feed-in tariff will be the one actually in force, revised on an yearly basis.

This new framework requires all the produced energy to be sold to the electricity supplier. Under the special regime, with the exception of biomass, the installation of a solar water heating system (minimum 2 m^2) is mandatory. The authorisation procedure is also simplified, mostly based on an on-line registry platform. It is expected that system licensing can occur in no more than 3-4 months.

The "Renewables on Demand" framework is expected to be fully operational during March 2008. The government predicts that about 165 MW of micro-generation capacity (more than 50 000 installations) will be realised by 2015, assuming a 20 % yearly growth rate.

Besides this schemes, other indirect market development mechanisms for renewables include reduction of VAT rate from 21 % to 12 % on renewable equipment, custom duties exemption and income tax reductions (up to 777 EUR for solar equipment).

Fig. 2 - PSIA power plant (Almodovar) – 2,15 MWp 2-axis tracking system.

TABLE 2 - LIST OF THE R&D UNITS WITH RESEARCH LINES IN PV TECHNOLOGY

R&D UNIT	INSTITUTE/ UNIVERSITY	PV TECHNOLOGY
Laboratory of Photovoltaic Applications and Semiconductors (LAFS)/ Condensed Matter Physics	FCUL	Crystalline silicon ribbon solar cells
Group of Complexity and Electric Proprieties/ Center of Physics (GCEP-CP)	UM	Thin film silicon solar cells
Group of Functional Coatings / Center of Physics (GFC-CP)	UM	Thin films solar cells Organic solar cells
Center of Excellence in Microelectronics, Optoelectronics and Processes (CEMOP)	FCT-UNL	Thin film solar cells
Center for Materials' Research (CENIMAT)	FCT-UNL	Thin film solar cells
Group of Molecular Chemistry / Centro for Structural Chemistry (GMC-CQE)	IST-UTL	Organic solar cells
Thin Films Semiconductor Group, Physics Department (TSFG-PD)	IST-UTL	Thin film silicon solar cells
Group for Research and Applications on Microelectronics, Optoelectronics and Sensors (GIAMOS)	ISEL-IPL	Thin film silicon solar cells
Center of Semiconductor Physics, Optoelectronics and Disordered Systems (FSCOSD)	UA	Thin film solar cells Organic solar cells
Technology of Chemistry Industries Department (DTIQ - INETI)	INETI	Organic solar cells
Renewable Energy Department (DER – INETI)	INETI	Crystalline silicon ribbon solar cells Organic solar cells
Basic Sciences and Enabling Technologies (BSET –IT)	IT-IST	Organic solar cells

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Fundamental research activities are carried out in a dozen public institutes and university R&D units and address mainly thin film technologies, crystalline silicon ribbon and organic cells (see table 2).

Applied research and demonstration are performed in several institutions such as Public Research Institutes (INETI – National Institute for Engineering, Technology and Innovation; IN+ - Centre for Innovation, Technology and Policy Research), Energy Agencies (ADENE and regional agencies), utilities (EDP) and private research institutes (INESC Porto - Institute for Systems and Computers Engineering). Besides these institutions, associations such as SPES (National Solar Energy Society) and APISOLAR (solar manufacturers and installers association) are also involved in dissemination activities.

The second edition of the international design competition – *Lisbon Ideas Challenge: Urban Design with Photovoltaics* – took place in 2007, under the auspices of the IEA-PVPS Programme (Task 10), sponsorship of Risk Capital PME Investimentos and supported by The Municipality of Lisbon, the Portuguese Agency for Economic Promotion (ICEP) and the European Photovoltaic Industry Association (EPIA) - www.lisbonideaschallenge.com.pt. Three prizes were awarded under the following categories: commercial buildings, social housing and public space.

Fig. 3 - Pao e Agua power plant (Mertola) – 756 kWp a-Si system.

Fig. 4 - Berlega Island – sustainable laboratory project.

IMPLEMENTATION

From 2002 to 2004, about 128 MWp PV capacity (corresponding to 104 MVA at the grid interface) were allocated by the government body DGEG under the IPP framework. Since then, the grid interconnection points allocation (first step of the licensing process) has been frozen. This had to do with the huge amount of requests received in 2005 (more than 3 000), which largely exceeded the national target of 150 MW.

However, some of the former licensed installations were concluded in 2007; adding more than 14 MW to the installed capacity in 2006 (3,4 MW), i.e., an increase of more than 5 times. Among these systems, the following started operation in 2007:

- 11 MWp single-axis tracking power plant in east Alentejo (Serpa municipality, south of Portugal), promoted by Catavento (a Portuguese IPP company), Powerlight Corporation and GE Energy Financial Services (USA). The plant includes 52 000 monocrystalline PV modules from Sharp, Sanyo, Sunpower and Suntech, trackers from Powerlight and inverters from Siemens (see Figure 1).
- 2,15 MWp two-axis tracking power plant in south Alentejo (Almodovar municipality), promoted by Ser Solar (Portuguese IPP) and WPD (Germany). The system comprises 12 780 PV modules from Kyocera, mounted on 426 Degger trackers, and inverters from Siemens (see Figure 2).
- 756 kWp a-Si plant in Mertola (south of Portugal) (see Figure 3).

The world largest centralised PV plant to be installed in eastAlentejo (Moura municipality), promoted by the local Municipality and Acciona Energía (Spain),will be downsized from 62 MWp to about 46,4 MWp. This hugeproject also involves the construction of a PV module manufacturingfacility, located in the same municipality. Both the factory and the plantstarted construction in 2007. The PV plant installation, which comprises 268.000 PV modules provided by the chinese Yingly group, to be mounted on single-axis tracking systems, is expected to be completed by the end of 2008.

Also in 2007 a large consortium, including local authorities, utilities (of which EDP), research institutes, environmental NGOs and industries, launched a pilot project called “Berlenga – Sustainable Laboratory,” which aims at integrating sustainable energy and environmental solutions on the island of Berlenga, located in the Atlantic Ocean, slightly north of Lisbon (see Figure 4). The project involves the following applications:

- Production and storage of energy from RES (60 kW PV plus 10/11 kW wind).
- integrated energy management system
- Dessalination plant, supplied by RES-E
- Waste water treatment
- Urban solid waste management system.

INDUSTRY STATUS

The PV industrial sector has been particularly active in the past few years. There are currently two PV module manufacturers in Portugal:

- A. J. Lobo Ltd, an assembling factory of mono and multi-crystalline modules formerly from Shell Solar, located in Évora, became an autonomous company called Open Renewables, S.A. The factory employs about 90 people and has a maximum annual production capacity of 35 MWp.
- Solar Plus, under a joint venture established with Energy Photovoltaics, Inc. (EPV), a solar energy manufacturer in New Jersey (USA), installed a 6,2 MWp per year thin-film (amorphous silicon tandem junction) PV module manufacturing facility in Oliveira do Bairro (north of Portugal) in 2007. The facility employs about 150 people and its capacity is expected to expand to about 8,2 MWp by the end of 2008 and 16,4 MWp by 2009 (see Figure 5).

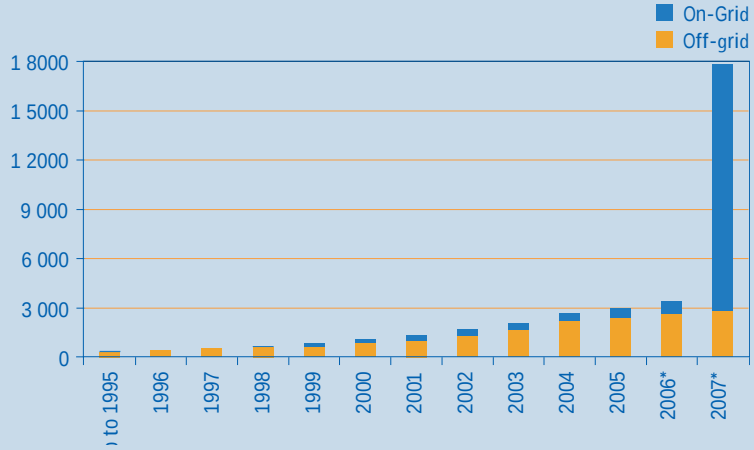
Besides the Moura factory that started construction in 2007, three other companies are planning to manufacture PV modules in Portugal: DST, Earth Life and Martifer Solar. The Martifer Solar facility will start production in October 2008, with an annual capacity of 50 MWp (mono and multi-crystalline Si modules) and expects to double this capacity by the end of 2009.

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

MARKET DEVELOPMENT

The Portuguese PV market increased strongly in 2007, from a cumulative power of 3,4 MWp to 17,8 MWp, due to the completion of the above mentioned power plants.

Fig. 5 - Solar Plus – a-Si PV manufacturing facility.



Cumulative PV Power Capacity Installed in Portugal (1995-2007)

As the off-grid market remained assumedly unchanged, with about 200 kWp/year installed power, the market structure changed radically and is now dominated by on-grid systems, with about 84 % share of the total installed capacity. This trend will be further reinforced in the near future when the remaining licensed plants will be concluded and the micro-generation scheme will be fully operationaL.

FUTURE OUTLOOK

The PV market in Portugal will continue to grow in the near future, based mainly on the already licensed grid-connected systems and plants which are currently under implementation, together with the contribution of the new micro-generation framework.

The new segmentation introduced within the IPP law, providing higher benefit for building integrated PV systems, doesn't seem interesting enough to promote the deployment of this particular market. Firstly, because the 5 kW cap for eligibility for the highest tariff rate, considered inadequate by the promoters, was not revised as expected; the feed-in tariff for systems up to 5 kW being not attractive at all. Secondly, because the administrative barriers generated within the licensing process, making it too complex and time consuming, were not removed. And thirdly, because the process under the IPP framework is still suspended and there are no positive signs from the government authorities for its continuation.

