IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS annual report 2008

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2008

CHAIRMAN'S MESSAGE

Welcome to the 2008 Annual Report of the IEA Photovoltaic Power Systems Programme. 2008 has been another remarkable year for photovoltaics. The awareness about the potential role of photovoltaics in the future energy supply has clearly increased among various public and private organisations. A landmark in this direction has been the publication of the IEA Energy Technology Perspectives (ETP) in June 2008. The message from ETP 2008 is very clear: What is needed in order to meet the challenges the world is facing is nothing less than a global revolution in ways that energy is supplied and used. ETP 2008 provides an analysis of different scenarios how the energy sector will need to be transformed over the next decades. According to the most advanced (BLUE Map) scenario which corresponds to IPCC emission reduction targets, renewable energy, by 2050, will account for 46 % of the global power. Among the renewable energy technologies underlying this scenario, photovoltaics will play a major role.

In the context of the 2020 renewable energy targets of the European Union and triggered by the expected grid parity costs of photovoltaics, the European Photovoltaic Industry Association (EPIA) recently estimated the possible contribution of photovoltaics up to 12 % of the electricity supply by 2020. Such figures are indeed impressive but their realisation requires rapid, strong and ongoing developments in research, technology, manufacturing and deployment as well as a dedicated cooperation among various sectors and countries.

As in all sectors, the difficult situation of the world economy has not made life easier for the photovoltaic industry. Nevertheless, and characterised by its long term and sustainable investment nature, photovoltaics is one of those promising sectors which can help to overcome the present crisis. Photovoltaics is therefore often part of the various economy recovery plans throughout the world.

As a leading international network of expertise, IEA PVPS has the mission and privilege to cooperate on a global level in this rapidly expanding technology area. IEA PVPS undertakes key collaborative projects related to technology progress, cost reduction and rapid deployment of photovoltaics in various applications. Providing objective and neutral high-quality information about relevant developments in the photovoltaic sector remains 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.

Outreach for new membership within IEA PVPS continued in 2008. Malaysia joined the PVPS Programme as the 23rd member during the year. I welcome Malaysia as the most recent IEA PVPS member and look forward to a long and fruitful cooperation. China has joined one of our Executive Committee meetings as an observer. Contacts have been ongoing with South Africa, India, New Zealand, Thailand and Singapore.

On the Task level, the interest for a follow-up activity to the PVPS Task 2 on Performance, Reliability and Analysis of Photovoltaic Systems has remained high and ways are being sought to establish a new Task 13 on Performance and Reliability of Photovoltaic Systems. Grid integration, high penetration of photovoltaic systems in electric grids and the relationship with the topic of smart grids have been discussed as themes for future cooperation.

The overall communication efforts were continued through systematic distribution of PVPS products at conferences, workshops and by means of direct mailings. Communication was further supported by the PVPS website www.iea-pvps.org. Moreover, booths at the industry exhibition of the 23rd European Photovoltaic Solar Energy Conference in Valencia and Solar Power International in San Diego attracted a large number of visitors and provided an excellent forum for dissemination purposes.

2008 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.

S. Nowak

Stefan Nowak
Chairman

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA

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

Collaboration in research, development and demonstration of new technologies has been an important part of the Agency's Programme. The IEA R&D activities are headed by the Committee on Energy 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 R, D & D 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-three PVPS members are: Australia, Austria, Canada, Denmark, EPIA, European Union, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States. The European Photovoltaic Industry Association (EPIA) joined PVPS in 2005.

IEA-PVPS MISSION

The mission of the IEA PVPS programme is:
To enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option.
The underlying assumption is that the market for PV systems is continuously expanding from the earlier niche markets of remote applications and consumer products, to the rapidly growing markets for building integrated and other decentralised 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 IEA-PVPS programme aims to realise the above mission by adopting the following objectives related to reliable PV power system applications for the target groups: governments, utilities, energy service providers and other public and private users:

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

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

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

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

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

Over time, photovoltaic-based electricity supply can play a key role in urban-scale developments. Such developments should follow a holistic approach to maximise society's total energy efficiency and use of renewable energy opportunities. There is already increasing awareness of the principles of sustainable design and maximum use of (active) solar energy potential but this can be further expanded. PV power systems can play a key role in providing the reduced electrical energy services needs of houses and buildings and have the potential to become a major grid-connected electricity supply source. Through effective knowledge sharing, PVPS aims to enhance 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 facilitate a cost reduction of PV power systems applications.	• To collect, analyze and disseminate information on the technical performance and cost structure of PV systems and their applications. • To share the knowledge and experience gained in monitoring selected national and international PV projects. • To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems. • To contribute to the development of improved photovoltaic systems and subsystems.	• Objective information on the technical performance, reliability and cost structure of PV systems, in an accessible form; • Recommended practices for improved design, construction and operation and maintenance of PV systems and subsystems, in an accessible form; • Recommendations concerning remaining technical issues for the interconnection to the grid of small-dispersed systems as well as large and very large PV systems; • Recommended practices for the main components of PV systems.
2 – To increase the awareness of their potential and value and thereby provide advice to decision makers from government, utilities and international organisations.	• To collect and analyse information on key awareness issues, such as policies, markets, applications, economic development, 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 address and specify the values of PV power systems in different applications; • 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; • To perform outreach activities (analysis, potential, scenarios) related to future large scale systems and applications.	• 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, electronically published four times 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 follow and where appropriate contribute to the development of codes and standards; • To address mortgage and insurance issues; • To identify steps in streamlining installation.	• 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, Vienna, Austria, October 2008.

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 (to be concluded in 2009).
- 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.

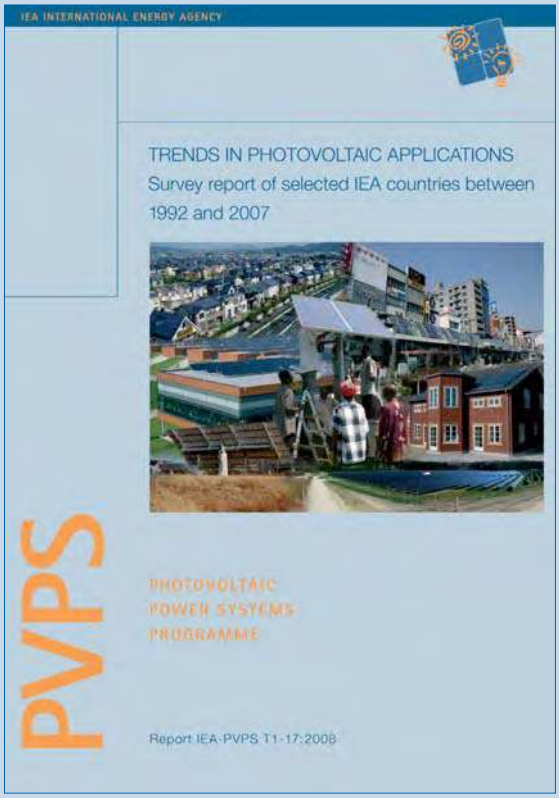
Task 1 activities are organized into the following subtasks:

SUBTASK 1.1: Status Survey Reports

Each year the printed 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 twelve issues had been published by the end of 2008.



Trends in Photovoltaic Applications, Survey Report of Selected IEA Countries between 1992 and 2007.

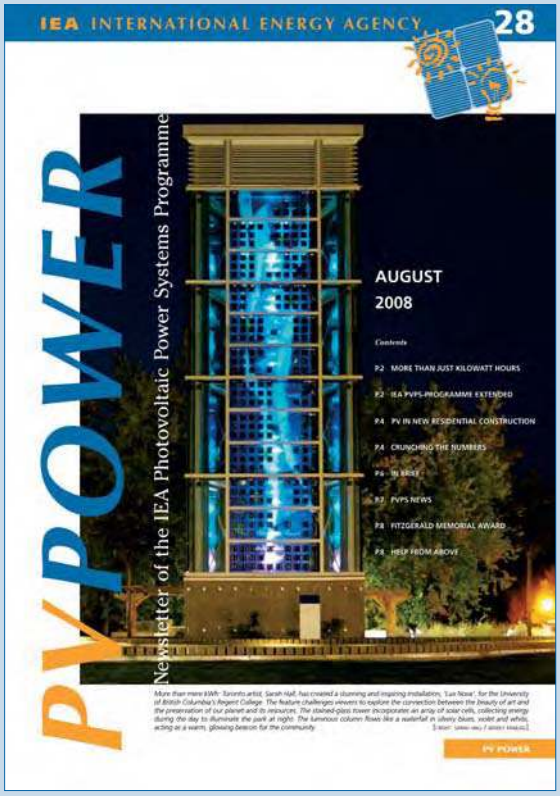
SUBTASK 1.2: Newsletter

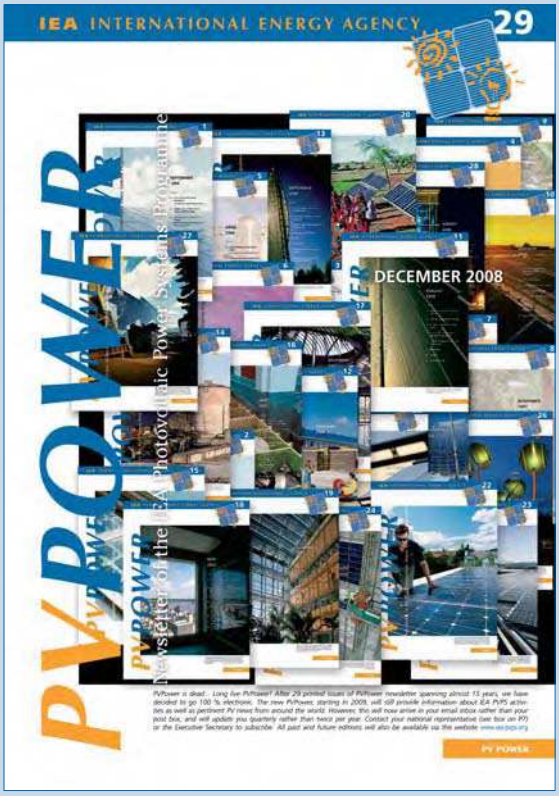
A printed, colour newsletter, *PVPower*, has been prepared and distributed to stakeholders by post and also via the website approximately each six months to present highlights of the IEA PVPS Programme as well as general features of interest about PV systems and components and market applications. The newsletter will now be published in electronic format only. 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 nine issues of the newsletter had been published by the end of 2008.

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, the Status of PV in the Asia Pacific Region and Grid Parity and Beyond. 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.





Newsletter PVPower Issues 28 and 29.

SUMMARY OF TASK 1 ACCOMPLISHMENTS FOR 2008

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 2008 for the Trends report process. However, late reports and last minute changes to key data from some countries continue to cause challenges. The quality of the reporting is excellent in most cases.

The 13th issue of the *Trends in Photovoltaic Applications* report was published in August 2008 and analyzed data collected between 1992 and the end of 2007. During 2007 by far the greatest proportion of PV was installed in Germany and Spain alone (73 %). Spain's cumulative installed capacity increased more than four-fold. Other markets experiencing strong growth were France, Italy, Korea, Portugal and the US. Japan's annual market declined from the level of the previous year. An interesting feature of the 2007 cumulative installed capacity compared to 2006 is the three-fold increase in capacity defined as grid-connected centralized. During the year, under feed-in tariff schemes in the IEA PVPS countries, payments of around 2,3 billion USD (1,68 billion EUR) were made for PV electricity. Japan remained the leading producer of photovoltaic cells during 2007. Production of cells and modules in Japan accounted for 39 % and 22 % respectively of the IEA PVPS countries' production, with Germany in second place for cell production with 35 % and first place for module production with a 36 % share. US output of thin film technologies almost doubled and represented nearly one half of world thin film production. Countries not part of the IEA PVPS reporting process now possibly account for around 40 % of both world cell and module productions.

Two conference papers based on the 2008 Trends work were prepared: one was presented in a plenary by Japan's Izumi Kaizuka at the European PV Conference in Valencia, Spain (September 2008); the other was also presented by Izumi Kaizuka at PVSEC-18 in Kolkata, India in January 2009.

SUBTASK 1.2: Newsletter

Editorial policy for the newsletter continued to emphasize that projects and products – both PVPS and other - must be tangible to be included. *PVPower* issue 28 was published in August 2008. *PVPower* issue 29 was published in December 2008. Current and back issues of *PVPower* are available on the public website.

SUBTASK 1.3: Special Information Activities

Swiss Task 1 participant Pius Hüsser contributed to the finance and PV workshop held in Kuala Lumpur, Malaysia in March 2008, continuing the strong link forged between Task 1 and Malaysia's BIPV Programme.

Task 1 Experts' Meeting, Sophia Antipolis, France, June 2008.

A workshop "Grid parity and beyond" was developed by Task 1 in conjunction with the EUPVSEC conference in Valencia, Spain in September 2008 and a second IEA PVPS workshop was developed for PVSEC-18 in Kolkata, India in January 2009.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2009

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

SUBTASK 1.1: Status Survey Reports

The deadline for receiving the next National Survey Reports (NSRs) is end of May 2009. IEA PVPS aims for NSRs to be available via the public website.

The target date for publication of the 14th issue of the *Trends in Photovoltaic Applications* report is August 2009. Electronic versions of the information will be made available on the public website in July 2009 and conference papers will also be developed.

SUBTASK 1.2: Newsletter

PVPower Issue 30 will be the first of the e-newsletters and will be made available in the first half of 2009. Task 1 will undertake the design and compilation work, and editorial policy will continue unchanged. Items for the newsletter will be based on results and activities of the IEA PVPS Programme and key policy and programme information from the participating countries. It is anticipated that the newsletter will be made available quarterly.

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 2009), Germany (in Hamburg in conjunction with the European PV conference in September 2009) and in Korea (in conjunction with PVSEC-19 planned for November 2009).

Specific topics that may receive further attention from the Task 1 group include issues of interest from along the PV industry value chain, the evolution of the global PV market and the role of electricity utilities in transforming the market.

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.

KEY DELIVERABLES (2008 AND PLANNED)

The following were published and also made available on the public website during 2008:

Trends in photovoltaic applications in selected IEA countries between 1992 and 2007 Report IEA-PVPS T1-17: 2008 (plus papers and presentations at the EUPVSEC and PVSEC conferences).

Newsletter – *PVPower* issues 28 and 29.

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 2009 it is planned to produce the fourteenth issue of the *Trends in Photovoltaic Applications* report, *PVPower* issues in e-newsletter format, a range of country and workshop information and continuing updates of the IEA PVPS website.

MEETING SCHEDULE (2008 AND PLANNED 2009)

The 31st Task 1 Meeting was held in Sophia Antipolis, France 17-18 June 2008.

The 32nd Task 1 Meeting will be held in Kota Kinabalu, Malaysia 4-6 March 2009, in conjunction with a workshop to be held in Kuala Lumpur.

The 33rd Task 1 Meeting will be held in Leipzig, Germany 17-19 September 2009, in conjunction with EUPVSEC and an associated workshop to be held in Hamburg.

TASK 1 PARTICIPANTS IN 2008 AND THEIR ORGANIZATIONS

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

COUNTRY	NAME	ORGANISATION
Australia	Greg Watt	Australian PV Association
Austria	Roland Bruendlinger	Arsenal Research
Canada	Josef Ayoub	Natural Resources Canada
Denmark	Peter Ahm	PA Energy A/S
European Photovoltaic Industry Association	Denis Thomas	EPIA
European Union	Andreas Piontek	DG Research
France	André Claverie	ADEME
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer & Roxana Dann	Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	CESI Ricerca S.p.A.
Japan	Osamu Ikki & Izumi Kaizuka	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
Malaysia	Wei-Nee Chen & Lalchand Gulabrai	PTM
Mexico	Jaime Agredano Diaz	IIE
The Netherlands	Otto Bernsen	SenterNovem
Norway	Fritjof Salvesen & Lars Bugge	KanEnergi AS
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Ulf Malm & Adam Hultqvist	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
Turkey	Mete Cubukcu	Ege University
United Kingdom	Sarah Davidson & Samantha Cook	IT Power Ltd.
United States of America	Ward Bower	Sandia National Laboratories
	Carol Anna	NREL

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

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

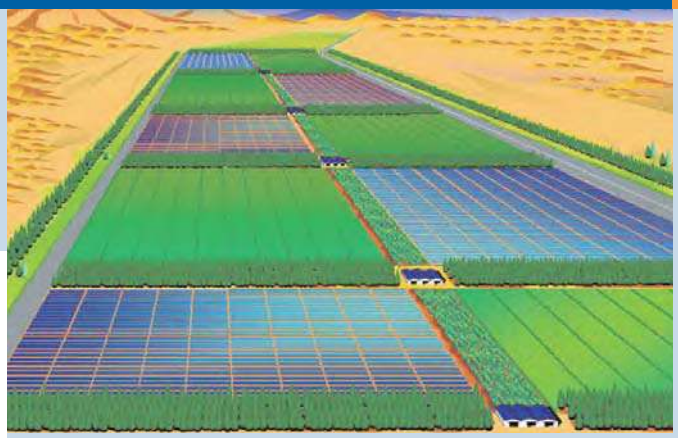


Fig. 1 – Image of a VLS-PV System in a Desert Area.

Fig. 2 – Technical visit to ECN at the 19th Task 8 Experts Meeting.

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 implementing VLS-PV projects in the future (See Fig. 1).

Since the first half of the 2000s, installation of MW-scale PV systems has been rising substantially year by year, and the capacity of MW-scale PV systems is expanding as well. The capacity would reach 100 MW in the near future, and after this stage, GW-scale PV plants consisting of several 100 MW scale PV systems should be realized toward the mid-21st century. Thus, VLS-PV systems are promising options for large-scale deployment of PV systems.

The work on VLS-PV first began in 1998, under the umbrella of IEA PVPS Task 6, and was officially established as the new Task 8 in 1999. Task 8 started its 3rd phase activity in 2006 under a three year Workplan.

In the 3rd phase activity, three subtasks have been organised:

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

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 the viewpoint of local, regional and global aspects.

SUBTASK 5: General Instruction for Practical Project Proposals to Realise VLS-PV Systems

Detailed practical instructions and a training kit for the development of other practical project proposals, to enable others to sustainably 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.

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

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 also be analysed.

SUMMARY OF TASK 8 ACCOMPLISHMENTS FOR 2008

During 2008, Task 8 concentrated on producing a technical report as an integrated result of the 3rd phase activity. Each subtask developed various kinds of outcomes by effective interactions. The draft manuscripts have been completed and the report would be published in Autumn 2009. In parallel, Task 8 actively performed dissemination events.

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

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

Environmental and Ecological Impacts of VLS-PV

- Life-cycle analysis of various kinds of VLS-PV systems;
- Estimation of ecological impacts of VLS-PV development

Global Potential Analysis

- Solar energy potential analysis by using remote sensing

Regional Case Study

- Case study on the Sahara desert;
- Case study on the Gobi desert

Fig. 3 – International Symposium held in Busan, Korea, October 2008, in conjunction with Renewable Energy 2008.

SUBTASK 5: General Instruction for Practical Project Proposals to Realise VLS-PV Systems

The following issues were discussed and drafted for a technical report:

Socio-Economic Considerations

- Potential benefits and considerable socio-economic aspects;
- Desert region community development;
- Development of agriculture system with PV;
- Desalination powered by solar energy

Financial Aspects

- Life cycle cost analysis;
- Requirement for financing VLS-PV;
- Proposal of VLS-PV business model

VLS-PV Roadmap

- Proposal of VLS-PV roadmap toward 2100

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

The following issues were discussed and drafted for a technical report:

Recent and Future Trends in PV Technology

- PV cell and module technology for VLS-PV;
- PV system technology;
- CPV and tracking technology

MW Scale PV System Installation Technologies Nowadays

- Recent progress of MW-scale PV systems;
- Advanced design of VLS-PV systems;
- System architecture and operation;
- Array structures, civil works and foundations

Future technical developments for VLS-PV Systems

- Matching VLS-PV systems to grid requirements;
- A statistical approach to energy storage;
- Solar hydrogen;
- Expert control systems based on cloud predictions

OTHER ACTIVITIES

International Symposium: "Energy from the Desert - Possibility of Very Large Scale PV Systems in Asia," in Busan, Korea.

As a side event of Renewable Energy 2008 held in October 2008, an international symposium, "Energy from the Desert - Possibility of Very Large Scale PV Systems in Asia", took place on 13 October 2008 in Busan, Korea. Task members introduced the main results of the 3rd phase activity and invited guests from Korean companies made impressive presentations.

Contribution to the International Conferences

Task 8 made presentations at the following international conferences, as dissemination activities:

- 23rd EU-PVSEC in Valencia, Spain (September 2008)
- Renewable Energy 2008 in Busan, Korea (October 2008)

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2009

Publication of the Technical Report

The final draft of Task 8 activity based on the 3rd phase activity has been completed, which is tentatively entitled, "Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-economic, Financial, Technical and Environmental Aspects." The report would be published in Autumn 2009.

Starting up 4th Phase Activity

In order to accomplish the VLS-PV activity, Task 8 will start its 4th phase activity in 2009 based on a new three year Workplan.

In the 4th phase activity, participants will discuss the following items. Based on the discussion including previous phases, implementing strategies and engineering designs for VLS-PV projects will be discussed and proposed. Furthermore, various kinds of environmental impacts will be evaluated and feasible technical options will be discussed in depth. Eventually, VLS-PV proposals which would be useful for stakeholders would be developed.

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

- Various kinds of environmental impacts of VLS-PV systems

SUBTASK 5: General Instruction for Practical Project Proposals to Realise VLS-PV Systems

- Instructions and strategies for implementing VLS-PV systems;
- Engineering designs of VLS-PV systems;
- Project proposals for implementing VLS-PV projects

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

- Future technical options for a global renewable energy system

KEY DELIVERABLES

Internal Publication

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 1 844073 637)
Book: "Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-economic, Financial, Technical and Environmental Aspects," (to be published in 2009)

MEETING SCHEDULE (2008 AND PLANNED 2009)

19th Task 8 Experts Meeting, 17-19 April 2008, Utrecht, the Netherlands
20th Task 8 Experts Meeting, 29-30 September 2008, Valencia, Spain
21st Task 8 Experts Meeting, 24-25 April 2009, Nanterre, France
22nd Task 8 Experts Meeting, September 2009, Germany

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	John S. MacDonald	Day4Energy Inc.
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Mongolia (observer)	Namjil Enebish	National Renewable Energy Center

TASK 9 - PHOTOVOLTAIC SERVICES FOR DEVELOPING COUNTRIES

Fig. 1 - Training PV vaccine refrigerator installers, India.

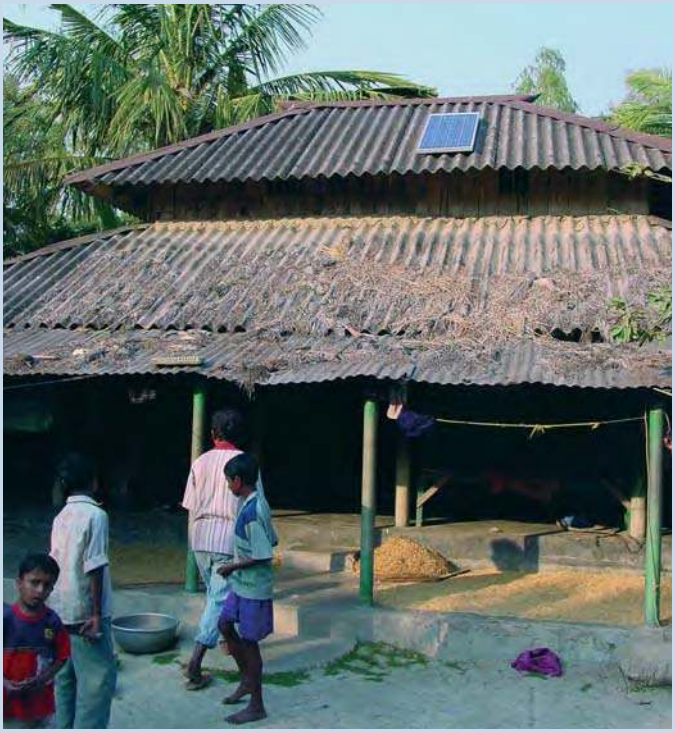

Fig. 2 - Typical PV 'Solar Home System' in India, one of several million in operation.

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). PV vaccine refrigerators are now the standard products of choice in most developing countries, and there is a well established pool of expertise (including Task 9) available to all choosers and users. Figure 1 shows a training course in progress for installers in India.

The MDGs were reaffirmed at the UN Summit in 2005. Since then the G8 Summit at Gleneagles in 2005 agreed 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. Integrating PV in such mini grids often is a cost effective solution. 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 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 are increasingly becoming a part of Task 9's work. In many locations, small wind generators and pico hydro units can be used in the same way as PV and at lower level cost.

Task 9's objective 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.

Fig. 3 - Donkey-powered water pumping, Morocco.

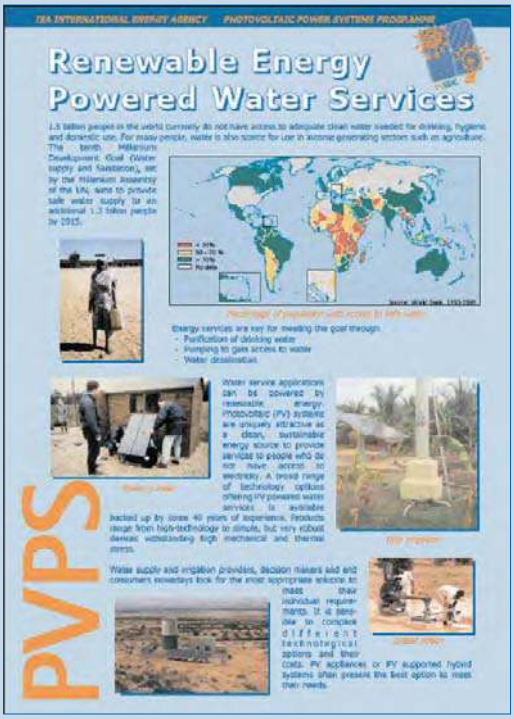

Fig. 4 – Task 9's Water Services Poster.

ACHIEVEMENTS IN 2008

In 2008, Task 9's relationships to and the cooperation with the European Photovoltaic Industry Association (EPIA) and the Alliance for Rural Electrification (ARE) have been continued. The Task 9 Operating Agent utilised the opportunity to join a delegation of ARE with development organisations in Washington including the World Bank, Inter-American Development Bank, and USAID. Task 9 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.

SUBTASK 10: Deployment Infrastructure

This work contributes to overcoming the critical barriers to widespread PV deployment and implementation through the development, dissemination and application of a series of guideline documents to promote the necessary infrastructure requirements in developing countries. The aim has been to develop and disseminate a coherent series of reports to promote the necessary infrastructure requirements in developing countries to help overcome the critical barriers to widespread PV deployment and implementation. Six Recommended Practice Guides (RPGs) have been published by Task 9. This period of activity was principally concerned with small "Solar Home Systems," as illustrated in Figure 2. Subtask 10 was essentially completed in Phase 1.

Clean water can transform lives; and in 2008 the Task 9 team expanded its work relating to Water Services. It may be surprising that in many countries, draft animal power is still used for irrigation, as illustrated in Figure 3 which shows a donkey-powered pump in Morocco. A Water Pumping Workshop was held in cooperation with the African Development Bank. Task 9 in close collaboration with the Alliance for Rural Electrification (ARE) further expanded its work on deployment of hybrid systems, in particular to reduce the dependance on costly generation. A workshop was held with the Club of 15 African Rural Electrification agencies and in Cambodia, where more than 80% of national power production is diesel based and the cost of power and tariffs amongst the highest in the world. Flyers are available on the Website.