On the contrary, the "Renewables on Demand" (micro-generation) scheme, to be fully operational by the first quarter of 2008, with its simplified, web-based permit procedure, is already stimulating the market; creating new business opportunities for the main actors involved (installers, industry and energy service companies) and a general enthusiasm on the consumers side.

TABLE 3- CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (1995-2007)

YEAR	OFF-GRID (KWP)	ON-GRID (KWP)	TOTAL ANNUAL POWER (KWP)	CUMULATIVE POWER (KWP)
Up to 1995	324	12		336
1996	88	-	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	215	73	288	2 989
2006*	200	227	427	3 416
2007*	200	14 254	14 454	17 870

*Data for off-grid installation are estimated

Cumulative PV power installed in Portugal (1995-2007).

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

JAVIER SANZ, CENTRO NACIONAL DE ENERGIAS RENOVABLES, CENER

GENERAL FRAMEWORK

2007 should be defined as an adjusting period. Targets as per Spanish National Plan "Plan de las Energias Renovables (PER)" for the Deployment of Renewable Energies have been over taken by reality as the feed-in tariff scheme proved to be more than successful in pushing forward PV deployment.

Royal Decree 661/2007 showed to be a success since very likely the target of 371 MW was reached in October 2007, well in advance of the 2010 plan. Nevertheless, there is a need for a new framework to avoid a major stop of the sector.

Nowadays, the Ministry of Industry and main actors (banks, promoters, associations, etc.) are working out proposals that should take over the current scheme beyond September 2008.

The deployment of installed capacity that is feeding the grid, in accordance with CNE (Spanish National Commission for Energy) figures, reached 371 MW in October 2007 and this figure is expected to reach above 500 MW by the end of 2007. No official figures were available at the time of this report, but in any case, the order of magnitude is showing that 2007 figures are 5 times higher than what was achieved in 2006.

Similarly to 2006, there has been an increase in the average size of facilities. The new Royal Decree will continue the stimulation of bigger facilities and the average size will be somewhere between 2 and 5 MW.

NATIONAL PROGRAMME

The deployment of PV technology is driven by the targets as per "Plan de las Energias Renovables (PER)" and the Royal Decree 661/2007. Once this target is achieved, there is a need for a new target or at least a new framework in which investors, promoters and manufactures can develop the PV market.

Since the target was reached in October 2007, as per CNE analysis, there is a transition period in which all facilities are running and with all the permissions approved before September 2008. Well in advance of that time, the new rules should be established to provide confidence and continuity.

Very likely a new tariff scheme will be approved and a new target defined. The new goals will be defined reviewing how mature is the industry and the size of the sector. In any case the discussion is quite open and there are initial proposals ranging from 1,2 GW up to 20 GW.

There are still some problems to be solved. The bureaucratic approval process, that involves many different agents, is getting more complex. Extremely long approval processes in addition to the regulatory uncertainty can kill many initiatives and in any case, seriously affect the business situation.

Fig. 1 - 1,5 MW Power Plant. This size is becoming the average size of facilities connected to grid.

R, D& D

No changes are foreseen in the current research agenda. The national platform PTFV has forwarded research needs to the authorities for the next coming years, and this input was fundamental in the definition of the National Research Programme. PV is included in the overall energy research strategy and both ministries, Industry and Science, are managing the national funds covering both demonstration and applied research; and basic research.

The main lines of activity can be summarized as follows:

- New materials: thin film technology, purity, semi-conductive substrates, hetero-union concepts, silicon of "solar type," etc.
- Production technologies to manufacture solar cells.
  - Industrial Automation
  - Efficiency.
- PV modules: building integration, certification.
- PV systems: Station balance, tracking systems, control and remote management, concentration mechanisms.
- Grid integration: inverters, energy quality.

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.

The industry is claiming that the investment in R&D activities throughout 2006 were over 40 MEUR. The figure is near to 7 % of their incomes and 2007 is showing same trends.

Fig. 2 - 1,5 MW Power Plant. This size is becoming the average size of facilities connected to grid.

The private sector has been supported by the public research centres (CENER, CIEMAT & IES). The huge development potential of the PV industry is clearly tied to the effort being done in research and it is expected that there is a need for continuity over the next 5 years.

IMPLEMENTATION AND INDUSTRY STATUS

The main focus of Spanish industry has been on cells and modules manufacturing, excluding ISOFOTON, which is evolving in the wafer manufacturing area. However, there is a clear movement in the direction of vertical integration of the value chain, with the aim of reducing foreign dependency. With regards to this point, there are some projects related to the development of a silicon ingot production.

Module production capacity is continuously growing. The capacity in 2001 was in the order of 1 MWp per year and nowadays this capacity is well above 400 MWp per year. There are industrial plans to double this figure.

The main actors in this industrial capacity are, as reported by ASIF: ISOFOTON, BP SOLAR, ATERSA, GAMESA SOLAR, SILIKEN, GRUPO SOLAR, GUASCOR, SOLARIA, PEVAFERSA, ENSOL & VIDURSOLAR. There are also other relevant players in the power electronics side like: ATERSA, INGETEAM & ENERTRON.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
LINUS PALMBLAD, SWEDISH ENERGY AGENCY; MONIKA ADSTEN, ELFORSK AB AND ULF MALM, UPPSALA UNIVERSITY

Fig. 1 - One of the in total ten PV systems installed at different schools in Älvsjö south of Stockholm (photo Switchpower).

GENERAL FRAMEWORK

The installed capacity of photovoltaic (PV) systems in Sweden has grown faster than ever during 2007, all as a result of the investment subsidy for PV systems on public buildings that was introduced in 2005. This support programme has given a significant boost to the Swedish PV market and it has put focus on larger, grid-connected and building integrated systems. It has also created some media attention and it has raised awareness within sectors that previously have not been exposed to PV. An important result is also that a number of new important actors have established themselves throughout the Swedish PV value chain.

The aim of the Swedish energy policy is to secure the supply of electricity and other forms of energy at internationally competitive prices, both in the short and the long term. The way to accomplish this is to create favorable conditions for efficient use of energy and cost-efficient energy production with minimum negative impact on health, environment and climate.

Carbon emissions from the Swedish electricity production (approximately 150 TWh per year) are very low. About 50 % is generated by nuclear power and hydropower accounts for 40–45 %, (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 (about 0,6 % and 5 % respectively).

There is a stable PV market for stand alone systems in Sweden. However, the market for grid-connected PV systems relies fully on supporting incentives. The main market mechanisms for introducing renewable energy sources in Sweden are the national renewable electricity certificate system and a tax on CO_2 emissions. But neither of these has an impact on the deployment of PV systems, and the total installed PV capacity is less than 6 MW. The current support programme for PV deployment in Sweden runs out by the end of 2008 and it is still uncertain if there will be a subsequent market support after the current one. This is a very critical issue for the Swedish PV market, especially since the cap of the support programme was reached by the end of 2007.

NATIONAL PROGRAMME

The Swedish Energy Agency (www.energimyndigheten.se) is the national authority 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. The main emphasis is on energy efficiency and on the development and promotion of renewable energy such as biomass, hydropower, wind power and PV.

PV is part of the national long-term energy research programme, which is managed by the Swedish Energy Agency and has a budget of about 90 MEUR per year for the period 2006–2008. The agency provides funding for PV research, co-financed technological development, demonstration and business development. The budget for PV is in the range of 2–2,5 MEUR per year, depending on which projects are currently running. Additional funding for PV research in Sweden can be received from e.g. the Swedish Research Council, the Nordic Energy Research programme and private foundations.

In addition to international cooperation through the IEA PVPS, Sweden is participating in PV-ERA-NET (www.pv-era.net), which is an EU-funded network for national programme owners. PV-ERA-NET started in October 2004 and runs over four years. The objective of the project is to increase collaboration and coordination between the national PV R&D programmes in the European Research Area.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The thin film CIGS research at Uppsala University has been going on since the 90s (www.asc.angstrom.uu.se). The technology is on the verge of industrial realisation and a spin-off company, Solibro AB, was launched in 2003 (see Industry Status below). The aim of the university research 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, minimization of the thickness of the active layer and increased process speed are the main objectives.

The Center of Molecular Devices (www.moleculardevices.se) at the Royal Institute of Technology in Stockholm connects different research groups from the Royal Institute of Technology, Uppsala University and the public-private partnership company IVF AB. The aim is to develop nanostructured dye-sensitized solar cells and modules that can be manufactured at very low cost. 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 long-term objective of manufacturing efficient and inexpensive solar cells for large scale electricity production.

There are several PV related projects that have received funding through the Swedish Research Council's call for basic research.

Fig. 2 - One of the largest and the most spectacular PV plant in Sweden was completed in July 2007 in the City of Malmö in the old hospital area of Sege Park (photo Malmö Stadsfastigheter).

One specific field that stands out is polymer solar cells, where research is conducted at several universities in Sweden.

At the division of Energy and Building Design at the University of Lund, research is conducted primarily on solar energy integration into buildings. One of the research themes is low concentration PV and hybrid systems with combined PV and solar thermal systems. The division for Environmental Systems Analysis, Chalmers University of Technology in Gothenburg are for example studying innovation systems and policy issues. The research group has e.g. studied the effects of support mechanisms for emerging energy technologies like PV.

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 utilities, manufacturing companies (PV and other) as well as building companies and property owners. The previous programme period ended at the end of 2007 and it has been decided that the programme will continue with a new period from 2008–2010. The budget is approximately 0,6 MEUR per year. 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 applications, analysis of performance and costs of PV systems (both technical and non-technical) as well as information dissemination.

As a part of the information dissemination effort, the SolEl programme follows and reports to Swedish organisations on the international development of PV, and serves as a reference group for participation in the IEA PVPS. The programme is used as national forum for exchange of information about PV.