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

SUBTASK 20: Support and Co-operation

Task 9 stimulates awareness and interest amongst decision makers in developing countries, and also the multi- and bilateral agencies, NGOs 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 from 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. From the 28th to the 29th of May 2008, Task 9 took part in a workshop on "Sustainable Rural Energisation in Major Emerging Economies." This Paris event has been organised by the IEA and has been attended by 11 emerging countries. The Operating Agent presented PVPS and Task 9 to the delegates. The platform for discussions and networking turned out very positive and it is intended to hold another workshop in 2009. During the workshop the need for more actions from IEA Implementing Agreements such as PVPS Task 9 has been repeatedly identified. Another finding is that the emerging economies would

Fig. 5 – Task 9 Experts' Meeting. Busan, Korea, October 2008.

Fig. 6 - PV Pumping training for AfDB, Tunisia, visit to installation at Ouled Aoun.

like to share experience regarding Rural Energisation technologies, capacity building, incentive policy and regulations to learn more about best practise and the challenges encountered in other countries in similar situations. Although it has also been stressed that there is no one-best solution that would work in all the different countries, a comparative analysis of approaches and results is considered helpful. Task 9 works actively in this perspective, and organised two regional events with this perspective in 2008, one in May in Mali, where a forum of 10 countries were present, and another in December, in Phnom Penh which was an opportunity for active exchanges between Lao and Cambodian institutional authorities and private sector.

In September 2008, Task 9 contributed to the PVPS booth at the European Solar Conference and Exhibition in Valencia, Spain with a poster, flyers, presentations and interesting discussions with related companies. Further conferences where Task 9 has been represented were the Water and Sanitation Conference in Edinburgh, KU in May 2008 and the annual meeting of the French PV Association.

The 18th Experts' Meeting was held alongside the IEA Workshop on Rural Energisation in Paris, in May 2008. The Workshop confirmed the importance of Task 9 and the interest in its activities.

The 19th Experts' meeting was held in Busan, Korea, in October 2008. On this occasion, the Japanese PVSDC experts presented broadly their water service projects, followed by a fruitful exchange between experts. Figure 5 shows the dedicated, if depleted in numbers, Experts in Busan. The 20th Experts' meeting was held in Phnom Penh, Cambodia in December 2008. Due to security issues at the flight hub in Bangkok, only 3 PVSDC Experts were able to attend this meeting.

Support and expertise has been provided to the African Development Bank (AfDB). A training workshop for employees and decision makers of the AfDB Tunis was implemented in June 2008. Part of the Workshop was a site visit to a PV water pumping system at Ouled Aoun, illustrated in Figure 6.

During the Workshop important deployment barriers in the form of inappropriate funding schemes and the lack of expertise for assessment of PV as alternative solutions have been identified.

In summary, the Workshop demonstrated that PV is less expensive (on a life-cycle basis) than diesel for pumping water. But, the rules of development banks like AfDB, do not allow investments or loans on this basis.

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 and Information & Communication Technologies (ICT) services, PV battery charging stations, hybrids and village mini-grids. The focus of activity is PV Based Energy for Water Services.

Progress with this subtask has been gained in 2008 as in April 2008 the French Expert presented IEA PVPS Task 9 at a meeting of the Club of Rural Electrification Agencies in Mali. Other Task 9 participants at this workshop were Germany, the ARE as well as PVPS Task 11 on hybrid systems. The awareness of the technical and economic advantages was already well spread among the participants and the main barrier perceived is the financing schemes – analogue to the situation of PV pumping systems.

Further progress has been achieved by organising a training workshop for employees and decision makers of the AfDB Tunis in June 2008 (as mentioned above).

In December 2008, Task 9 organised an IEA PVPS workshop on "Deployment of renewables and diesel-hybrid systems in Developing Countries," in Phnom Penh, Cambodia. It was supported by representatives from the industry and widely deemed as an important contribution and a massive success.

SUBTASK 50: Market Penetration Activities

Training and capacity building are essential for sustainable market development. The RPGs prepared by Task 9 are used for these purposes. Task 9 also co-operates and assists with training courses.

Due to lack of resources, progress in terms of the original Workplan has not been made. An alternative Subtask relating to PV-diesel systems in developing countries has been launched, led by France and is still under development. The work will be coordinated with Task 11.

PLANS FOR 2009

The focus of work in 2009 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. Global expenditure is set to increase significantly. The Task 9 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 success of PV Water Pumping Workshops in Bangkok, and Tunis for the African Development Bank (AfDB), Task 9 will organise a Workshop on Water & Energy, led by Switzerland. This will also input to the World Water Week in Stockholm. The European Off-Grid Electrification Conference in Munich in May is an opportunity where the Task will present itself to the international audience. A final report will be presented to the PVPS ExCo at its second meeting in 2009.

TASK 9 MEETING SCHEDULE (2008 AND PLANNED 2009)

2008

18th Experts' Meeting, May, Paris, France.
19th Experts' Meeting, October, Busan, Korea.
20th Experts' Meeting, December, Phnom Penh, Cambodia.

2009

21st Experts' Meeting, May, Munich, Germany.
22nd Experts' Meeting - Not fixed yet.

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
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France	Anjali Shanker	IED
France	Lara Bertarelli	IED
Germany	Rolf Posorski	GTZ
Japan	Sakurai Masahiro	JPEA
Japan	Takayuki Nakajima	JPEA
Japan	Tetsuji Tomita	IEEJ
Switzerland	Alex Arter	ENTEC
United Kingdom	Bernard McNelis	IT Power
United Kingdom	Rebecca Gunning	IT Power
United Kingdom	Anselm Kröger-Vodde	IT Power
ARE	Ernesto Macías	ARE
EPIA	Eleni Despotou	EPIA

TASK 10 – URBAN SCALE PV APPLICATIONS

INTRODUCTION

The workplan for Task 10 is designed for flexibility towards the fast growing and emerging PV market. Task 10 work was initiated in January 2004 at which time the annual PV market was shy of 500 MW per year. Early estimates indicate that the 2008 market may exceed 5 GW. The Task's work was targeted at a wide array of stakeholders, realizing that this 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. Solar Cities and multi-party utility scale business models are using the results of Task 10 and all PVPC products to assure benefits to all stakeholders.

Task 10 had a 5 year planned period of work, but was extended for six months. 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 titled 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. The results of Task 10 and PV-UP-Scale represent a broad range of work which will continue to facilitate creative solutions in the urban energy market.

OVERALL OBJECTIVE

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

- making connections between the building design and development industry;
- deriving recommendations for stakeholders to remove barriers to mass market uptake of photovoltaics;
- developing system components, design and applications with the largest global market penetration potential, including aesthetic values as well as the mechanical and energy related values;
- 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.

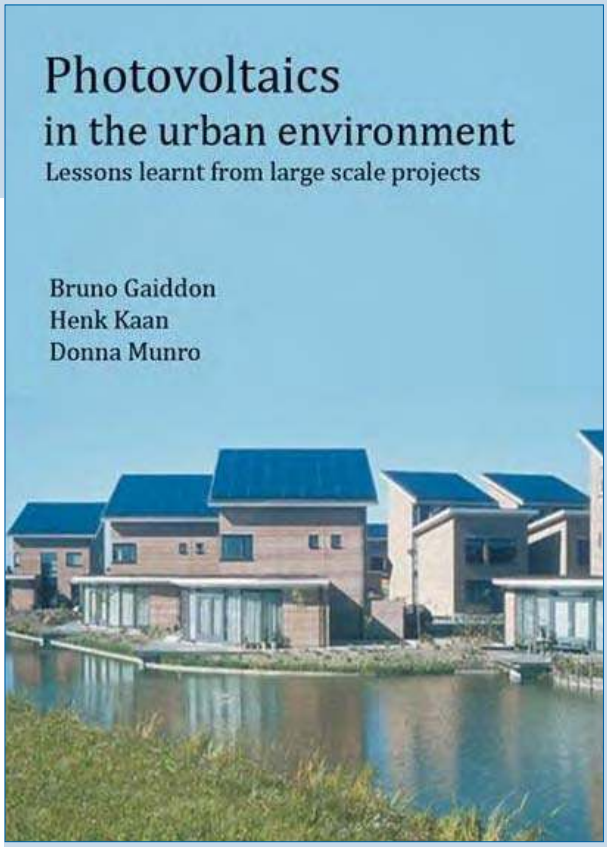


Fig. 1 – Joint PV-UP-Scale and Task 10 Urban Planning Book.

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. With traditional energy costs rising and PV costs declining this goal seems achievable even with the unstable economy. In the stakeholder list below, goals as related to stakeholders has been included.

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 multiple 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 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

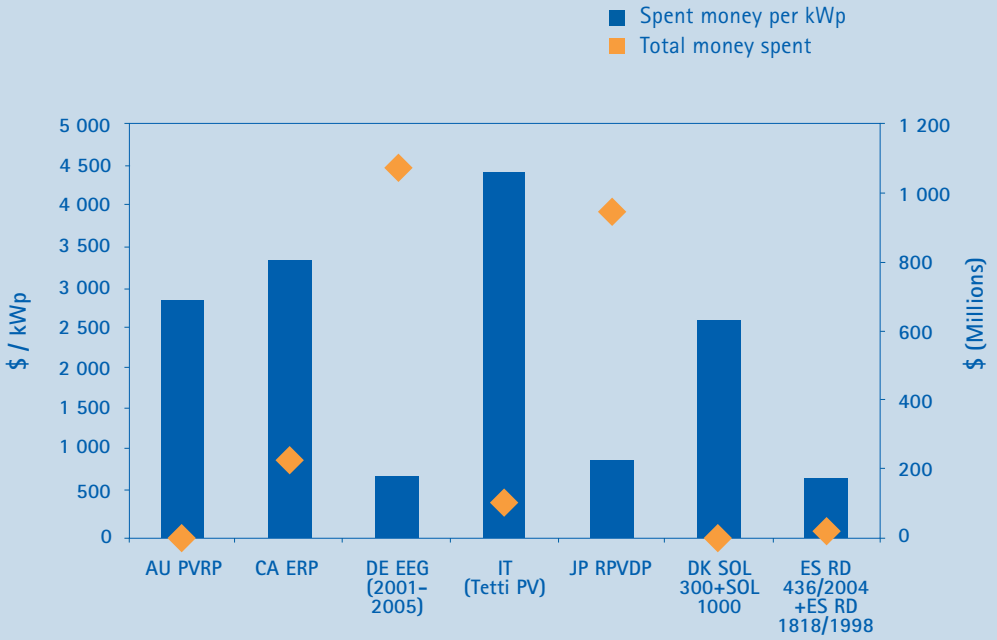


Fig. 2 - PV Market Drivers Success Criteria -Costs to the Public. From report titled, "Promotional Drivers for PV."

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, loan 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 stake-holder 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. The report was 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. This work will be completed this year.

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.
The PV-UP-Scale report, "Economical drivers and market impacts of urban PV, 2 was completed in 2006. The expanded Task 10 report is currently being balloted. A major objective of this study is to analyse which measures consumer's willingness-to-pay and which policies are necessary to achieve a favourable change of the supply curve. The report defines and quantitatively measures five success criteria, one of which is cost to the public as shown 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 such 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 through a guide providing processes and approach for setting quantifiable urban-PV goals and objectives in the planning process. Architectural considerations such as building aesthetics, land use, shading, and urban renewal opportunities for BIPV will be included as planning elements. Additionally, community energy use forecast and planning impacts related to the whole building approach and coordinated utility or community system load control to increase demand reduction and increase PV capacity value. Switzerland 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 will be completed this year.

Switzerland has developed a case study analyzing electricity purchasing conditions for the city of Neuchâtel to determine the economic consequences of including PV in forward electricity purchasing mix. This work is in the ballot stage and should be finalized this year.

Switzerland also developed a report of analysis of Task 10 countries aspects of urban planning as collected through a questionnaire of 17 cities.This report will finalise the balloting process this year.
A joint Task 10/PV-UP-SCALE project, led by France, has gathered case studies on urban palling and design from start to implementation. This information has been developed into a book which includes 14 existing urban area plans and 8 future urban plans. Also included in the book are lessons technical guidelines, impacts of regulatory and financial framework, as well as visions for the future. The book has been finalized and sent to the publisher, with an expected publication date of September 2009. See Figure 1.

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

Pal-Town Jyosai-no-mori, located in Ota, Gunma, consists of 553 houses with PV systems, a total of 2,16 MW of PV power in the community. (2,6-5,0 kW/house). The Community-scale PV development serves as a test field for NEDO. The objective of the 5 year (FY2002-FY2007) test project is to demonstrate that a power system of several hundred residences, where each residence installs the PV system, can be controlled by the technologies developed in this program without any technical problems. All residences have data monitoring.

There are four research subject areas:
1) Development of technology to avoid restriction of PV output (including storage devise trials on lithium-ion battery and electric double layer capacitor - EDLC)
2) Analyses and evaluation of higher harmonics
3) Analyses of mis-actuation of function to prevent islanding operation
4) Development of applied simulations including economic analysis

Fig. 3 – An excerpt from the Task 10 PV Communities Report.

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," was completed and distributed electronically 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. It is available at www.iea-pvps-task10.org

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 at www.pvdatabase.org.
Japan developed the report on "Community-Scale PV: Real Examples of PV Based Housing and Public Developments," which includes 38 single family housing developments, multi-family housing and public building developments. Each development has a two page brief which can be used as a separate document and the main text of discussion summarizing the information. This is available at www.iea-pvps-task10.org and will also be included in the database above. See Figure 3.

Fig. 4 – Task 10 Experts in Langawi, Malaysia.

Fig. 5 – Task 10 Experts in Sydney, Australia.

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 will be completed this year. 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 is completed and currently being balloted. The Grid Effect Visualisation Tool is in a power point format and animates/narrates grid issues and solutions. The visual tool is completed and is available at www.iea-pvps-task10.org

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 Task 10's third year included 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 also 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 mush 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- Upscale project.

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

Lisbon successfully completed two urban ideas challenge competitions entitled "The Lisbon Ideas Challenge I and II." The final reports for these competitions have been completed.

TABLE 1 - LIST OF PARTICIPANTS AND THEIR ORGANISATIONS

COUNTRY	PARTICIPANT	ORGANISATION
Australia	Mr. Mark Snow	University of New South Wales
Austria	Mr. Reinhard Haas	Institute of Power Systems and Energy Economics
	Mrs. Assun Lopez-Polo	Energy Economics Group
	Mrs. Demet Suna	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	Politecnico di Milano
	Mr. Michele Pellegrino	CER ENEA
	Mr. Carlo Zuccaro	CESI SpA
	Mr. Antonio Berni	ETA Florence
Japan	Mr. Keiichi Komoto	Environment, Natural Ressources and Energy
	Mr. Tomoki Ehara	Mizuho Information & Research Institute Inc.
	Mr. Shogo Nishigawa	Nihon University
Korea	Mr. Hee-Jin Lim	Korea Photovoltaics Development Organization
Malaysia	Mr. Ahmad Hadri Harris	Malaysia Energy Center, PTM
European	Mr. Henk Kaan	Energy Research Centre of the Netherlands through EU, PV-UP-SCALE
Norway	Mrs Inger Andresen	SINTEF Civil and Environmental Engineering
	Mrs. Anne Grete Hestnes	
Portugal	Mrs. Maria Joâo Rodrigues	Center for Innovation Technology and Policy Research
	Mrs. Joana Fernandes	Instituto Superior Têcnico (Technical University of Lisbon)
Sweden	Mr. Mats Andersson	Energibanken AB
	Mrs. Anna Cornander	City of Malmo
Switzerland	Mr. Pierre Renaud	Planair SA
	Mr. Lionel Perret	
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 (2008 AND 2009 PLANNED)

MEETING	DATE	PLACE
10th Task 10 Technical Experts	March 3-4, 2008	Langkawi, Malaysia
11th Task 10 Technical Experts	Nov. 24-25, 2008	Sydney, Australia
12th Task 10 Experts Meeting	Week of May 11th, 2009	Rome, Italy

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.

Activity 4.5 Continuous Communication

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. And the website and resources for Task 10 remain up to date.

INDUSTRY INVOLVEMENT

As Task 10 is completed, industry participation appears minimal relative to the technical experts participating in the Task. However, in individual countries and throughout Europe, it is evident that industry is giving feedback to Task 10. Also, industry uptake of Task 10 products is high, especially utilities and solar integration companies. The Activity under Subtask 1, entitled "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. Both Lisbon Ideas Challenge I and II were supported by industry.

KEY DELIVERABLES (2008 AND 2009 PLANNED)

The following key deliverables were prepared and presented in 2008:

- Final Report "Community Scale Solar Photovoltaics: Housing and Public Development Examples"
- "Network Issues and Benefits Visual Tool"
- Final Report "Lisbon Ideas Challenge I"
- Final Report "Lisbon Ideas Challenge II"

The following key deliverables are planned for 2009:

- Report "Economic and Institutional Barriers"
- Report "Promotional Drivers for PV"
- Report "Municipal Utility Economics" and "Predictatool" for municipal utility forward purchasing
- Book "Photovoltaics in the Urban Environment"
- Report "Impacts & effects of PV connection, Guidelines & Network Operation Policies, Countermeasures & Technologies, and Case Studies" (including annexes of codes and standards and certification practices)

TASK 11 - HYBRID SYSTEMS WITHIN MINI-GRIDS

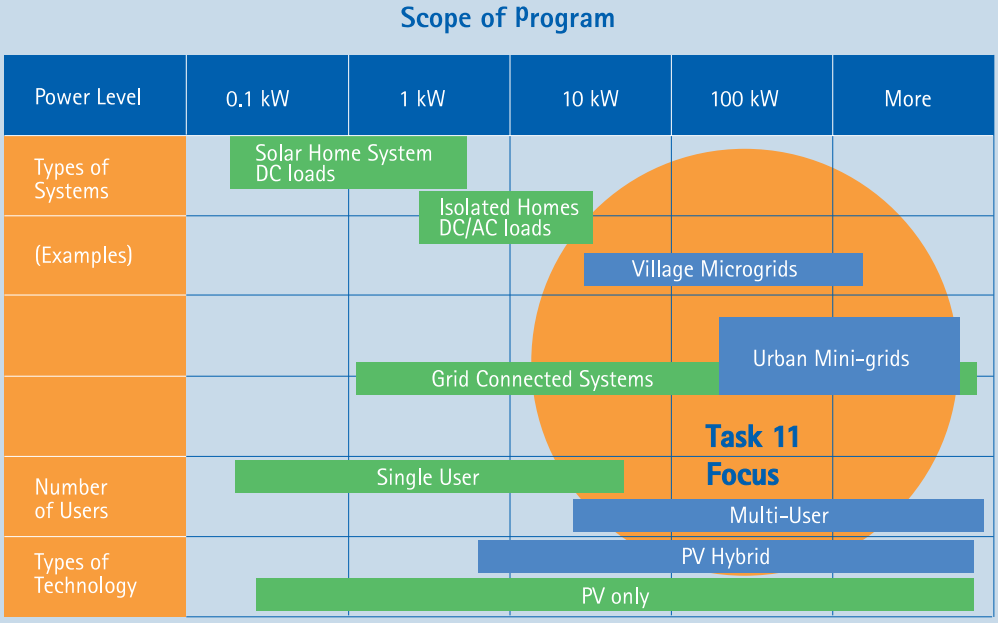


Fig. 1 - Scope of the Task 11 Program.

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 relatively 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 Workplan 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.

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.

Fig. 1 – Task 11 Experts Meeting in Glyfada, Greece, May 2008.

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 2008

Several changes in Subtask and Activity leaders during 2008 slowed progress on the Workplan. However Task 11 has completed the initial phase of data collection and analysis in several activities in the Workplan and has begun planning the deliverable reports which will be published in 2010 and 2011. Progress in individual subtasks is summarized below.

SUBTASK 10: Design Issues

Subtask 10 has surveyed available material on design of PV hybrid mini-grids, with a focus on design guidelines suitable for practitioners rather than research-oriented literature. It has also gathered information on the architecture and technical characteristics of installed PV hybrid mini-grids in numerous locations around the globe. This data will form the basis of the deliverable report on current hybrid mini-grid system architectures.

Subtask 10 also continued its work on software design and simulation tools for PV hybrid mini-grids. A paper on the results of its survey of software design tools was presented at the 4th European Conference on PV-hybrid systems and Mini-grids. As an additional method of dissemination, and to begin the discussion on needed advances in design tools, Subtask 10 organized a Workshop on software design and simulation tools for PV hybrids and mini-grids in conjunction with the 23rd European Photovoltaic Solar Energy Conference in Valencia in September 2008. The workshop had presentations from software tool developers about the current status and future developments of software tools and presentations from the user community about their experiences using the tools and their needs for the future. The presentations from the Workshop can be found in the Public Downloads page of the Task 11 web-site at http://www.iea-pvps-task11.org/index.htm.

SUBTASK 20: Control Issues

The first phase of this subtask is also to assess the current state of the art. Subtask 20 has used surveys, literature reviews, and expert assessments to gather the basic data. Chapter outlines or drafts were presented at the two Experts Meetings in 2008 for most of the topics to be addressed in the deliverable reports.

SUBTASK 30: PV Penetration in Mini-grids

The first draft of a set of performance assessment criteria for PV hybrid systems was peer reviewed by Task 11 participants. A final draft was presented and discussed at the second Experts Meeting in November 2008 and will be used as the basis for the deliverable report.

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. A total of 36 system descriptions using were submitted by Task 11 countries. The systems have a worldwide spread, with varying architectures, power ratings, and data availability. A short list of twelve systems was selected for detailed study. Unfortunately changes in Subtask and Activity leaders during 2008 have delayed these detailed studies. However progress was made on workplans and report outlines for the Activities on financial and environmental sustainability.

PLANS FOR 2009

In 2009, Task 11 expects to complete document plans and first drafts of deliverable reports in all Subtasks.

PUBLICATIONS AND DELIVERABLE ITEMS

There are as yet no formal reports or publications from the Task 11 Activities. However, several papers have been presented at conferences to publicize the Task, outline its mission and Workplan, and present interim results. Task 11 Experts presented numerous papers at the 4th European Conference on PV-hybrid systems and Mini-grids in May 2008, including the following, which directly relate to Task 11 activities:

- K. Mauch, "Current State of the Art in PV Hybrid Mini-Grids – Early Results from IEA PVPS Task 11", 4th European PV-Hybrid and Mini-Grid Conference, May 2008.
- A. Lippkau, "World-Wide Overview About Design And Simulation Tools for Hybrid PV Systems", 4th European PV-Hybrid and Mini-Grid Conference, May 2008.
- F. Katiraei, D. Turcotte, A. Swingler, J. Ayoub, "Modeling and dynamic analysis of a medium penetration PV-Diesel Mini-Grid system", 4th European PV-Hybrid and Mini-Grid Conference, May 2008.
- J.C. Marcel, "IEA PVPS Task 11 (Hybrid System within Mini-Grid) Sub Task 40: Sustainability Conditions", 4th European PV-Hybrid and Mini-Grid Conference, May 2008.

Task 11 also disseminates news about its work through its website at http://www.iea-pvps-task11.org.

MEETING SCHEDULE (2008 AND 2009 PLANNED)

Task 11 had the following Experts Meetings in 2008:

- **5th Task 11 Experts Meeting**, 27-28 May 2008, Athens (Glyfada), Greece
- **6th Task 11 Experts Meeting**, 22-23 November 2008, Alice Springs, Australia

Task 11 plans to have two Experts Meetings in 2009. The first will be:

- **7th Task 11 Experts Meeting**, 2-3 April, 2009, Vienna, Austria.

TABLE 1 - INDUSTRY INVOLVEMENT

Task 11 is fortunate to have significant industrial participation from manufacturers and system integrators. The table below summarizes the 2008 industrial (private sector corporate) participation.

COMPANY	COUNTRY	BUSINESS ACTIVITY
Caterpillar Inc.	USA	Engine-generator manufacturer
Conergy AG	DEU	PV system integrator and equipment manufacturer
arsenal research	AUT	Research and development
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
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

Fig. 2 – Task 11 Experts' technical tour of the King's Canyon PV system in Australia, November 2008.

TABLE 2 - TASK 11 PARTICIPANTS

As of the end of 2008, the following IEA PVPS countries are participating in Task 11 – PV hybrids in mini-grids: Australia, Austria, Canada, France, Germany, Italy, Japan, Korea, Norway, Spain, Switzerland, and the USA. The management of the Task - the Operating Agent - is being executed by Canada. The national contacts of IEA PVPS Task 11 are:

COUNTRY	NATIONAL CONTACT	CONTACT ORGANIZATION
Australia	Wolfgang Meike, Novolta Pty.	wolfgang.meike@novolta.com.au
Austria	Christoph Mayr, arsenal research	christoph.mayr@arsenal.ac.at
Canada	Konrad Mauch –Operating Agent, KM Technical Services	konrad.mauch@ieee.org
France	Nadine Adra, Transenergie SA	n.adra@transenergie.eu
Germany	Michael Müller, Steca GmbH	michael.mueller@steca.de
Italy	Francesco Groppi, CESI Ricerca	francesco.groppi@cesiricerca.it
Japan	Masanori Ishimura, NEDO	ishimuramsn@nedo.go.jp
Korea	Kee Hwan Kim, Semyung University	khkim@semyung.ac.kr
Norway	Tor Martin Fossan, SWECO Grøner AS	tormartin.fossan@sweco.no
Spain	Xavier Vallvé, Trama TecnoAmbiental	tta@tramatecnoambiental.es
Switzerland	Michel Ryser, Sputnik Engineering AG	michel.ryser@solarmax.com
United States of America	Benjamin Kroposki, NREL	benjamin_kroposki@nrel.gov

TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

Fig. 1 - Task 12 Experts Meeting in Valencia, Spain, 30th August 2008.

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 the 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 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 (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

The study carried out By Ökopol and co-funded by EPIA and BSW in the framework of PV CYCLE has been finalized during the spring 2008. The study *"For the Development of a Recovery and Recycling System for Photovoltaic Products"* is sponsored by BMU and it is available in both German and English at www.pvcycle.org. The study deals with PV market and technologies analysis, waste forecasts, political and legal parameters, recycling processes and techniques, eco-balance aspects (environmental impact of the different recycling options), benchmarks of a voluntary recovery systems of PV modules and logistic costs for such a system.

The Members of PV CYCLE (representing more than 70 % of the European PV market) have committed to collecting a minimum of 65 % of photovoltaic modules installed in Europe since 1990 and to recycling 85 % of the collected waste. PV CYCLE's declaration to that effect was made on 19 December 2008 and supported by French Energy Minister Jean-Louis Borloo, as well as Environment Commissioner Stavros Dimas.

The association is at the final stage of developing its recycling scheme that should be publicly presented by 1 April 2009.