Examples of projects funded by the programme are feasibility studies for PV projects, studies on the added value of PV, development of concentrating and PV/thermal systems as well as monitoring of the performance of grid-connected systems (www.elforsk.se/solenergi).

The latter is closely related to the activities in IEA PVPS Task 2. The interest in the programme from the building industry has increased during the last couple of years, due to the rapid international development of building-integrated photovoltaics (BIPV). This has led to a shift of focus towards BIPV, with planning tools for architects and builders being developed. Other examples of projects and activities are regional PV seminars, international study tours, handbooks and guidelines.

IMPLEMENTATION AND MARKET DEVELOPMENT

The market for PV in Sweden has traditionally been 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 not available. Apart from the off-grid domestic market, there are off-grid non-domestic systems, supplying electricity for tele-communication systems, lighthouses, etc., and a few grid-connected systems. Until May 2005, the lack of market support for PV resulted in a comparatively slow development of the PV market in Sweden. Total cumulative PV power installed amounted to approximately 4 MW; of which 226 kW were grid-connected. These grid-connected systems are mostly demonstration projects intended to test and display the PV technology in general or for the purpose of research.

Things changed in May 2005 when an investment subsidy for the installation of PV systems in public buildings was introduced. The subsidy is a part of a comprehensive investment programme for energy efficiency and renewable energy in public buildings such as sports centres, conference halls, churches, schools, airports, railway stations, etc. There is a cap of about 16 MEUR, corresponding to about 3 MW in additional capacity. The subsidy is given as a 70 % investment support of the total system costs, including both material and labour costs. There is an upper limit of 0,55 MEUR per building. The subsidy scheme has jump-started the domestic market for PV in Sweden and many new actors have come in contact with the PV technology as a result. An important motive for the programme was to promote the development of professional know-how among installers, architects, project developers, etc. The support programme runs until the end of 2008. By the end of 2007, applications for 15,5 MEUR (corresponding to almost 3 MW installed PV capacity) had been approved and the cap is thereby more or less reached. Hence the total installed PV capacity in Sweden will almost double in three years time and the installed capacity of grid-connected BIPV applications will increase more than tenfold.

Since there are not that many BIPV systems in Sweden many of the new systems built within the support programme are built to create extra attention. During 2007 there were several examples of new spectacular BIPV systems, such as the 86 kW system on the Ullevi Stadium in Gothenburg, the two systems at Sege Park in Malmö with a total of 165 kW PV power and the 78 kW system at Båstad Tennis Stadium.

There are still very few grid-connected residential systems in Sweden, mainly due to the high prices of PV systems, the high cost of

Fig. 3 - In time for the Swedish Open tennis tournament in July 2007; approximately 80 kWp split into two systems, were installed at the Båstad Tennis arena (photo Glacell /Sharp).

grid-connection and the lack of financial support for private PV installations. However, the issue of the cost for grid-connection has been debated in the PV community and the government is aware of these problems and an assessment of possible solutions was performed during 2007. The recommendations from this assessment are expected to be delivered in the beginning of 2008.

INDUSTRY STATUS

The Swedish PV industry has grown significantly over the last couple of years. Today, there are five companies in Sweden that produce PV modules. All of them buy cells from abroad and assemble modules, which to a large extent are exported. Gällivare PhotoVoltaic AB (GPV) was the first module manufacturing operation set up in Sweden. There are two module manufacturers in Gällivare, the other one is called ArcticSolar AB. In 2006, there was even a third factory, n67 Solar AB, established in the same region of northern Sweden. PV Enterprise Sweden AB is one of the younger module manufacturing companies in Sweden; it was started in 2002 by the former head of GPV. ScanModule AB, which is a subsidiary of the Norwegian Renewable Energy Corporation (REC), commenced its module production in 2003 and has undergone rapid expansion to become the largest module manufacturer in Sweden; with 160 employees in 2006. This has been possible thanks to the supply of cells from the sister company REC ScanCell AS in Norway. The expansion continued during 2007 with the introduction of more automated production technology, in conjunction with a capacity expansion to 100 MW per year.

Despite the new investment subsidy, the annually installed PV capacity in Sweden only constitutes a small fraction of the approximately 55 MW per year of modules produced. The share of the production that is exported varies from manufacturer to manufacturer, but is generally more than 90 %.

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, but there are plans for production of thin-film CIGS cells by the company Midsummer AB (see below).

The company Solibro AB conducts development of large scale processing and module integration of CIGS thin-film solar cells. The company was founded as a spin-off from the thin-film solar cell group in Ångström Solar Center. In November 2006, a joint venture with German solar cell manufacturer Q-Cells GmbH, called Solibro GmbH, was announced. This provided additional funding for a fullscale manufacturing facility that will be located in Thalheim, Germany. The industrial research part of operations will remain in Uppsala.

Independently from Solibro AB, another company, Midsummer AB, has developed another production process for CIGS solar cells. The founders of Midsummer AB have experience from e.g. the thin film and semiconductor industries. Their aim is to reduce the production cost of CIGS cells by combining knowledge from these industries, experience from mass production and an unconventional manufacturing process. Large scale cell production is planned to start during 2008.

Low-concentrating combined photovoltaic/thermal systems are a Swedish niche, in which research and development has been conducted for more than ten years. Recently, the company Arontis Solar Concentrator AB has been established to commercialise this technology. Arontis's first product is an 8X concentrating, east-west oriented, sun tracking PV/T system that produces electricity and hot water simultaneously.

FUTURE OUTLOOK

The high costs of grid-connection and obligatory metering are obstacles for the deployment of PV in Sweden. The recommendations from the assessment of grid-connection of renewable energy sources are expected to suggest improvements in the conditions for grid-connection of PV systems in Sweden. If these recommendations are implemented it will create better prerequisites for new PV systems in Sweden. However, changes are not likely to be implemented before July 2009.

A critical point in the development of the Swedish PV market is what will happen after the current support scheme. This issue is especially urgent since the cap of the support scheme is reached already at the beginning of 2008; almost a year before it is planned to end. PV advocacy groups like the Scandinavian Photovoltaic Industry Association (www.solcell.nu) and Svensk Solenergi (www.svensksolenergi.se) are currently lobbying for a new support for PV deployment. 2008 will still be a busy year for the PV system installers in Sweden, but with declining activity towards the end of the year and if there is no subsequent support scheme in place after 2008, it will most likely result in a sudden halt for the Swedish PV market.

2008 will also be an interesting year for the two Swedish companies working with CIGS solar cells, Midsummer AB and Solibro AB, who are both planning to start large scale production during the coming year.

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS

STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.,
ON BEHALF OF THE SWISS FEDERAL OFFICE OF ENERGY (SFOE)

Fig. 1 - Extension of the solar power system on the football stadium Wankdorf in Bern to 1,35 MWp (PV design, engineering and installation: energiebüro®, Ingenieurbüro Hostettler, Minder Energy Consulting, TRITEC; photo: TRITEC).

GENERAL FRAMEWORK

Throughout 2007, the framework for photovoltaic technology development in the public sector did not experience any particular changes: Research and development activities persisted on the level of previous years whereas support for new pilot and demonstration systems continued to be very limited. The latter continues to pose a barrier to the rapid transfer of results from R&D into industrial solutions and products. On the other hand and driven by the rapid growth of the worldwide photovoltaic market, industry development continued to be strong with new entrants and production facilities announced.

Energy policy matters remained constantly high on the political agenda with various important decisions at government and parliament level all throughout the year 2007. Early in the year, the federal council announced the main energy policy goals along four main priorities, namely in-creased energy efficiency, increased use of renewable energies, new large scale power plants and a specific foreign policy for energy. In spring 2007, the parliament decided for the introduction of a CO_2 tax in the heat and power sector and concluded the debate for a new act on the liberalisation of the electricity market. In September, the Department of the Environment, Transport, Energy and Communications announced action plans for energy efficiency and renewable energy.

Of greatest relevance for photovoltaics and other renewable energies is the new act concerning the liberalisation of the electricity market. After the rejection by public referendum of the first attempt on this subject in 2002, a new law has now been adopted. Within this law, a goal of additional 5 400 GWh from “new” renewable energies by 2030 is formulated. The feed-in tariff model was decided as the main support scheme to be implemented. However, the law also includes green power marketing as a possible market model and the two promotion schemes may be changed during the lifetime of a power system. To support the deployment of renewable electricity through the feed-in tariff model, a levy of 0,6 cCHF per kWh of consumed electricity has been decided, yielding a total annual amount of about 320 MCHF. This amount is divided into maximum contributions from each of the renewable energy technologies.

Following the adoption of this law in March 2007 by the Swiss parliament, the rest of the year was devoted to elaborating the concrete terms and details. The act came into force on 1 January 2008 and actual payments in the feed-in tariff scheme will commence in 2009. This represents an important advance for the Swiss photovoltaic market deployment. It should allow the photovoltaic sector to follow a steady albeit quite limited growth over the years to come. Increased interest in renewable energy in general and photovoltaics in particular could be observed throughout the year 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, with 2007 as the last year of 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). During 2007, the next 4 year energy RTD master plan, covering the period 2008 – 2011 was adopted. It confirms the important position of photovoltaic RTD in the Swiss energy RTD landscape.

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 were limited during 2007. 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 has so far mainly been driven by voluntary green power marketing programmes of utilities. This will now change to the feed-in tariff scheme as explained above. Finally, the programme places emphasis on information and communication in order to raise the awareness for opportunities involving photovoltaics.

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 2007, the first term of the interdepartmental platform for the promotion of renewable energy in international

Fig. 2 - Minergie-P-eco office building Marché International in Kemptthal with 45 kWp solar power system (architect: Beat Kämpfen, PV design and engineering: Suntechnics, photo: Suntechnics).