TABLE 1 – TASK 12 PARTICIPANTS

COUNTRY	ORGANISATION	PARTICIPANT
The Netherlands	Utrecht University	Mr. Erik Alsema
		Mr. Nils Holger Reich
	ECN	Ms. Mariska de Wil-Scholten
Belgium	EPIA	Ms. Eleni Despotou
		Mr. Daniel Fraile
USA	Brookhaven National Laboratory	Mr. Vasilis Fthenakis
	Columbia University	Mr. Hyung Chul Kim
Germany	LBP Stuttgart University	Mr. Michael Held
	ZSW	Ms. Wiltraud Wischmann
	Deutsche Solar	Mr. Karsten Wambach
Switzerland	ESU-Services	Mr. Rolf Frischknecht
Austria	Umweltbundesamt GmbH	Mr. Werner Pölz
Norway	ELKEM Solar	Mr. Ronny Glockner
Spain	ESCi	Mr. Marco Raugei
Japan (Observer)	Nedo	Mr. Masanori Ishimura
	Mizuho Information & Research Institute Inc.	Mr. Keiichi Komoto
	Kyocera Corporation	Mr. Mitsutoshi Hino

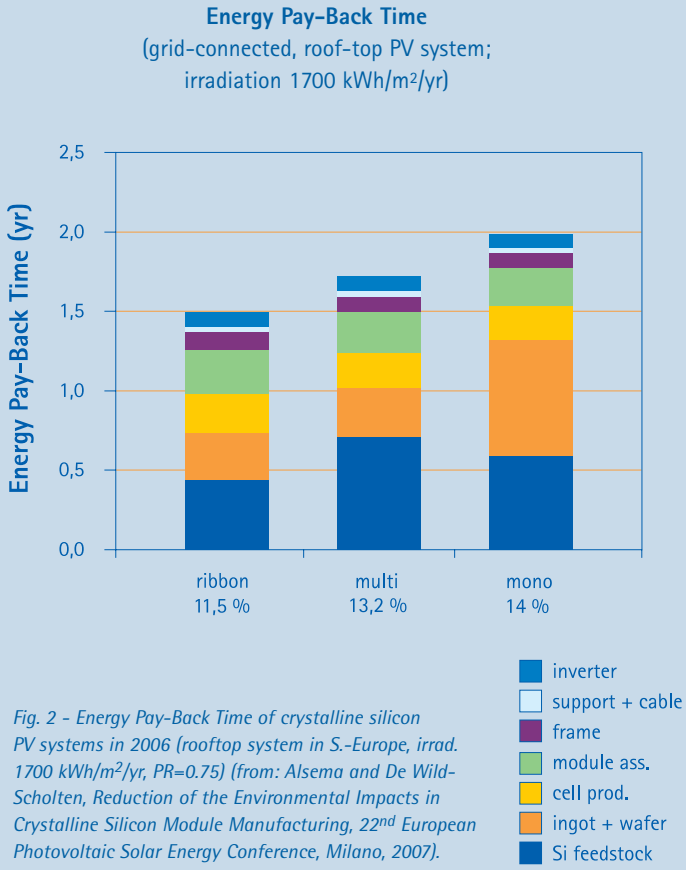


Fig. 2 - Energy Pay-Back Time of crystalline silicon PV systems in 2006 (rooftop system in S.-Europe, irrad. 1700 kWh/m²/yr, PR=0.75) (from: Alsema and De Wild-Scholten, Reduction of the Environmental Impacts in Crystalline Silicon Module Manufacturing, 22nd European Photovoltaic Solar Energy Conference, Milano, 2007).

SUBTASK 2: Life Cycle Assessment

Task 12 experts from Brookhaven National Laboratory (BNL), University of Utrecht, Energy Research Centre of the Netherlands (ECN), Stuttgart University and Elkem Solar are engaged on ongoing projects on LCA. These researchers presented papers at the 23rd EU PVSEC in Valencia, Spain, September 2008, and also submitted several articles to major journals.

Studies on LCA have been carried out for different Concentrated PV products and for the Solar grade silicon through a metallurgical route (Elkem Solar Silicon – ESS™) based in a low energy production process.

In 2008, a complete LCA model for estimating climate impact and energy consumption was finished. Results from this were disseminated at the "SCSI IX - Silicon for Chemical and Solar Industry" at Holmen Fjordhotel in Asker, Norway, June 2008. The models were upgraded with sensitivity analysis on the re-use of waste heat internally and externally in the production process. These results were presented at the 23rd EUPVSEC - European Photovoltaic Solar Energy Conference and Exhibition in Valencia, September 2008.

Update of the life cycle inventories of selected BOS components and of the GaAs modules embedded in the life cycle assessment database ecoinvent.

A draft of the "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" was presented during the experts meeting in Valencia, September 2008 and afterward, several discussion have taken place to agree on the assumptions. The work in this area is now advancing quickly and the final version is expected to be ready by March 2009.

A number of papers related to life cycle assessments and other environmental aspects have been published during 2008 and can be found at:

- http://www.ecn.nl/publicaties/default.aspx?au=44649
- http://www.clca.columbia.edu/publications.html
- http://www.pv.bnl.gov

SUBTASK 3: Safety in Facilities

Eugene Ngai, Air Products, and Vasilis Fthenakis, Brookhaven, gave a seminar on Silane Safety in conjunction of the IEEE PVSC, San Diego, in April 2008, where they highlighted the risks involved with silane and presented an overview of proper silane safety procedures and practices.

Besides the cooperation with specific companies, negotiations among the Semiconductor Equipment and Materials International association (SEMI), the Semiconductor Safety Association Europe (SSA) and Task 12 members are taking place in order to bring the long experience on safety issues from the semiconductor industry to the photovoltaic industry. Presentations will take place during 2009 and some forms of collaboration are being discussed.

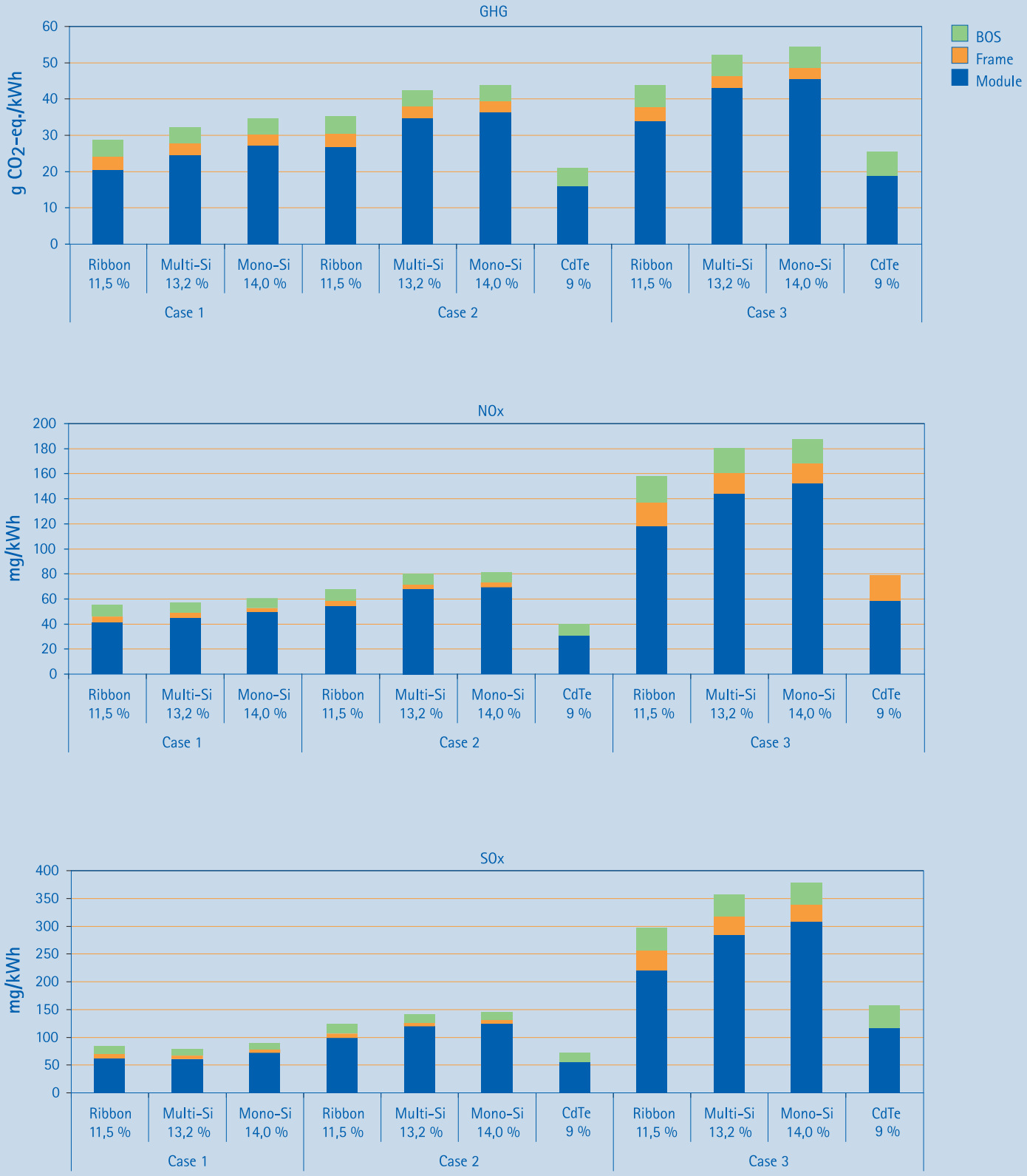


Fig. 3 - Life-cycle emissions from silicon and CdTe PV modules. BOS is the Balance of System (i.e., module supports, cabling and power conditioning). Ground-mounted systems, Southern European insolation, 1,700 kWh/m^2/yr, performance ratio of 0.8, and lifetime of 30 years. Case 1- current electricity 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 (from: Fthenakis, Kim and Alsema, Emissions from Photovoltaic Life Cycles, Environmental Science and Technology, 42(6): 2168–2174, 2008).

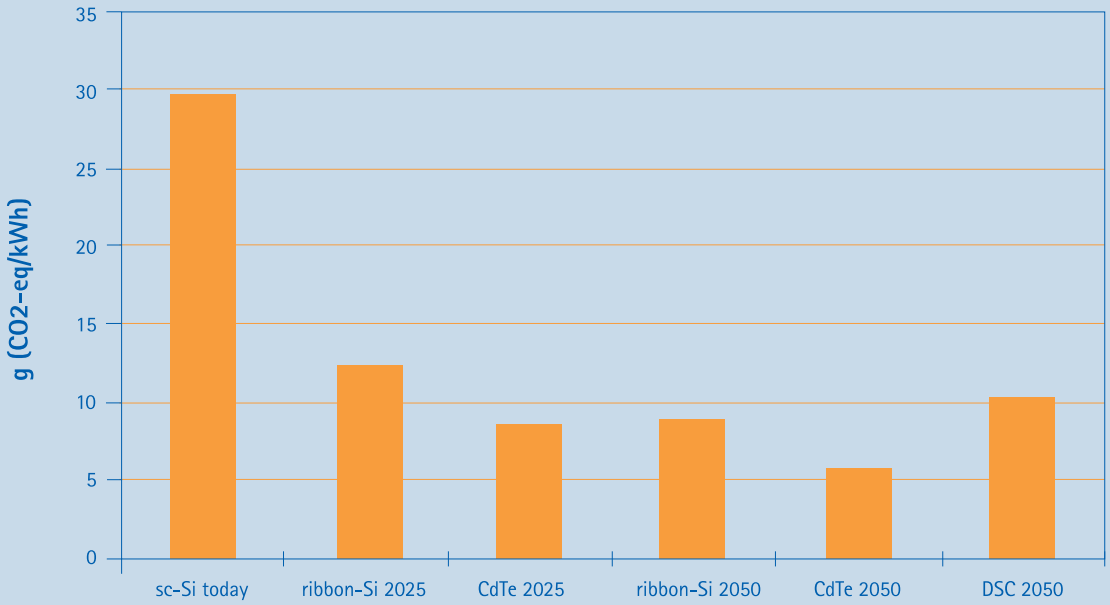


Fig. 4 - GWP results for future PV systems, based on an update of the scenario analysis performed within the NEEDS [1] project (from: Raugei and Frankl, Life cycle impacts and costs of photovoltaic systems: current state of the art and future outlooks, Energy, in press).

SUBTASK 4: EH&S Information Dissemination

The Task 12 website www.iea-pvps-task12.org was created in 2008 and is currently being developed.

The website will host the Task 12 documentation, announcements, products and will provide links to other IEA and PV Technology and EH&S and LCA research websites (e.g., Brookhaven National Laboratory, Columbia University, University of Utrecht, ECN, University of Stuttgart, National Renewable Energy Laboratory, PVCYCLE, ESU-services Ltd).

Literature related to life cycle assessment of photovoltaic systems, as well as literature related to recycling of photovoltaic components will be posted on the website.

Nevertheless, the main objective of this website is not only to offer EH&S technical information such as scientific papers and studies (as the one of PVCYCLE), but also to provide general information about the environmental benefits of PV. It should be a reference of point for journalists when searching for this kind of information.

PLANS FOR 2009

The "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" are being finalized and are expected to be ready by March 2009. Once they are approved by the ExCo, they will be printed and disseminated.

A study has been initiated at the Brookhaven National Laboratories, U.S.A, to define the cost of collecting and recycling thin-film PV modules and the cost of setting up a collection infrastructure in the U.S.

A workshop on Recyling for the US industry is proposed in conjunction with the IEEEPVSC, Philadelphia, June, 2009, Philadelphia, PA, USA, June 6-11 June, 2009.

A workshop on Recycling may be organized in Europe by PV Cycle with the Support of EPIA in the second half of 2009.

A Task 12 technical and administrative meeting will be held in conjunction with the 24th EU PVSEC, Germany, in September 2009, and perhaps the IEEE PVSC, US, 6-11 June 2009.

The Next version of ecoinvent data v2.1 will be ready incorporating updates of thin-film GaAs modules and updated figures on BOS components. It will also include Metallurgical grade silicon production:

- include microsilica as by-product
- refine CO_2 emissions
- include emissions of PAHs and dioxin

By spring 2009, PV Cycle expects to have completed the design of the recycling model in detail and to have documented this model through the voluntary agreement signed lately in 2008 with the commitment of the PV industry producers. Having done so, the association will introduce the Phase II of the project.

PUBLICATIONS AND DELIVERABLES

In 2009, articles and papers will be presented in the press and during international conferences like 24th EUPVSEC; some of which include:

- Life Cycle Impacts and Costs of Photovoltaic Systems: Current State of the Art and Future Outlooks, Energy, (Marco Raugei and Paolo Frankl)
- Life Cycle Assessment of CdTe PV modules (it will present and discuss the results of the whole life cycle of CdTe modules and will present results from a scenario analysis concerning possible future environmental profiles of CdTe modules). Michael Held, LBP University of Stuttgart
- Control of Emissions from Crystalline Silicon Solar Cell Manufacturing (M.J. de Wild-Scholten, M. Schottler)
- Meeting the NEEDS of European Environmental Sustainability Assessment, (Frischknecht R., Krewitt W)

Footnotes

1 *http://www.needs-project.org*

AUSTRALIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
DR MURIEL WATT, IT POWER AUSTRALIA

Fig. 1 – Conergy photovoltaic system installed by Solar Newcastle. 17 kW PV system at the Tighes Hill Campus of Newcastle TAFE. Modules: Conergy S175 M. 16 kW is mounted on the Conergy SolarFamulus mounting system, with the remaining 1 kW mounted on the single axis tracker.

GENERAL FRAMEWORK

In November 2007 a new Labor Government was elected in Australia. It has ratified the Kyoto protocol, has pledged to increase the Renewable Energy Target from its current level of 9 500 GWh by 2010 to 45 000 GWh by 2020, to substantially increase the Solar Schools program, to extend the Solar Cities program to a total of 7 cities and to support increased solar research and development. It has also announced an Australian emissions trading scheme, called the Carbon Pollution Reduction Scheme, which is to begin by 2010, albeit with only a 5% emission reduction target on 2000 levels by 2020.

The national government has indicated an interest in a uniform PV feed-in tariff across Australia but has left it to the States to consider. The Northern Territory Power and Water Authority, as part of the Alice Springs Solar City, is offering an AUD 0,45/kWh tariff for all electricity generated from the 225 homes being supported through the program. This is about twice the daytime electricity tariff and the buyback is capped at AUD 5 per day (effectively limiting the tariff to 2 kW systems). In conjunction with capital grants available, system costs are expected to be repaid within 10 years. The South Australian and Queensland governments announced new net export feed-in tariffs of AUD 0,44/kWh and the Victorian government AUD 0,66/kWh. The Australian Capital Territory is considering a total generation tariff set at 3.88 X standard tariffs, with the aim of paying back system costs within 10 years. The NSW and Western Australian Governments have announced feed-in tariffs, but no details have been released.

NATIONAL PROGRAMMES

Whilst there is no specific national PV programme, there are a number of key PV support mechanisms which drive the Australian market. These include the *Solar Homes and Communities Plan*, which has seen 25 MW of PV installed up to November 2008; the *Renewable Remote Power Generation Program* (RRPGP) which has provided 50 % of off-grid renewable energy system costs, with the aim of reducing diesel fuel use, but now has restricted grants to smaller systems via a AUD 200 000 cap; the *Solar Cities* program, which is creating a useful driver for PV installations for the next 5 years, particularly in the otherwise neglected commercial sector; and the *Solar Schools* program, which could see the installation of 20 MW of PV over the next 8 years. The majority of small PV systems installed create *Renewable Energy Certificates* (RECs) under the *Renewable Energy Target* (RET) scheme and some are registered under GreenPower programs, although many of these may have benefitted from the grant programs as well.

The most important new driver for the PV market in 2007 and 2008 was a doubling of the residential grant from the PV Rebate Program, now called the Solar Homes and Communities Plan, from AUD 4 000 to AUD 8 000 for the first kW installed. This resulted in significant market growth, the establishment of many new businesses and a marked increase in PV installer accreditation. 150 MAUD was allocated to the program over 5 years. However, system installations increased from an average of 300 to over 1 000 per month and in early 2008 the government introduced a means test to reduce demand and keep within

Fig. 2 – Solar arrays at the Desert Springs Solar Test Centre, Alice Springs Kyocera amorphous modules, 1,08 kW each unit, 135 watt panels, 13,5 % efficiency, Wattsun tracker. Five trackers connected to grid through a 5 kW inverter. Behind amorphous array are the CdTe panels (photo Simon Troman).

its budget limits. A total of 4,6 MW of PV was installed under the Program in 2007 and more than 11 MW in 2008, up from 1,8 MW in 2006.

From mid 2009, the program is to be replaced with Solar Credits, whereby PV systems less than 1.5 kW will be eligible to create 5 RECs for each MWh of electricity generated, rather than the standard 1 REC. This will apply for 3 years, after which the multiplier will reduce each year and reach parity by 2016. RECs can be deemed for 15 years, so this mechanism can reduce up front capital costs. Of course, the support received will be higher for areas with higher solar insolation levels, and will depend on prevailing REC prices.

The Solar Cities Program includes funding and promotion of energy efficiency and solar options (PV and solar water heating). It is one of the few programs providing funding for larger systems on community, commercial and industrial premises. The aim is to test a variety of marketing strategies and tariff structures which support the uptake of energy efficiency and solar technologies which can then be used in the wider Australian community in future. State Governments, local utilities and other businesses are also involved so that the program is expected to generate wide community interest.

R, D & D

Photovoltaics research and development is undertaken across a range of university, government and industry facilities. University research groups undertake both fundamental device research and applied industry-oriented R&D, while industry-based and collaborative research involves PV manufacturing processes and PV systems. A total of 64,69 MAUD of government funds was allocated to R, D & D in 2007, most of this (83 %) to the market support programs described above.

The new Australian Solar Institute (ASI) will provide funding of 100 MAUD over 4 years for solar PV and solar thermal electric research. A portion of the funding is tied to core projects, with the remainder being available through a competitive grant process. Funding for large scale demonstration projects is available over the next 2 years through the AUD 500 M Renewable Energy Fund, although industry must contribute AUD 2 for each AUD 1 of Government funding.

INDUSTRY STATUS

In 2007 the PV business in Australia was worth an estimated 210 MAUD, with another 81.6 MAUD in exports, while the value of imports was about 100 MAUD. Direct employment attributed to PV in the different sectors of policy, R&D, manufacturing, distribution and installation is estimated to be around 1 660 people.

There is only one module manufacturer in Australia – BP Solar, which produces its own cells and modules from imported wafers. In 2007, 75 % of cells produced at the BP Solar Sydney plant were exported

and 52 % of modules. Standardisation of products continued and larger kit systems were marketed while improved anti-reflect coatings on glass were introduced. However, BP Solar has announced that it will close its Sydney plant in early 2009.

Solar Systems manufactures concentrator PV systems using imported cells, but is in the process of setting up cell manufacture in Australia. There are a number of Australian manufacturers of inverters, battery charge controllers and inverter/chargers, particularly catering for the off-grid system market, including Selectronics, Plasmatronics, Latronics and Solar Energy Australia. Some of these manufacturers also supply inverters suitable for grid interconnection. Inverter prices typically range from AUD 0.5 – 1.5 per W. Although some battery components are made in Australia, only a few companies manufacture complete solar batteries. These include Exide's Energystore products and Battery Energy's Suncycle range. Battery Energy, in conjunction with the Commonwealth Scientific & Industrial Research Organisation (CSIRO), has also developed a solar gel battery, Sungel.

The Australian PV industry has historically shown strength in industrial innovation, providing solutions for different market requirements. This innovation was initially focused on the telecommunications network as well as on the power requirements of remote households, cattle stations and communities. The ongoing need for reliable power in remote locations has more recently seen innovations in large-scale concentrator PV systems as well as in water pumping applications. To service the Australian off-grid market, the PV industry has developed very reliable systems, as well as distribution and installation networks and remote monitoring systems. In addition to meeting customers' expectations, reliability is also driven by the high cost of travelling to remote systems for maintenance and repair. Products must be suitable for hot deserts, colder regions of southern Australia and extremely humid conditions in the tropical north.

MARKET DEVELOPMENT

By the end of 2007, over 82 MW of PV had been installed in Australia, with just over 12 MW of this in 2007. Grid-connected systems accounted for 52 % of 2007 installations but just under 22 % of cumulative installed capacity. The 2008 market is estimated to be 15-18 MW, largely due to the increased take-up under the Solar Homes and Communities Plan.

Module prices dropped to AUD 7 /Wp in 2007 and small grid system prices were AUD 10-12/Wp. There was increased evidence of collective purchasing schemes to lower prices, while some mainstream appliance stores began to retail PV systems. In the longer term, these trends will change the structure and make-up of the Australian PV supply chain.

FUTURE OUTLOOK

In 2007 PV prices fell slightly in Australia for the first time in several years. Grid electricity prices around Australia are set to rise consistently over the coming decade so that, if PV prices continue to fall, a more robust market should develop. Market support is likely to be needed for a few more years, although grid parity could begin to be reached in some areas of Australia within a decade.

Fig. 3 - Tranz PV water pump at the Desert Springs Solar Test Centre, Alice Springs (photo Simon Troman).

With the close of the BP Solar plant, the Australian PV market will be entirely reliant on imported product. This increases the risk of supply and price, and exacerbates the sensitivity to exchange rates. It also removes the opportunity for local uptake of Australian PV research and for local employment of manufacturing graduates. Nevertheless, there are several companies looking at establishing new plant in Australia. In the longer term, as grid parity is reached, the potential market is large, so that local manufacture will become more attractive.

The off-grid market will remain important for PV in Australia, since little additional grid extension is likely and we have many extremely remote locations in need of reliable power. With an increased reliance on imported diesel, likely continued diesel price increases over the long term, as well as the constant problems of fuel delivery to remote locations, PV remains a sensible option. The cost-effectiveness of PV in the off-grid market is dependent not only on PV module prices, but also on balance of system prices, availability and reliability. This includes inverters, load management, batteries, and control systems which allow for automatic operation and interconnection of different energy technologies.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

HUBERT FECHNER, UNIVERSITY OF APPLIED SCIENCES, TECHNIKUM VIENNA

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

Manufacturing of photovoltaic products has developed very well in Austria, however the market is still lacking continuity in public support schemes for a significant home market. This leads to typical export rates from individual companies of 90 % or even more. Many of the innovative PV systems from Austrian production and design are installed in other European and outer European countries, due to the still insignificant and instable Austrian market support schemes.

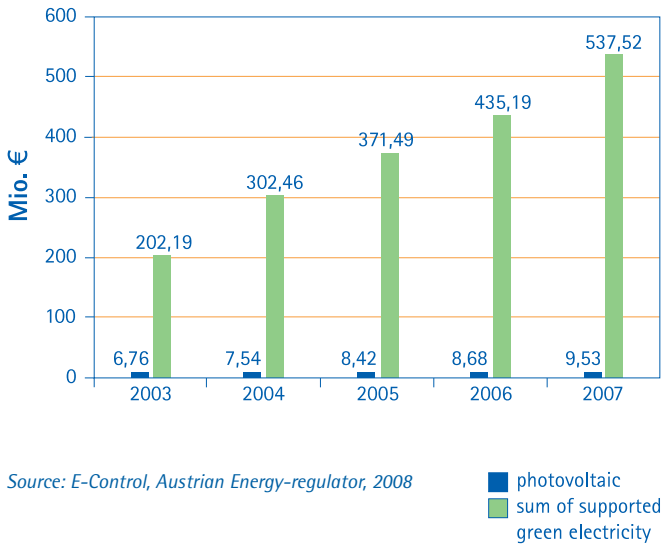
A wide public support for PV installations as well as for other "new renewables" (Austria has about 60 % electricity from large hydro) will also most probably not be achieved within the upcoming year; the revision of the green-electricity act (GEA) is not yet in operation, it can be expected that the huge potential of PV and the industrial opportunities for Austria will again not be addressed accordingly.

Even though the "new *RES*" are supported since the beginning of this act mainly via long-term guaranteed feed-in tariffs, the financial cap is too low to introduce significantly these "new *RES*" on the market. 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.

The main pillars of the new regulation are:

- Annual additional funding volume reduced to 21 MEUR for all renewable energy sources
- Photovoltaics and other green plants will receive about 10 % of the support volume
- The duration of the program is 10 years constant + 2 years declining support

Table 1: Subsidy Volume Development for Green Electricity in Austria



Source: E-Control, Austrian Energy-regulator, 2008

Fig. 1 - Power Tower, Energie AG Linz (photo Energie AG, Wilk).

Fig. 2 - Chamber of Commerce, Vienna, 57 kWp PV-System (photo Austrian Chamber of Commerce).

It is often criticised that no definitions for supporting specific PV applications (as e.g. Building Integrated PV like proposed in the Federal "Austrian PV Technology roadmap") niche markets, where Austrian companies could maybe reach a leading position, had been made.

According to the former edition, by this feed-in-tariffs only systems > 5 kW will be supported; systems up to 5 kW have to undergo the procedure of application by the limited sources of the governmental Austrian Climate and Energy Fund.

This intermittently launched support initiative will support only small systems (private households) and was opened for the first time in August 2008 by one tender with a total budget of about 10 MEUR to support private PV Systems (< 5kW) which lead to another about 900 PV Systems with a total of about 4 MW. However, these singular initiatives are by many PV stakeholders not seen as appropriate basis to seriously and continuously develop a national PV market. Differently to the feed in tariff system this support scheme provided financial benefits to building integrated systems.

It can be expected that about 5-8 MW annually installed systems in Austria will be installed 2009 if the support systems will be operational.

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

RESEARCH AND DEVELOPMENT

Following the national PV Roadmap as first step in a continuous PV technology development process (issued 2007 by the Ministry of Transport, Innovation and Technology), a National PV Technology Platform was founded in September 2008 along with the 6th Austrian PV conference. The PV Technology Platform brings together the 10 leading industries in order to discuss their needs for a long term strategy towards an international competitive positioning on the growing world market. Currently, about 1 500 employees are working in the PV industry in Austria. This initiative was again launched by the Department of Energy and Environment of the Ministry of Transport Innovation and Technology.

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 as well as in different tasks of the IEA PVPS Programme as well as concerning grid interconnection in the IEA ENARD Implementing Agreement. The RTD development and approach is widespread located and decentralised orientated.

Two national programmes "New Energy 2020" by the Austrian Climate and Energy fund as well as "Buildings of Tomorrow Plus" again by the Ministry of Transport, Innovation and Technology were launched in 2008 and cover quite broad research items on energy technologies including PV with a focus on PV building integration. 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 to PV can be financed within this well designed activity.

On the 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.

The electricity companies are investing more and more in renewable. Departments were founded to establish businesses, mainly through investments in new and existing renewable energy plants. However, due to the insufficient national support for renewables, they mainly invest in other European countries. For PV, most relevant activities were done by Verbund – Austrian Renewable Power: They acquired two PV power plants in Spain with a total peak power of approx. 3 MW. These power plants have been developed, constructed and turn key delivered by the Austrian KIOTO Photovoltaics Group.