Fig. 3 - Zero energy multifamily buildings Eulachhof in Winterthur with 176 kWp solar power system (PV design and engineering: Amstein & Walthert, TRITEC, photo: TRITEC).

co-operation – REPIC – was successfully concluded (www.repic.ch). This platform supported different photovoltaic projects of Swiss entities in developing countries. The four participating government agencies decided to extend the REPIC platform for a second term and to introduce energy efficiency as an equal topic to be promoted in the future.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Swiss Photovoltaic RTD Programme is based on a 4 year RTD master plan, covering the period 2004 – 2007. In the last year of this period, overall 55 projects, supported by various national and regional government agencies, the research community and the private sector were 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 2007, emphasis on transfer from R&D to industrial processes and products continued. Work on thin film silicon at the University of Neuchâtel concentrated on the efficiency and reproducibility of micromorphous solar cells as well as the rapid large area deposition of its individual layers of amorphous and microcrystalline silicon, including work on transparent conductive oxides (TCO) and intermediate reflector layers. In the area of thin film silicon, strong co-operation with the companies VHF-Technologies and oerlikon solar continued. During 2007, the equipment manufacturer oerlikon solar extended its activities as a leading supplier of manufacturing systems of thin film silicon solar cells on glass and was able to acquire a number of important large orders. 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 aluminium. During 2007, the spin-off company FLISOM, active in this solar cell technology, continued its efforts towards an industrial product.
For dye-sensitised solar cells, work continued on new dyes and electrolytes as well as high temperature stability of the devices. Exploratory work was undertaken on new solar cell concepts (organic solar cells) at the Swiss Federal Laboratories for Materials Testing and Research EMPA.

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 25 years of operation. Continuous development of system solutions has resulted in a number of industrial products which are increasingly being exported.

Along with the examples of the solar powered airplane project SolarImpulse (www.solar-impulse.com) by Bertrand Piccard and the solar powered boat project PlanetSolar (www.planetsolar.org), both of which plan to travel around the world by air and respectively on water in the coming years, the solar powered car project Solartaxi (www.solartaxi.com) started its actual trip in 2007. By the end of 2007, it had reached the Asia Pacific area and was in Bali during the UNFCCC Climate Change Conference.

International co-operation continues to form a strong pillar of the R&D activities with 11 projects running in the 6th and 7th framework RTD programmes of the European Union during 2007, of which 3 are integrated projets. Swiss research groups are participating in the integrated projects FULLSPECTRUM, PV-ATHLET and PERFORMANCE. International projects are also carried out as part of programmes such as the European Space Agency: The project envisolar aimed at the increased use of satellite based solar radiation information in solar energy industries and for monitoring purposes. The co-operation within the IEA PVPS programme has remained a further strategic activity. Founded in 2005, a national IEA PVPS pool receiving support from the electric utilities of the city of Zurich, the Cantons of Basel as well as Geneva, the Mont-Soleil Association and SWISSOLAR contributed to the Swiss expert participation in IEA PVPS. The support to Swiss IEA PVPS activities could thus be broadened, in particular for activities in Tasks 2 and 10.

Fig. 4 - Industrial production equipment for thin film (amorphous and micromorphous) silicon solar cells from oerlikon solar (photo: oerlikon solar).

On the programme level, international co-operation is also taking place through the PV-ERA-NET project (www.pv-era.net) and the European Photovoltaic Technology Platform (www.eupvplatform.org).

IMPLEMENTATION

Up to 2006, market implementation of PV systems was mainly driven by green power marketing schemes of utilities. 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. 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. Small scale private, domestic and non-domestic systems form a complementary part of the Swiss photovoltaic market which is served by local businesses.

In expectation of the introduction of the feed-in tariff scheme, interest for photovoltaic projects strongly increased throughout 2007. As the new promotion scheme allows projects back to 2006 to be promoted under the feed-in tariff scheme, many new projects were initiated during 2007. In particular, farmers with their large roof buildings have become very interested in realising photovoltaic projects.

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 190 MW/year. The Studer Company produces stand-alone inverters and is also very successful in exporting. ASP solar is the third company active in the inverter area.
On the PV industry supply side, an increasing number of companies are serving the worldwide photovoltaic market, e.g. wiresawing machines for silicon ingots from Applied Materials Switzerland (formerly HCT) as well as from Meyer & Burger; stringing, tabbing and soldering machines for solar cells from KOMAX or measuring equipment for PV module manufacturers from Belval. Swisswafer is extending its production capacity for silicon ingots and wafers. Solar plugging systems are offered by Multicontact as well as Huber & Suhner. The Alustand® and SOLRIF® mounting systems for building integrated applications have been very successful on the market.

Sarnafil, now a part of the SIKA Company, has developed a flexible, watertight flat roof PV system based on thin film silicon solar cells and 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 (oerlikon solar) and products based on thin-film technology (Flexcell® from VHF-Technologies, FLISOM). In 2007, oerlikon solar received a number of large orders for industrial production equipment of amorphous silicon solar cells and newly introduced the production equipment for micromorphous solar cells. Using oerlikon solar's technology, the project of a 30 MW production line by the Pramac Company, to be implemented in the southern part of Switzerland near Locarno, was announced. During 2007, VHF-Technologies announced the plan for a 25 MW production line for thin film silicon solar cells on flexible substrates. Furthermore, Swiss Solar Systems (3S) is building some of the world's largest

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2006 (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
2005	200	1 900	23,8	17 800	850
2006	250	2 150	26,1	21 000	845

(grid-connected systems)

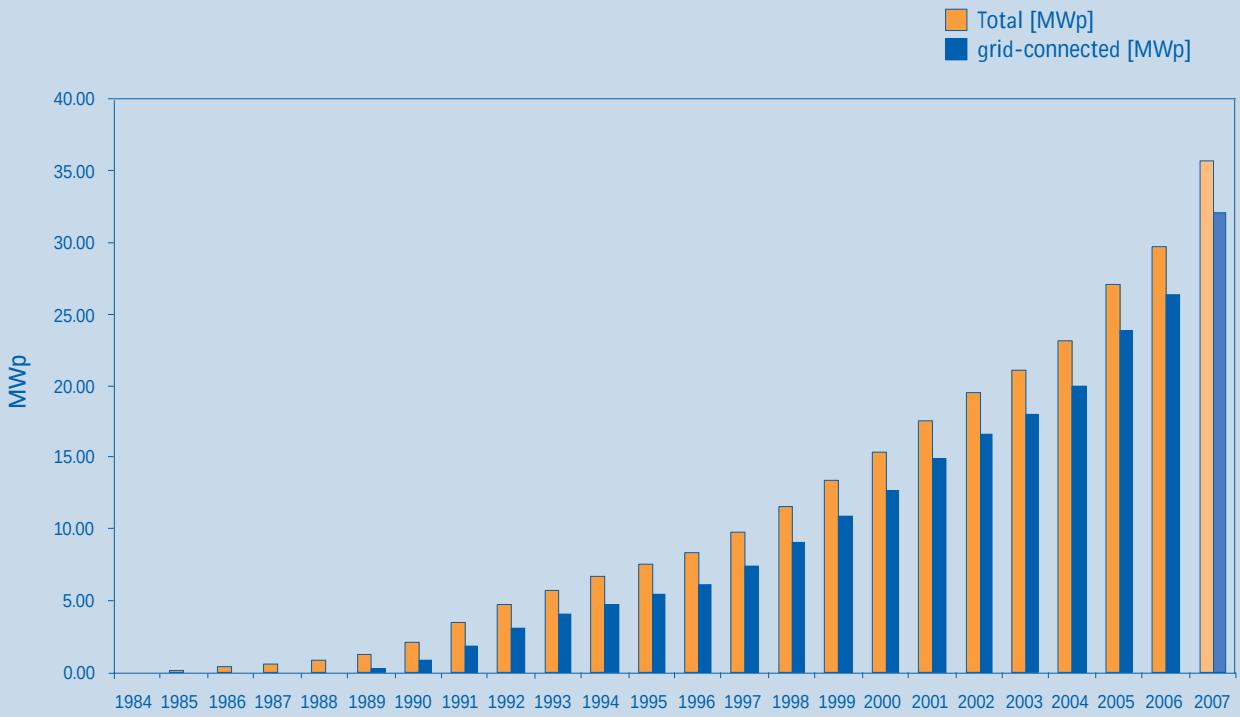


Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between1984 and 2007 (total and grid-connected, estimated values for 2007).

PV module laminators. 3S has continued the strategic cooperation with the German company Schmid.

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 total export volume of Swiss photovoltaic products is estimated to more than 500 MCHF in 2007. 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, so far mainly driven by green power marketing schemes of utilities, supported by a few remaining promotional programmes and actions in some cantons, has experienced a stronger development in expectation of the feed-in tariff to be introduced soon. The annual market volume for grid-connected systems is estimated to a value around 6 MWp, which is about twice the market size of previous years. The total installed capacity has thus risen to about 36 MWp (Figure 5), corresponding to about 5 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 2006 is thus approaching 21 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue with an ever-increasing focus on industrial developments, new products for niche markets and ongoing international involvement. For solar cells and modules, the efforts to bring Swiss technology to the market place is expected to materialise in further industrial activity. 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 7th 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 and joint projects will be established in the framework of the PV-ERA-NET project.

With the introduction of the feed-in tariff scheme in 2008, becoming operational in 2009, the next years will be most interesting concerning the domestic market development. On the supply side, new players can be expected, leading to increased competition. On the demand side, stronger marketing activities and end-user orientation will need to take place in order to reach and satisfy new customers. Due to the present limits built in the feed-in tariff scheme, some of the high expectations may not be fulfilled in the short term and the policy debate is expected to continue.

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS
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GENERAL FRAMEWORK

Turkey, with a population of 70 586 256 in 2007 and a surface area of 781 000 km^2, lies in a sunny belt between 36°-42° north latitudes and is geographically well situated with respect to solar energy potential. Turkey is located in an "energy corridor" which is between the major oil and natural gas producing countries in the Middle East and Caspian Sea and the Western energy markets. According to official reports of EIE (The General Directorate of Electrical Power Resources Survey and Development Administration), annual sunshine duration of Turkey is 2 640 hours and annual horizontal solar irradiation is 1 311 kWh/m^2 (Figure1).