Research highlight of photovoltaics in Austria are:

- The Christian Doppler Laboratory "Applications of Sulfosalts in Energy Conversion" in Salzburg succeeded in the development of a deposition process for the worldwide first all-sputtered sulfosalt thin film solar cell. Efficiencies are still low but the increase will be a task of the near future. New sulfosalt phases with specific crystal structures have been discovered and the study of their physical properties is subject of the ongoing work.

- Research on PV inverter specification (MPP, fault-ride-through, efficiency aspects...) is done at arsenal research attracting world wide inverter manufacturers for collaboration.
- Smart electricity networks are the main focus of several national and EU financed projects, with a national technology platform launched in May 2008. Even though PV interconnection is not yet the main technology driver, it is part of the game.
- Cost reduction and optimization of new solutions for building integrated PV are addressed within several EU projects.
- Organic Solar Cells based on thin plastic films have been intensively investigated during the last 10 years, at the Kepler University of Linz. This lead to the foundation of a local branch of an U.S. PV company in Linz.
- 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 in addressing architectural building design.
- In the area of system technology, the activities for quality assurance, certification and testing of PV modules were extended. The Austrian Research and Testing Centre "arsenal research," known as the internationally accredited PV module test institute according to according to the IEC/EN 61215 standard, thin film modules according to the IEC/EN 61646 and module safety qualification according to the EN 61730, as well as testing PV inverters.
- The national PV Technology Platform was established in September 2008 bringing together the 10 leading industries in PV manufacturing.
- The Energybase, home of the new Bacc. and MSc. Programmes "Renewable Urban Energy Technologies" (University of Applied Science Technikum Vienna) with the largest passive solar office building, was opened; featuring a 45 kW highly innovative PV Facade

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 27 MW of PV power had been installed in Austria by the end of 2007. Figures are not yet available for 2008, but it is expected that currently not more than about 31 MW are totally installed in Austria.
The annual growth rate in 2008 was at a total of 2,5 MW; which is amongst the lowest.
Despite the weak home market, Austria has some internationally well positioned manufacturers nearly exclusively involved in foreign trade, mainly focusing on the neighbouring large German market as well as the well developed markets of Spain and Italy.

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 a few remarkable installations were realised, amongst them the so far largest PV Facade at the federal Chamber of Commerce in Vienna.

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 2008 focussing on the export of their products predominately to the booming German and other International markets. In Austria, there are about 1 500 employees in the PV business which seems to be a success; but this relies very much on the development outside the country's borders.

Blue Chip Energy GmbH started production of silicon solar cells in the energy autarkic municipality of Güssing (Burgenland) in 2008. They are expected to finally employ 350 people.

Ertex-Solar (a subsidiary of Ertl Glas AG) realized couple of projects all over the world in recent years. A new and innovative laminated safety glass production line for BIPV modules started in June 2008 in order to follow the huge demand regarding BIPV projects. One of their main products is VSG; a laminated safety glass which can also be assembled easily to insulating glass.

KIOTO Photovoltaics: Produces modules with a current capacity of 40 MWp p.a. and develops turn key PV power plants in various southern European countries. KIOTO Photovoltaics is part of the KIOTO Clear Energy AG, which also has a strong foothold in the solar thermal business (mainly with the group company GREENoneTEC).

PVT Austria, the first manufacturer of PV modules in Austria produces standard and tailored modules from imported crystalline silicon cells. The company successfully increased their output taking profit from the German PV boom.

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.

SOLON-Hilber Technology: A subsidiary of the German SOLON manufacturer produces solar trackers and solar modules in Tyrol, close to Innsbruck. It began production in 2003 and currently more than 200 employees are working with this company.

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 for many years and is one of Europe's leading manufacturer of inverters for grid connected PV systems.

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

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

Ulbrich of Austria is manufacturing string- and buswires for PV Cells and modules with a planned capacity of more than 1,5 GW.

MARKET DEVELOPMENT

The Ministry of Environment, engaged in climate protection has started a large programme of initiatives to reduce CO_2 emissions ("klima:active") in 2004, by addressing and fostering various technology sectors like biomass-heating, solar thermal systems, heat-pumps, low energy buildings, environmental benign transport and others and 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 significantly expanded their activities by creating a national network for dissemination of information on PV and initiating awareness raising activities. By fostering the political contacts, intensive political lobbying work and a broad series of articles in newspapers for PV, the association aims at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives; preferably based on feed in tariffs.

By the end of 2008, more than 100 companies and people involved in the PV business were Association members, which is about four times as much as at the end of 2005.

The annual National Photovoltaic Conference 2008 (a two days event), organised by some of the main PV stakeholders and supported by the Ministry of Transport, Innovation and Technology, was once again a great success, with more than 220 experts participating. This conference is now established as THE annual come together of the Austrian PV stakeholders. The foundation of the new PV technology platform and the great industrial potential for Austrian companies was discussed this year at the event.

The Austrian Research and Testing Centre "arsenal research" (known as the internationally accredited PV module test institute according to IEC 61215 as well as testing PV inverters) has continued its "Certified PV Training" with another four trainings for installers and planners in 2008, 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 2009.

FUTURE OUTLOOK

The situation of the local PV market still remains unsatisfactory, mainly because of the complex, instable and primarily 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.

The situation of the steadily growing Austrian PV industry is expected to be further improved, mainly due to the international booming PV market, but still lacks support locally.

Some initiatives (PV Roadmap, Technology-platform, PV Lobbying by the Association, PV Conference, etc.) might draw the attention of decision makers, hopefully leading to a comprehensive long-term strategy for PV-development in Austria.

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, 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 courses are currently under development. All of them include PV as an essential part of the future energy strategy. The importance of proper education for PV system installers and planners will increase, depending on the market situation. Training is already available and can be extended easily. Concerning higher level education, the University of Applied Science Vienna (Technikum-Wien) has started its Bachelor degree program in "Urban Renewable Energy Technologies" with PV-Systems as a core element of the education. A Masters degree program (MSc.) in the same field will commence in autumn 2009.

It can be expected that the National PV Association and other important PV stakeholders will further significantly promote the topic in Austria. The vital local PV industry, currently taking advantage of the strong German and other European markets is very much interested in creating a home market for PV, and is still waiting for an improvement of the economic frame conditions.

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

JOSEF AYOUB AND LISA DIGNARD-BAILEY, CANMETENERGY NATURAL RESOURCES CANADA
(HTTP://WWW.CANMETENERGY.NRCAN.GC.CA)

GENERAL FRAMEWORK

Natural Resources Canada's (NRCan) CanmetENERGY[1] is the Canadian leader in clean energy research and technology development. With over 450 scientists, engineers and technicians and more than 100 years of experience, they are Canada's knowledge centre for scientific expertise on clean energy technologies. CanmetENERGY supports NRCan's priorities to promote the sustainable and economic development of Canada's natural resources, while improving the quality of life of Canadians. It manages the science and technology programs and services, supports the development of energy policy, codes and regulations, acts as a window to federal financing and works with our partners to develop more energy efficient and cleaner technologies. The federal R, D & D in photovoltaic technology is led by the CanmetENERGY research centre located in Varennes, Quebec.

The Canadian Solar Buildings Research Network (SBRN)[2] 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. The SBRN pools the R&D resources of eleven universities and federal departments to develop the future generation of experts knowledgeable in solar buildings research. In 2008, the SBRN and NRCan collaborated on a high profile demonstration of a combined solar heat and power generating system that was installed on the façade of a new building at Concordia University in downtown Montreal. The RD and D efforts of the SBRN are providing in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions, and are supporting innovation in the construction industry in order to accelerate the adoption of low and net-zero energy solar homes.

In 2008, the Government of Canada invited builder and developer teams in British Columbia, the Atlantic Region and the North to design and build or renovate eco-friendly homes as part of the second phase of Canada Mortgage and Housing Corporation (CMHC) EQuilibrium Housing Sustainable Demonstration initiative[3]. 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 initial phase approved the selection of twelve Canadian homebuilder teams. Federal PV experts as well as the efforts they undertake continue to provide technical and financial support to some of the demonstration house in this initiative.

NATIONAL PROGRAMME RESEARCH AND DEVELOPMENT

The federal photovoltaic activities are geared towards helping develop and deploy photovoltaic energy technologies in Canada. To this end two strategic approaches are being taken: to accelerate the deployment of this technology while supporting R&D activities. This

Fig. 1 - The combined solar PV – Thermal installation at the John Molson School of Business (JMSB), Concordia University, Montreal, Canada (photo: J. Ayoub, CanmetENERGY).

mandate is funded by several federal sources including the Program of Energy Research and Development and the ecoENERGY Technology Initiative[4], and is implemented by NRCan's CanmetENERGY technology research centre located in Varennes, Quebec. The efforts undertaken provide stakeholders with the necessary information to make informed decisions. This includes the coordination of various research projects, participation in international committees on the establishment of standards, and producing information that will support domestic capacity-building. These efforts also actively seek innovative partnerships within the industry. Most research projects are carried out, on a cost-sharing basis, with industry, universities, research groups, quasi-public agencies, and other departments and governments. It also leverages its expertise by participating in international committees on photovoltaics, participating in joint projects with industry, developing software to assist in feasibility studies, as well as developing information and training tools. The aim of these activities is to generate knowledge and facilitate its communication to decision makers in Canada.

The grid integration of decentralized energy resources and renewable energy into the main electrical grid is introducing a new paradigm of electric power generation and transmission: from where electrical power was generated in large power plants, sent to the consumption areas through transmission lines, and delivered to the consumers through a passive distribution infrastructure, to a distributed and dynamic power generation and smart grid infrastructure. CanmetENERGY is responsible for delivering on the R&D mandate of the Grid Integration of Renewable and Distributed Energy Resources (DER)[5] – a Program that supports national science and technology

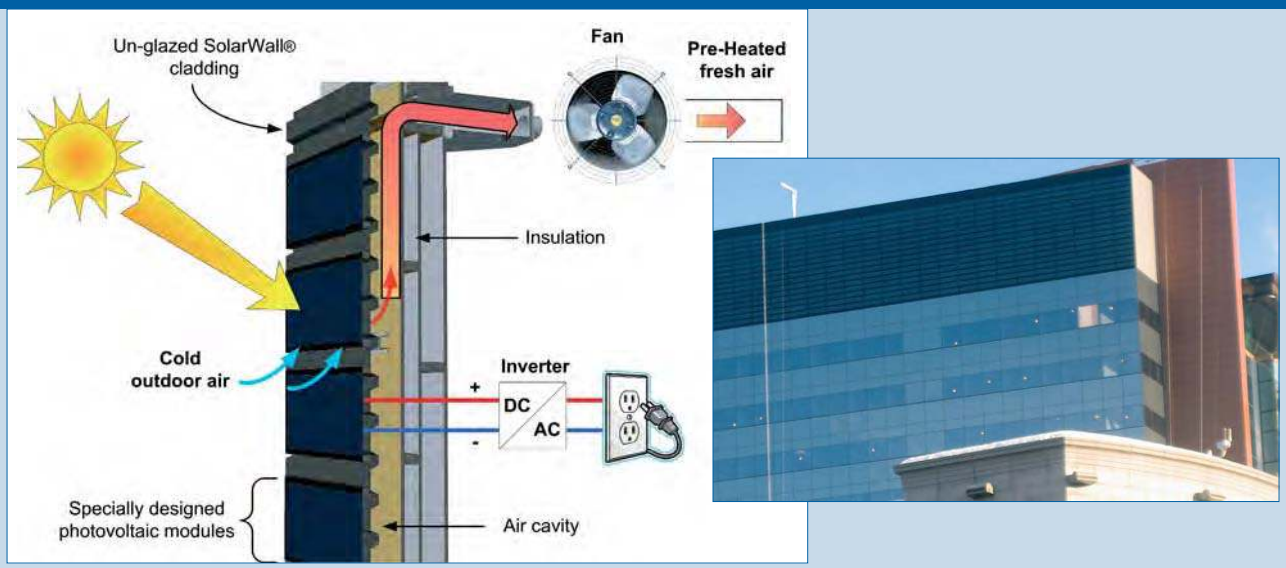


Fig. 2 - Schematic of the he combined solar PV – Thermal installation at the JMSB (photo B. O'Neill, Canadian Solar Buildings Research Network).

efforts that will contribute to the modernization of the electricity grid network, enhance the benefits of renewable and clean distributed energy resources, increase the diversity and reliability of supply, and facilitate recovery after disruptions. While numerous benefits are associated with this change, such a transition also represents many challenges for all stakeholders (utilities, independent power producers, governments, regulators, manufacturers, housing industry). Through the Energy Science and Technology funding, NRCan addresses the technical, institutional and regulatory barriers, with the aim of promoting the grid integration of clean power including photovoltaic.

DEMONSTRATION

The John Molson School of Business Concordia University, Montreal, Quebec

In 2008, the federal government trough NRCan's CanmetENERGY in collaboration with Concordia University of the Canadian Solar Buildings Research Network and the Canadian solar industry (Day4Energy Inc, suppliers of the PV panels; Conserval Engineering, suppliers of the Solarwall® and Sustainable Energy Technologies, suppliers of the inverters) have completed the design and installation of a combined solar power and heat generation system on a new building located at the university's headquarters in downtown Montreal (Figure 1). The integrated 24.5 kWp PV panels and the 75 kWp of heat by fresh-air solar heating with the SolarWall® cover approximately the top two floors of the building's south facing façade - approximately 300 sq. meters (Figure 2). This PV-T demonstration in a commercial building showcases innovative means by which buildings of the future could produce energy for their own use thereby reducing their demand on the electricity grid.

IMPLEMENTATION

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

In 2008, the Province of Ontario's Renewable Energy Standard Offer Program (RESOP) has exceeded all expectations - achieving in excess of 1,000 megawatts of contracted projects (Table 1) - surpassing the 10-year target for renewable energy, in the first year. Because of its popularity, the Ontario Power Authority (OPA), in the first quarter of 2008, undertook a comprehensive review of the Program in order to implement several changes that it has learned since the RESOP's inception to ensure its continued success.