In Turkey, electricity is mainly produced by thermal power plants, by consuming coal, lignite, natural gas, fuel-oil and geothermal energy, wind energy (recently) and hydropower plants (TEIAS web page, 2008). The electricity requirement, which is called gross demand, was reported as 174 000 GWh in 2006 by TEIAS (Turkish Electricity Transmission Co.). The electricity is mainly produced by thermal power plants and accounted for 74,82 % of the total, while hydro power energy was 25,11 % and the wind power energy was 0,07 %. In the thermal electricity production, the lignite part was 18,37 % and natural gas was 44 %. Compared to other energy sources, PV systems don't have sufficient contributions to gross electricity demand. There are no sufficient governmental driving forces to support PV systems in Turkey yet. Turkey's annual solar energy potential is estimated to be 1015 kWh, which is more than 5 700 times of the present electricity consumption.

NATIONAL PROGRAMME

Turkey announced in the development plans, the main objectives of its energy policy are to ensure sufficient, reliable and economic energy supplies in order to maintain economic and social development, to provide the growing energy demand, to reform and to liberalize the energy sector to increase productivity and efficiency and to advance transparency. The main difficulties are the increasing demand and the import dependence. The events because of the global climate change caused to take into account the environmental concerns in all stages of energy chain. Turkey is taking steps to respond to the threat of climate change. Turkey acceded to the United Nations Framework Convention on Climate Change, UNFCCC, in May 2004. The Turkish Grand National Assembly adopted a decision to set up a Research Commission on the causes and effects of global warming in the country in February 2007. However, Turkey has not yet signed the Kyoto Protocol. Turkey needs to consider some form of emissions reduction requirement in the foreseeable future.

The new "Energy Efficiency Law (No.5627)" has enabled the utilization of the utility grid as an energy reserve until 200 kWp power for renewable energy sources without permission. Although there is not any feed in tariff, the law also has enabled to provoke some new PV applications as grid-connected systems.

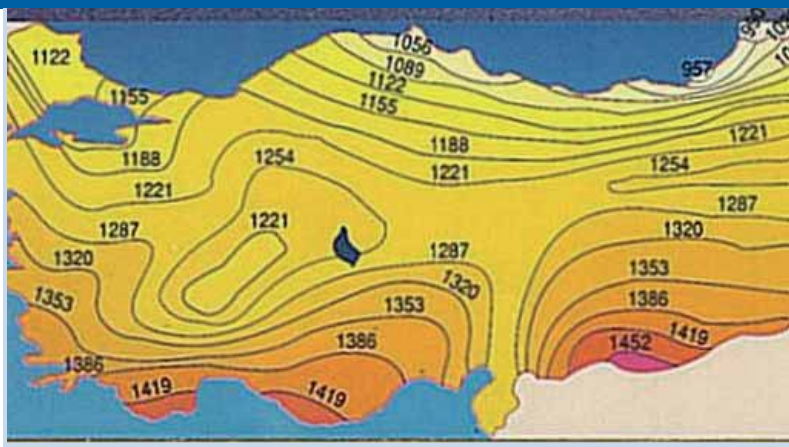

Fig. 1 - Solar Map of Turkey (kWh/(m^2.year) (photo EIE, General Directorate Of Electrical Power Resources Survey And Development Administration).

R, D & D

PV research has been realized in the Turkish University Research Laboratories to gain further experience in PV. The Solar Energy Institute, situated on the campus of Ege University in Izmir, was founded in 1978 for graduate education and research on Solar Energy and its applications. Ege University Solar Energy Institute is still the only research institute which mainly works on solar energy research topics. The institute also supports some projects of the municipalities and the other societies to increase the PV applications in Turkey. A project which is mainly financed by United Nations with the support of the institute has been executed as a solar lighting system in Gokceada which is the biggest island of Turkey. The studies are maintained in the production of organic dye-sensitized solar cells by the Solar Energy Institute of Ege University. – Ege University Solar Energy Institute increases its PV power capacity by producing the solar modules with the lamination technique of silicon solar cells (Figure 2). The total PV capacity has reached to 24 kWp. The grid-connected PV power systems were followed/examined during the year (Figure 3). 14 kWp of the PV system has reorganized as a new stand-alone hybrid PV power system at the end of 2007 (Figure 4).

IMPLEMENTATION

The recent historical development of the solar energy sector in Turkey can be summarized as follows: The total installed photovoltaic power system has reached about 3 MWp in Turkey.

2001

- The Solar Energy Institute of Ege University began to R&D studies on organic dye-sensitized solar cells to realize and to simplify the production processes and to lower the cost.
- A 14 kWp PV power plant was installed for starting up energy of some units in Berke Dam.

2002

- Installation of the largest grid connected PV power plant to date in Mugla University with 10,4 kWp capacity.

Fig. 2- The silicon based PV module production from the cells in 2007 by the Solar Energy Institute of Ege University.

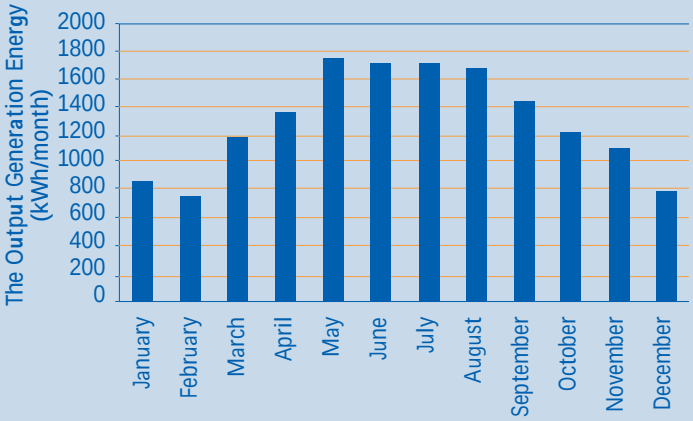

Fig. 3 - A Review of the 11kWp PV Power System in Izmir.

Fig 4 - PV power system in Izmir by Ege University Solar Energy Institute (14 kWp stand-alone and 10 kWp grid-connected PV system).

Fig. 5 - PV-wind-diesel generator hybrid power system in an island in Fethiye-MUGLA by Girasolar Ltd.

2004

- Mugla University increased the total PV power capacity to 54 kWp.

2005

- The Solar Energy Institute of Ege University installed 22,2 kWp PV grid-connected power plant in Izmir.
- TUBITAK (The Scientific and Technological Research Council of Turkey) initiated the first Formula-G solar car race between the Turkish universities. The TUBITAK plans to continue these solar car races in the next years in order to introduce solar electricity energy to the university students.

2006

- The Solar Energy Institute of Ege University set up a PV module production laboratory which is the first of its kind in a university.
- A Turkish company (Akkanat Technologies A.S.) began to produce PV modules with 5 MWp/year capacities in Istanbul (The manufacturer stopped the production at the present).

2007

- The first PV-wind-diesel generator hybrid power system was installed in a island by Girasolar Ltd. (Figure 5). Ege University Solar Energy Institute contributed to the project, as well. The project was performed on an island (Fethiye-Kizilada) which doesn't have any utility grid connection. On the island, a restaurant provides the required energy with this hybrid system (17,5 kWp multi-crystalline solar modules, 15 kWp wind turbine, 35 kVA diesel generator, 48 V 3000 Ah battery capacity).
- In March 2007, the Energy Minister of Turkey opened a "Clean Energy House" in Pamukkale University, Denizli-Turkey. The house has a PV system that totals 5 kWp , which will also be used for hydrogen production.
- 30 kWp grid-connected PV power systems were installed in the TESCO-KIPA supermarkets in Marmaris and Kusadasi (totally 60 kWp PV systems) by Enisolar Ltd. (Figure 6). Some attractive small PV applications were also performed by Enisolar Ltd. in 2007 (Figure 7).
- TUBITAK-MRC has installed a stand alone renewable hydrogen demonstration park in Gebze. Ege University Solar Energy Institute was a participant of TUBITAK-MRC in the project. The autonomous system includes PV-wind-fuel cell hybrid power components (Figure 8).
- Turk Telecom has decided to install a 250 kWp photovoltaic power system for telecommunication systems. The company of Analtech Ltd. began to install these PV power systems in 2007. Some small PV systems were also installed for GSM telecommunication systems (Figure 9).

INDUSTRY STATUS

The photovoltaic sector in Turkey is still fairly small, providing work for only a small number of employees. The main actors consist of several companies and a number of research institutes. There are approximately 30 companies which are operating in Turkey's

Fig. 6 – 30 kWp grid-connected PV system in Marmaris by Enisolar Ltd.

Fig. 7 - A small PV-wind application by Enisolar Ltd. in Istanbul.

Fig. 8 - HYDEPARK Project in TUBITAK-MRC in Gebze. (12 kWp PV modules, 5 kWp wind turbine, 2,4 kWp PEM type fuel cell, 48 V 1500 Ah battery capacity, inverters, a meteorology station, etc.).

Fig. 9 - A hybrid PV-wind application for telecommunication systems by OZMAK Ltd. in Cesme-Izmir.

PV sector. The main business types are importer, wholesale supplier, system integrator and retail sales. The companies serve in the installation, engineering and project development sectors.
PV modules, battery charge controllers and inverters are mainly imported. Batteries, solar lighting systems, etc., may be supplied by the domestic market. Some of the domestic products (batteries, tempered glass, etc.) are exported. There is not any cell production factory in Turkey.

MARKET DEVELOPMENT

The potential of Turkey as a photovoltaic market is very large, since the country abounds in solar radiation and large areas of available land for solar farms. At present, Turkey doesn't have any reasonable legal structure which enables the production of more PV energy and the selling of excess energy to the grid. Therefore, the most PV applications are used for stand-alone power systems. The Turkish government has to arrange the legal structure according to the PV grid-connected power systems and to finance a part of the cost. Turkey needs feed-in tariffs in the renewable energy field in order to meet European standards; as Turkey is seeking full membership in the European Union. Photovoltaic power systems should be included in the new energy programmes in Turkey

FUTURE OUTLOOK

The energy policy objectives of Turkey essentially require diversifying the energy sources, to use domestic energy resources, to increase efficiency in electricity generation and consumption and to create an environment-friendly power system. It is clear that all of these objectives include increasing the share of renewable energy sources in total electricity generation. Although the Turkish government and citizens have been familiar with wind energy and accepted it as renewable energy technologies in recent years, most of them don't have enough knowledge about solar electricity potentials as alternative energy sources. Most of the Turkish people believe that solar energy that can only be used for water heating. To improve a level of understanding and acceptance of PV systems, first, the production of PV panels and the usage of the PV power systems should be promoted for low cost systems. R&D studies at the universities and institutes in the PV area should be significantly supported, as well.

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UNITED KINGDOM

PV TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK

The Energy White Paper, published in May 2007, sets out the Government's energy strategy to tackle climate change and ensure a secure, clean and affordable energy supply. One of the key elements to the strategy is to support the development of low carbon technologies.

The 2007 White Paper confirmed and strengthened the government's commitment to The Renewables Obligation (RO), the UK's key mechanism for encouraging new renewable generating capacity. The RO was introduced in 2002 and requires licensed electricity suppliers to source a specific and annually increasing percentage of their sales from eligible renewable sources. For 2007/08 the level of the RO is 7,9 % rising to 15,4 % in 2015/16. Suppliers can meet their obligation by either presenting Renewable Obligation Certificates (ROCs); paying a buyout price (34,30 GBP per MWh in 2007/08 rising each year with inflation); or a combination of the two. Renewable Obligation Certificates (ROCs) are issued to generators for every 1 MWh of eligible renewable electricity that they generate. These ROCs can then be sold to suppliers. At the end of an obligation period the money in the buyout fund is recycled to those suppliers who presented ROCs on a pro rata basis.

Minor changes to the RO introduced in April 2007 included measures to make it easier for small generators such as photovoltaic systems to access the benefits of the RO.

More significant changes to the RO are planned for 2009 and consultation on the proposed changes was conducted during 2007. The changes include providing differentiated levels of support to different technologies in order to encourage a larger contribution from emerging renewable technologies. Microgenerators (i.e. generators under 50 kW) including PV will receive two ROCs per MWh generated from April 2009.

A consultation on how the UK is to meet its contribution towards the European Union's 20% renewables by 2020 target was announced in November 2007. A full renewable energy strategy is to be published in 2009.

NATIONAL PROGRAMME

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

- Research and development, funded by the Department for Innovation, Universities and Skills (DIUS) sponsored Technology Strategy Board and the Engineering and Physical Sciences Research Council (EPSRC);∑
- Implementation of the Government's Microgeneration Strategy (BERR) which includes a grants programme (The Low Carbon Buildings Programme);
- 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. Research and development programmes are focused on cost reduction and novel PV materials.

Fig. 1 - The 23 kW solar roof at the Print House in Dalston, East London is the largest PV roof tile installation in the UK (photo The Bootstrap Company).

The UK PV Domestic Field Trial (PV DFT), which began in 2000 was the first widespread monitoring of PV systems in domestic buildings in the UK. Along side the Domestic Field Trial, the UK Large Scale Field Trial for building integrated photovoltaics was implemented to raise awareness and create confidence in the application of PV and increase UK capabilities in the application of the technology. The success of the field trials was continued by the Major Demonstration Programme which provided capital grants for quality PV projects between 2002 and 2006.

In 2006 the Government launched its Microgeneration Strategy. The term microgeneration includes solar photovoltaics, micro wind turbines, micro hydro, solar thermal, ground/water/air source heat pumps, biomass, renewable CHP, micro-CHP (combined heat and power) and fuel cells (below 50 kW). The objective of the Microgeneration Strategy is to create conditions under which microgeneration becomes a realistic alternative or supplementary energy generation source for the householder, communities and small businesses.

The strategy includes a range of actions including a new accreditation scheme, The Microgeneration Certification Scheme which has just been launched for both products and installers. Over 400 installers have already signed up. MCS assesses products and installers against robust standards for each of the microgeneration technologies (see www.microgenerationcertification.eu). The aim is to help create a rapidly growing and sustainable microgeneration industry, based on quality and reliability.

Fig. 2 – 13,7 kW PV array at Lewisham Hospital, London (photo Dulas).

Fig. 3 - This 9,9kW array was installed during 2007 as part of the Isle of Eigg Electrification project (photo Wind and Sun).

The Low Carbon Buildings Programme provides grants for certified microgeneration installations and forms part of the implementation of the strategy.

RESEARCH AND DEVELOPMENT

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 Government funded Technology Strategy Board. Within a new call launched in Autumn 2007, the Board sought proposals for research into whole systems approaches to integrating microgeneration in buildings and also for PV technology Research and Development that significantly reduces costs and improves efficiencies.

The EPSRC Sustainable Power Generation and Supply (Supergen) Programme supported two multi-disciplinary consortia focused on advanced PV materials during 2007:

- The 'Photovoltaic Materials for the 21st Century' consortium was launched during 2004 and aims to develop low-cost thin-film solar cell devices fabricated from inorganic semiconductors. This thin film process has the potential for considerable cost reductions. The project has been approved for funding for a further four years from 2008.
- The Supergen Excitonic Solar Cells consortium, led by the University of Bath, is researching dye and nanoparticle- sensitized and organic cells which may offer the possibility of low toxicity, flexible and easy to manufacture PV materials. Consortium members are concentrating on understanding the factors which limit efficiencies as well as on combining their expertise to devise entirely new types of solar cells.

IMPLEMENTATION

The Low Carbon Buildings Programme forms part of the above mentioned Microgeneration Strategy and provides grants for micro-generation technologies including PV for householders, community organisations, schools, the public sector and businesses. The three year, UK wide scheme aims to demonstrate how energy efficiency and small scale renewables will work hand in hand to create low carbon or zero carbon buildings. Minimum energy efficiency standards must be met before applying for a grant. Up to 50 % funding is available for new PV projects, subject to maximum levels per kW. The programme has been extremely popular with householders; an additional 6 MGBP for the householder stream was announced in March 2007 (see www.lcbp.org.uk).

Figures for the PV capacity installed during 2007 are not yet available but early indications point to similar growth to that experienced in 2006 with around 3,5 MW being installed during the year. This brings the total cumulative installed capacity to approximately 18 MW. The majority of systems being installed are grid connected building mounted installations.

INDUSTRY STATUS

PV Crystalox Solar manufactures silicon ingots in Oxfordshire, United Kingdom. The company listed on the London Stock Exchange in June 2007. Sharp, with its PV module manufacturing facility in Wrexham continues to be the single largest employer in the UK PV industry and in February 2007 announced plans to double its production capacity from 110 MW to 220 MW. Small quantities of BIPV are manufactured by Romag, the specialist glass manufacturer in Consett, County Durham.

FUTURE OUTLOOK

The ongoing implementation of the Microgeneration Strategy, including the low carbon buildings programme, will support continued growth in the UK's PV industry.

Beyond 2009 the main source of funding for domestic scale renewables will come from The Carbon Emissions Reduction Target (CERT), an obligation for energy suppliers to achieve reductions in carbon emissions in the household sector. Under CERT, which will build on an existing similar scheme called the Energy Efficiency Commitment, energy suppliers will promote energy efficiency, microgeneration and behavioural measures that will deliver financial benefits to consumers and contribute to the eradication of fuel poverty.

2007 saw the announcement of the Government's intention for all new homes to be zero carbon by 2016. This is to be implemented through changes in the building regulations. Since PV is ideally suited for building integrated applications it is likely that this will increase demand for PV and support ongoing growth.

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND FUTURE OUTLOOK

LAUREN POOLE, NATIONAL RENEWABLE ENERGY LABORATORY

GENERAL FRAMEWORK

For the United States, photovoltaic (PV) innovation defined 2007. The future of PV in the United States began to take shape as innovative PV products and programs in states and cities made PV more affordable for homeowners and businesses. Throughout the year, solar advocates lobbied Washington to extend and expand the federal tax credit, which provides a 30 % credit for commercial and residential solar installations (up to 2 000 USD for residential). The federal tax credit and other investment tax credits were not included in the Energy Independence and Security Act signed in late 2007. The new energy bill also did not require utilities to produce 15 % of their electricity from renewable sources, although roughly half the states have enacted a renewable portfolio standard (RPS). Meanwhile, the U.S. Department of Energy (DOE) partnered with national laboratories, universities, and private industry to advance PV technology by financing product innovation and market transformation. Interest in utility-scale PV projects increased as states created more incentive programs for PV installations. Top policy issues at the state level included interconnection agreements, renewable portfolio standards, and net metering. According to a report published by several nonprofit organizations titled "Freeing the Grid," New Jersey and Arizona led the nation with the best interconnection policies, while Colorado, Maryland, New Jersey, and Pennsylvania led the nation in net-metering policies. Solar energy also became more popular with consumers in 2007 as new residential "solar communities" began to emerge along with new solar businesses that offered a variety of PV products and financial assistance.

NATIONAL PROGRAMME

Launched in 2006, the Solar America Initiative (SAI) is a DOE effort to make PV technology cost-competitive with conventional forms of electricity by 2015. In 2007, the national program strategy and priorities included supporting fundamental research and prototype development of next-generation, low-cost PV products; testing and evaluation; and expanding PV awareness among U.S. policymakers. SAI also fostered work with cities, states, and the federal government to explore innovative financing, increased grid integration, and policy measures to aid new PV technology developments. DOE worked with the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories to create industry roadmaps for each major PV material system and processing approach. DOE also began work on a new PV Industry Roadmap in partnership with the solar industry and the Solar Energy Industries Association that will include 3-, 10-, and 25-year projections for the following: supply and demand, costs, standards, and potential collaboration areas.

Key research and development activities included financial awards to 25 "Future Generation" PV projects that showed promise of significant future cost reductions; 10 U.S. companies totaling more than 27 MUSD (matched by company cost share) for innovative PV research that can be demonstrated in pilot scale; and

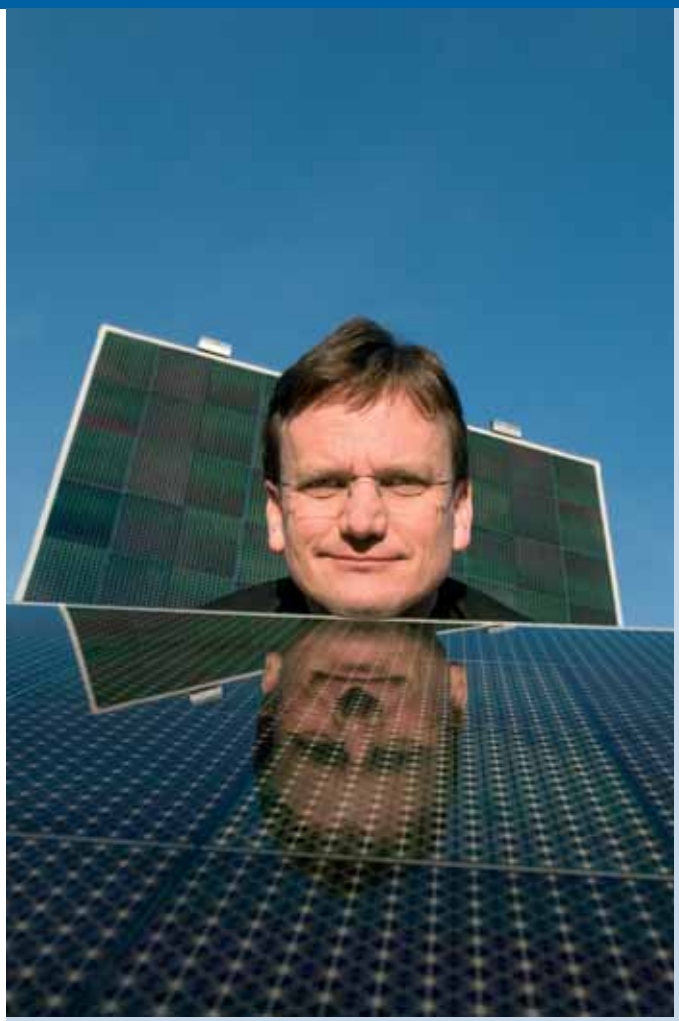

Fig. 1 - Popular Science Magazine gave Nanosolar its "Innovation of the Year" award for its new PowerSheet flexible solar cells. CEO Martin Roscheisen exhibits the company's new utility solar panels.

13 "Technology Pathway Partnership (TPP)" awards for a total of 168 MUSD (matched by company cost share) to teams focused on bringing innovative PV systems to market. The 13 U.S. solar manufacturers leading the TPPs and their projects are:

- Amonix – A low-cost, high-concentration PV system for utility markets
- Boeing – A high-efficiency concentrating PV power system
- BP Solar – A low-cost approach to grid parity using crystalline silicon
- Dow Chemical – PV-integrated residential and commercial building solutions
- General Electric Energy– Development of various PV cell technologies to accelerate industry-wide growth
- GreenRay – A high-powered, ultra-high-efficiency solar module that contains an inverter
- Konarka – Building-integrated organic photovoltaics
- Miasole – Low-cost, scalable, flexible PV systems with integrated electronics (left the program in 2008)

- Nanosolar – Low-cost, scalable PV systems for commercial rooftops
- PowerLight – A PV cell-independent effort to improve automated manufacturing systems
- Practical Instruments – Low-concentration concentrator PV systems for rooftop applications
- SunPower – Grid-competitive residential solar power generating systems
- United Solar Ovonic – Low-cost, thin-film, building-integrated PV systems.

SAI's market transformation activities included the inauguration of 13 "Solar America Cities" and technical assistance for the installation of several large-scale, in excess of 100-kilowatt (kW), PV installations. The national program awarded funds to several organizations to provide technical assistance to states and utilities interested in pursuing PV installations and policies, including the Interstate Renewable Energy Council (IREC), the Clean Energy Group, the National Association of Regulatory Utility Commissioners (NARUC), and the Solar Electric Power Association (SEPA). SAI also established the Solar America Board of Codes and Standards (Solar ABCs).

RESEARCH, DEVELOPMENT AND DEMONSTRATION

Research highlights for the national program and universities included:

Solar Cell Efficiency Records

- NREL—Achieved 19,9 % efficiency for a copper indium gallium diselenide (CIGS) solar cell; fabricated a 33,8 % triple-junction PV cell under AM 1,5 conditions.
- NREL/Spectrolab—Achieved 40,7 % conversion efficiency for its High-Efficiency Metamorphic Multi-junction (HEMM) Concentrator Solar Cell (R&D 100 Award).
- Plextronics—Achieved a 5,4 % efficient single-layer organic solar cell.

New Products & Processes

- Harvard University—Developed a new nanowire that generates its own electricity.
- New Jersey Institute of Technology—Developed a new plastic solar cell that could someday be produced using ink-jet printers.
- University of Delaware—Developed a new flexible solar cell manufacturing process.

Testing & Evaluation

- NREL—Created a new multichamber, vacuum-sealed, robotic tool for testing silicon solar cells.
- Sandia—Demonstrated a bench-scale, non-immersion, ultrasonic, solder-bond diagnostic and characterized cracks in silicon wafers using acoustic technology. Sandia also characterized the perform ance and operations of a 3,51-megawatt (MW) PV utility-scale project over its 5 years of operation.

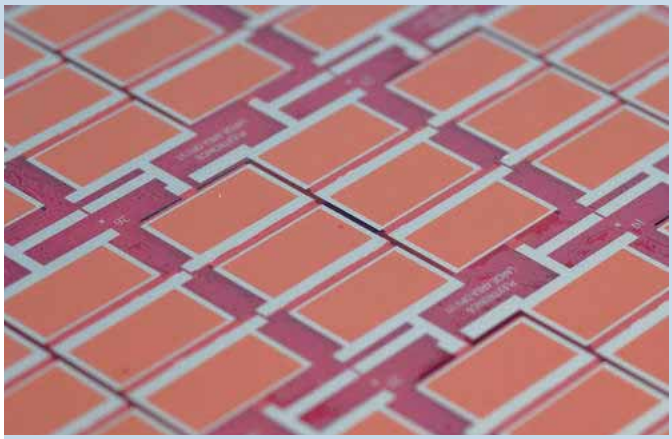

Fig. 2 - Plextronics' plastic-like polymer solar cell set a new world record for organic solar cell efficiency in 2007. A close-up of the organic solar cell is shown above.

Balance of Systems

- DOE/Sandia—Completed its High Reliability Inverter Initiative with Xantrex and GE delivering innovative prototype inverters with >10-year mean-time-between-failure.
- Sandia—Issued a "Request for Proposal" for the DOE-SAI Solar Energy Grid Integration Systems (SEGIS) program; characterized four commercial inverters for long-term evaluations; completed a proof-of-concept for a microinverter with no electrolytic capacitors and a calculated mean-time-between-failure of 250 000 hours of operation; completed a MATLAB (programming language)-based inverter model for single-and three-phase inverters; and developed the concept paper for PV-related power electronics, systems controllers and energy management in grid-connected high-penetration applications.

Workshops & Publications

DOE convened a workshop for using computer simulation to develop novel solar materials and for optimizing solar energy conversion processes. DOE/Sandia convened workshops for advanced integrated inverters and energy management systems that lead to SEGIS and the need to launch a Renewable Systems Interconnection Study to assess the impact of large amounts of PV-generated energy on the electrical grid. NREL published a new report on land use requirements for solar energy that is state specific.

IMPLEMENTATION

More than 13 states embraced new energy efficiency initiatives and renewable energy policies, bringing the total to 25 states and the District of Columbia with renewable energy mandates. Seven states increased the percentage of electricity sales drawn from renewable energy sources. Maryland, Delaware, New Mexico, and Arizona doubled their RPSs and added solar set-asides ranging from 2 % to 4,5 %.

New State Programs

- California Solar Initiative—Implemented a new mandate that requires all builders of developments of 50 homes or greater to offer solar power as an option for homebuyers by 2011.

Fig. 3 - Sunpower's 14,5 MW PV power plant at Nellis Air Force Base, Nevada, is the largest PV-powered solar electric power plant in the world.

- New Jersey—Developed a solar renewable energy credits (REC) market as part of the state's Clean Energy Program. Individuals and businesses can finance their solar installations by trading a solar renewable energy certificate (SREC) once the system generates 1 MW. Utilities can purchase the SRECs to meet the state's RPS.
- Nevada—Plans to deliver 100 MW of solar power from the Solar Enterprise Zone, which includes parts of the former Nevada Test Site.
- Oregon—Expanded its business energy tax credit in 2007 to include builders who install PV systems on homes. Homebuilders receive the residential tax credit plus 3 000 USD up to a maximum of 9 000 USD or 3 USD per watt for PV, plus 3 000 USD.

New Utility Programs

- Pacific Gas & Electric (PG&E)—Created a Solar Schools Program that offers grants to 40 schools each year for the purchase of a 1-kW PV system; connected more than 18 000 PV customers to the grid as of 2007, representing more than 153 MW (the largest ever); provided nearly 200 MUSD in rebates, including 4,5 MUSD to Google, Inc., to install a 1,6 MW PV system at its campus. PG&E also funded California's "Clean Energy Fund," which plans to finance 40 % to 50 % of the cost of solar developments that can be repaid over 15 years with SRECs, at 12,11 % interest.
- Sacramento Municipal Utility District (SMUD)—Launched the Solar Shares Program to meet its solar generation targets by purchasing bundled solar energy in 1 MW units from developers via a solar Power Purchase Agreement (PPA), a utility service model pioneered by SunEdison. The model allows cities and building owners to purchase solar power with no up-front capital. SMUD will then sell its solar "shares" to its residential and commercial customers.
- NSTAR—Launched the "Everygreen Solar Alliance" to work toward aggressive goals for installed solar power generating capacity (from 2 MW in 2007 to 250 MW by the end of 2017). Promotes standardized systems installed by pre-approved solar contractors.
- Public Service Electric & Gas Company (PSE&G)—Submitted a solar loan program plan to the New Jersey Board of Public Utilities that includes a 100 million U.S. dollars investment to finance PV installations on homes, businesses, and municipal buildings in its service area. The loans would be similar to a 15-year mortgage loan and cover 40 % to 50 % of the cost of a PV installation project. Remaining project costs would be covered by a host customer or equity partner eligible to collect the federal investment tax credit (utilities are prohibited from collecting the tax incentive). PSE&G would be repaid in SRECs.

New Industry Programs

- Google, Inc.—Announced a new initiative to develop electricity from renewable sources.
- Sun Run Generation—Launched a program allowing homeowners to deposit 8 000 USD and then lease solar energy from a "rented" PV system on the home under a 20-year lease contract.
- General Electric—Announced a new consumer loan program for solar products. Loans are available through the Yes! Solar Solutions™ in Sacramento, California.

INDUSTRY STATUS

The development of new PV products, businesses, and solar villages surged in 2007. Despite an increase in home foreclosures, home builders constructed and sold homes with PV systems two to three times faster than conventional homes, implying that PV was helping to differentiate them from the competition. More than 12 500 people attended the Solar Power 2007 conference, an event described by some media as "a castle under siege" because of the number of people who came to see the new PV products on "Public Night." California's Silicon Valley was renamed "Solar Valley" by the national media because of the emergence of many new solar companies in the area. Google, Inc., located in Silicon Valley, began backing PV start-ups it claims will revolutionize the industry and it plans to spend hundreds of millions of dollars on renewable energy projects in 2008. Popular Science magazine gave Nanosolar, located in Silicon Valley, an "Innovation of the Year" award for its PowerSheet flexible solar cells, beating out Apple for the iPhone. Underwriters Laboratories (UL) announced the construction of a new PV testing lab in Silicon Valley that will be the largest commercial laboratory for PV testing and certification in the United States. The lab will be up and running by June 2008. Outside of Silicon Valley, countless new solar businesses sprang up across the nation as investors poured money into an industry growing by leaps and bounds.

Utility-Scale PV Projects

PG&E announced an agreement with two developers of utility-scale PV solar power systems: Cleantech America LLC and GreenVolts, Inc., to deliver up to 7 MW of PV power for its customers throughout northern and central California. The U.S.-based SunEdison and the Canadian company, SkyPower, joined forces to develop, build, own, and operate an up to 50-MW PV farm in Ontario, Canada. XCEL

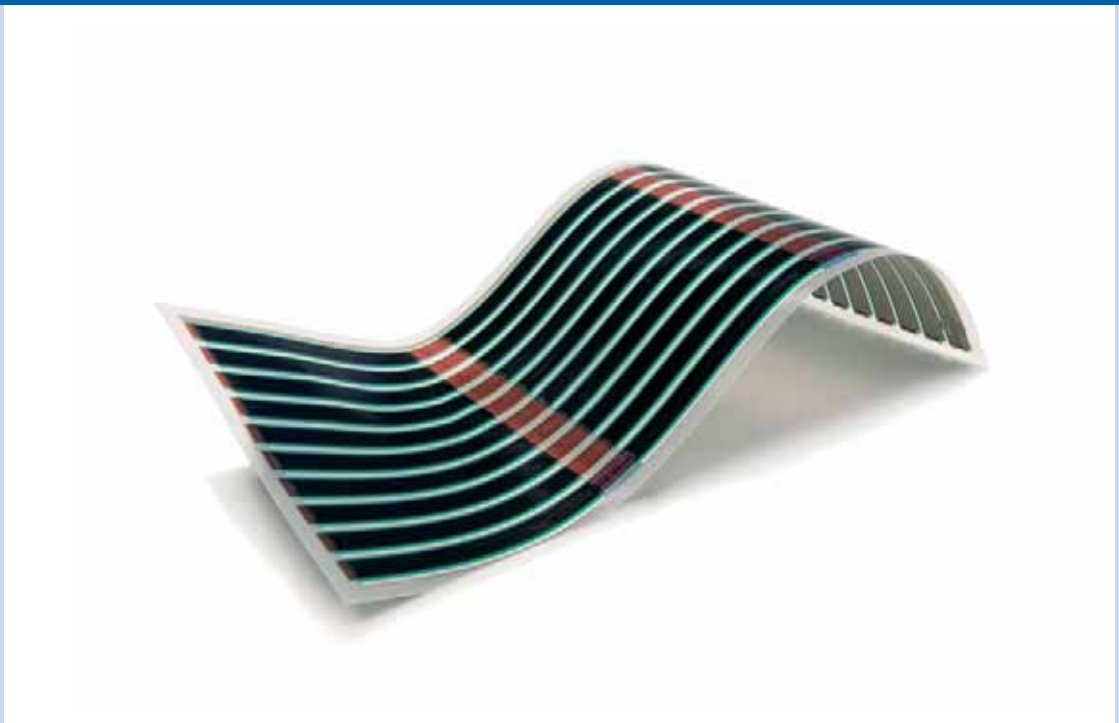

Fig. 4 - Konarka is one of 13 U.S. companies awarded funds by the U.S. Department of Energy's Solar America Initiative to bring innovative PV systems to market such as Konarka's "PowerPlastic" flexible organic PV on film shown above.

Energy began purchasing 8,2 MW of PV from a plant near Alamosa, Colorado. Nellis Air Force Base celebrated the completion of North America's and the world's largest utility-scale PV system. The 14-MW PV system, which is a joint effort of the U.S. Air Force, MMA Renewable Ventures LLC, SunPower Corporation, and the Nevada Power Company, will supply approximately 25 % of the total power used at the base.

MARKET DEVELOPMENT

California accounted for 70 % of all PV installations in the country. Total U.S. PV capacity growth increased by an estimated 34 % in 2007, rising from 658 MW in 2006 to 883 MW. Feedstock challenges continued to plague the industry, a trend not likely to ease up until late 2008. However, the industry's supply issues should begin to improve as structural changes begin to impact the industry in early 2008.

Supply and Demand

On the supply side, the United States provided an estimated 9 % of PV module shipments worldwide, more than half of which were from thin-film manufacturers (First Solar and United Solar). Many thin-film PV manufacturers ramped up production capacity, adding several new >100 MW plants in 2007. On the demand side, the U.S. consumed an estimated 6 % of the global demand for module products or 175 MW.

FUTURE OUTLOOK

The omission of PV tax credits in the new energy bill concerns many in the solar industry that sales could drop in 2008. Unless the tax is extended in late 2008, the commercial tax credit will decrease from 30 % to 10 % of the value of a PV system and the residential credit will disappear on January 1, 2009. Despite these setbacks, states are moving ahead and investors are optimistic about America's solar future. Some analysts predict PV could reach grid parity in 4 to 8 years without government subsidies because of increased concerns about global warming, rising electricity prices, and the decreasing cost of PV. Established solar cell manufacturers remain optimistic as well, stating the high efficiencies and long-term reliability of their products combined with an expanding manufacturing scale ensures them a secure place in the industry's future. In addition, construction began on more silicon plants that plan to start production in late 2008, so the cost of solar will continue to decrease as those plants come online. In 2007, the United States was far ahead of Europe in terms of investment in new PV technology, which could encourage federal policy to come up to speed in 2008. Last year, revenues for PV companies totaled 15,6 BUSD and are conservatively estimated to increase sharply to 69,3 BUSD within 9 years. It's clear that 2007 was the year of PV innovation in the solar industry, which allowed the U.S. market to mature to a new level.

Acknowledgments: The author would like to thank the following people who reviewed and contributed to this report: Katie Bolcar, U.S. Department of Energy; Robert Margolis, Ruby Nahan, and Susan Moon, National Renewable Energy Laboratory; Ward Bower, Sandia National Laboratories; Rusty Haynes, N.C. Solar Center/NCSU; Travis Bradford, Prometheus Institute; Lawrence Kazmerski, National Center for Photovoltaics; and Julia Hamm, Solar Electric Power Association.

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.

CONTACT INFORMATION

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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, NET Nowak Energie & Technologie 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
Mulgrave, Victoria 3170, Australia

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 deliverables: www.iea-pvps.org
Task 7 website: www.task7.org
Task 7 demosite: www.demosite.ch
PV Projects database: www.pvdatabase.com

ANNEX A

IEA – PVPS EXECUTIVE COMMITTEE

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Cover Photograph
Raimund Hächler
Task Status Reports
PVPS Operating Agents
National Status Reports
PVPS Executive Committee members and Task 1 experts
Editor
Mary Jo Brunisholz
Layout and Design
Nuance, graphisme, web, communication, Givisiez, Switzerland
Paper
Normaset Puro blanc naturel
Type set in
Rotis
Printed in 1200 copies by
Imprimerie St-Paul, Fribourg, Switzerland