TABLE 1: SUMMARY OF THE PROVINCE OF ONTARIO RESOP CONTRACTS IN 2008 (ROUNDED TO THE NEAREST KW)[6]

RE SOURCE	CONTRACTS	CAPACITY (KW)
Solar PV	290	525 581
Wind	93	745 516
Water Power	20	66 879
Bio-Energy	21	73 728
TOTAL	424	1 411 504

The planned improvements to the RESOP are intended to:

- Make RESOP open to more participants by restricting proponents to a single 10 MW project per feeder or transformer station. The OPA has opportunities for larger projects under its Renewable Energy Supply III competitive procurement process, where these larger projects belong.
- Encourage broader participation in the standard offer program by limiting any proponent to a maximum of 50 MW under development per technology at any one time. This means that once a developer brings their project into service, they are welcome to reapply for an additional RESOP contract.
- Simplify RESOP for micro-scale residential projects by removing the requirement for interval data for embedded generators.
- Implement a number of administrative revisions to the RESOP, in response to stakeholder concerns, in order to improve overall program efficiency and to further simplify the program."
- "Make RESOP more efficient by requiring that projects make progress toward in service or else lose their contracts. This will provide opportunity to another project developer to participate in the standard offer program."[7]

ecoENERGY for Renewable Power

The ecoENERGY for Renewable Power (ecoENERGY RP) program[8] which was announced in early 2007 by the Government of Canada as a component in a suit of initiatives to combat climate change and air pollution was revised in 2008 to address issues raised during the

first year of operation. The ecoENERGY RP was designed encourage the production of 14.3 terawatt-hours of clean electricity from low impact renewable energy sources, such as solar photovoltaic, wind, hydro, and biomass and ocean energy. In 2008, the program registered 227 projects for a total capacity of about 11,250 MW and signed 32 contribution agreements for about 1,780 MW in capacity and expected payments of about 570 million CAD 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."[9]

Interconnection of Distributed Generation to the Electricity Grid

NRCan's CanmetENERGY in partnership with key industry players and associations to undertake 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[10]. In 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. Tutorial material has been developed to promote and educate utility personnel that are tasked with conducting these interconnection "impact assessments" in Canada[11]. In 2008, CanmetENERGY conducted targeted workshops designed under continuing education programs to support the training needs of the electricity industry in Canada.

Net-Metering Landscape

Electric power generation in Canada is a provincial jurisdiction. Canadian electricity customers who want to install renewable energy technology generating systems at their sites and interconnect them to their local utility grid may do according to their local distribution company's requirements. Net metering regulations have been put in place in several provinces that establish rules for the flow of electricity between utilities and distributed PV systems. The implementation of these regulations is challenging, requiring the installation of new equipment (e.g. proper meters) and new billing systems. Some utilities have developed and implemented programs that streamline the application process specify net metering requirements and set out approved tariffs (BC Hydro, Toronto Hydro, and Hydro Quebec Distribution) (Figure 3). Where local distribution companies do not have streamlined application processes, the approval process can be complex for individual consumers responsible for their installation. Canadians in those regions must deal with different types of approval or verification to install a rooftop system that are handled on a case-by-case basis. Deregulation of the Canadian electric utility industry is creating opportunities for distributed power generation to occupy a significant share of the electricity markets of the future. PV has an important role to play in this market, and appropriate policies to promote investments in PV are being pursued.

Fig. 3 - Net-metering landscape in Canada – 2008.

Federal Programs in support of technology demonstration to market commercialization

Sustainable Development Technology Canada (SDTC)[12] - an arms-length foundation that operates as a not-for-profit corporation, established by the Government of Canada in 2001 to support the development and demonstration of innovative technological solutions continued in 2008 to invest in clean energy technology solutions. SDTC works closely with an ever-growing network of stakeholders and partners to build the capacity of Canadian entrepreneurs, helping them to form strategic relationships, formalize their business plans, and build a critical mass of sustainable development capability in Canada. SDTC is the premier federally-funded body that leverages private sector resources to demonstrate market-ready technologies including solar photovoltaic.

Technology Early Action Measures (TEAM)[13] - a federal inter-departmental technology investment Program that has supported late-stage development and first demonstrations of GHG-reducing technologies since its inception in 1998, has in 2008 began to wind-down its activities as its mandate came to an end. TEAM has invested nearly 130 MCAD in 150 projects with total investments of 1.16 BCAD. It was instrumental in funding PV technology demonstrations in Canada with total investments of 12 MCAD in eight photovoltaic early market-entry ready 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 and the City of Kelowna in the western Province of British Columbia.

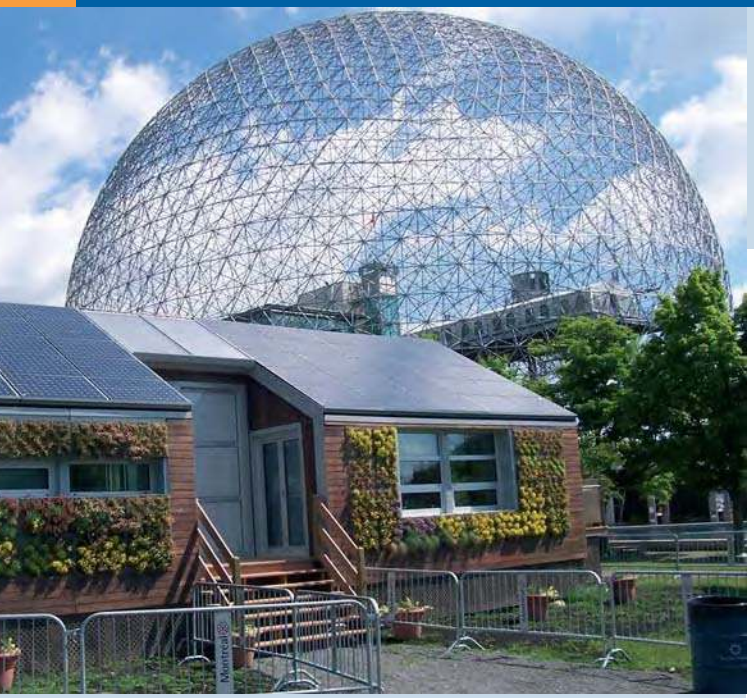


Fig. 4 - The solar house, designed by students from McGill University and the Université de Montréal and the École de technologie supérieure for the international competition, the 2007 Solar Decathlon, in Washington, D.C., is now located on the site of the Biosphère on Sainte-Hélène Island, Montréal, Canada (photo Y. Poissant, NRCan/CanmetENERGY).

INDUSTRY STATUS

There are over 300 solar energy companies (sales companies, wholesalers, product manufacturers, project developers, private consultants, systems installers and industry associations) operating in Canada. The Canadian PV manufacturing sector has grown significantly in the last six years to serve both the domestic and export markets. In the last two years, there have been increased investments in silicon feedstock production. Canadian-based Timminco Limited[14], a leader in the production of silicon metal for the electronics, chemical and aluminum industries entered into the production of of solar grade silicon through its wholly-owned subsidiary, Bécancour Silicon Inc. (BSI) in its new facility in Bécancour, Québec in late 2007. In 2008, the company registered total production of 1,214 metric tons (mt) of solar grade silicon. Also in 2008, Timminco commissioned its fifth and sixth production lines bringing their production capacity to about 7,200 metric tons annually. The company is a supplier to Q-Cells, one of the world's leading cell manufacturer. They have also reported signing long-tem contracts with leading solar cell manufacturers - up to 16,000 mt under contract beginning in 2010.

In 2008, the REC Silicon, a division of Norwegian multinational group Renewable Energy Corporation has announced its intention to invest more than 1.2 billion CAD to build a polysilicon manufacturing plant at the Bécancour industrial and harbour park in Bécancour, Quebec. Construction of the plant is scheduled in phases and is anticipated to begin in 2010 with production starting in 2012. The plant is expected to employ more than 300 people in the region.

In 2008 Burnaby-based Xantrex Technology Inc.[16], 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, announced its sale to Schneider Electric S.A., a global specialist in energy management with operations in more than 100 countries with headquarters in Rueil-Malmaison, France[17]. With the completion of the sale Xantrex's common shares ceased to be listed for trading on the Toronto Stock Exchange as of September 30, 2008. Also Day4Energy Inc.[18] a manufacturer of PV modules, also based in Burnaby in the Province of British Columbia, announced in 2008 that it is meeting its plans to expand it production capacity to 97 MW in 2009. At the end of the third quarter of 2008, the company was operating a production facility capable of producing 47MW of product based on a three shift, 5 day week basis. Day4Energy also announced in 2008 that it has entered into a multi-year manufacturing supply agreement with Jabil Circuit Inc., a leading global electronic solutions company. Under the terms of the multi-year agreement Jabil will purchase from Day4 Energy certain equipment required for the manufacture and supply of the modules and produce Day4 Energy's brand of modules for residential and commercial applications.

The province of Ontario's Renewable Energy Standard Offer Program (RESOP offer PV 0.42 CAD/kilowatt-hour) continues to attract several large energy developers in 2008. For example OptiSolar Farms Canada[19], the Canadian subsidiary of OptiSolar Inc. of California, has several large PV projects under development in the province, installing solar panels made with OptiSolar's proprietary thin-film technology and manufacturing process. Skypower Corporation[20], a subsidiary of Lehman Brothers, a US-based private equity business and one of Canada's leading independent renewable energy developer, and SunEdison Canada LLC, a subsidiary of SunEdison LLC the largest solar energy service provider in North America, continue to cooperate on RESOP solar projects in Ontario.

MARKET

Growth in the Canadian sector has been consistent over the past 16 years, with capacity growing by more than 20 % percent annually between 1993 and 2008. 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 2008 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 16 years in Canada and continues to accounts for about 85 % 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

The Province of Ontario's RESOP is viewed is by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. By the end of 2008, the RESOP had exceeded its 5-year target with 525 MW of contracts signed, but project implementation delays have led to only 1,2 MW being connected to date. Delays in connection queues in strategic areas of the province are being reviewed with intent to address the backlog of applications for connection to secondary distribution feeders. The Ontario Smart Grid Forum, managed by the Independent System Operator of Ontario, will be making public its recommendations on the benefits of a Smart Grid, including improved system reliability, increased customer participation and environmental benefits such as improving the integration of smaller generators embedded in the distribution system.

The Solar Buildings Research Network is generating opportunities for demonstrations of innovative PV projects in Canada and is expanding the knowledge base to the benefits and added value of PV technology in the buildings of the future. The collaborative R&D focus is providing in-depth analyses to Canadian stakeholders on the optimization of low and net-zero energy homes for Canadian climatic conditions and is helping to support innovation in the residential construction industry in order to accelerate the adoption of low and net-zero energy solar homes. In addition the SBRN partners are contributing to two Canadian teams from universities in the provinces of Alberta and Ontario that will compete in the US Department of Energy sponsored Solar Decathlon competition that will take place in Washington, DC, in the fall of 2009 (Figure 4).

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 and in silicon feedstock production. The Canadian Solar Industries Association[21] and Énergie Solaire Québec[22]. have continued their promotional and marketing activities. CanSIA in particular has been very active in 2008 in developing the foundation for significant changes in polices and programs that will support the solar industry in the coming years.

Footnotes with relevant websites:
(Endnotes)

1 *http://canmetenergie.rncan.gc.ca/eng/index.html*
2 *Solar Buildings Research network website: http://www.solarbuildings.ca*
3 *EQuilbrium replaces the working name of this initiative, Net Zero Energy Healthy Housing. Website: http://www.cmhc-schl.gc.ca/en/inpr/su/neze/*
4 *http://www.nrcan.gc.ca/eneene/science/perdprde-eng.php*
5 *http://canmetenergy.nrcan.gc.ca/eng/renewables/integration_der.html.*
6 *Information extracted from OPA, "A Progress Report on Renewable Energy Standard Offer Program, December 2008".*
7 *http://www.powerauthority.on.ca/sop/Page.asp?PageID=751&SiteNodeID=412&BL_ExpandID=190*
8 *Natural Resources Canada - ecoENERGY for Renewable Power website: http://www.ecoaction.gc.ca/ecoenergyecoenergie/power-electricite/conditions-eng.odf*
9 *Natural Resources Canada http://www.ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/conditions-eng.odf*
10 *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*
11 *Cyme T&D technical engineering courses: http://www.cyme.com*
12 *Sustainable Technology development Canada website: http://www.sdtc.ca/en/index.htm*
13 *Technology Early Action Measure website: http://www.climatechange.gc.ca/english/team_2004/*
14 *Timminco Ltd. Website: http://www.timminco.com*
15 *http://www.timminco.com/PressRelease.aspx?id=24&tprId=936484*
16 *Xantrex Technology Inc. website: http://www.xantrex.com*
17 *Schneider Electric S.A. website: http://www.schneider-electric.com/sites/corporate/en/home.page*
18 *Day4 Energy Technology Inc. website: http://www.day4energy.com/*
19 *http://www.optisolarfarms.ca/index.html*
20 *Skypower Corporation website: http://www.skypower.com*
21 *Canadian Solar Industries Association website: http://www.cansia.ca*
22 *Énergie Solaire Québec website: http://www.esq.gc.ca*

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK

The Danish government proposed in early 2007 a new energy plan called Energy Vision 2025. This plan was in principle adopted by a majority of the Parliament early 2008 in terms of a national energy plan. 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 the government wishes 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 following or surpassing the national targets as defined in the EU RE Directive, but no technology specific targets. The market forces are supposed to promote the most suitable and competitive RE technologies. However, a new support instrument was introduced covering 2008 and 4 years ahead targeting demonstration of PV, wave power and other "emerging technologies." The first concrete PV related result of this new support instrument has been a grant of 22 MDKK for a project to demonstrate 1 MW PV on the buildings of the Skive municipality.

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 2008 more than 26 % 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 in early 2004, the Danish Energy Authority (EA) in collaboration with the electricity sector, the industry and other key stakeholders finalized a national strategy on PV after a public hearing. This PV strategy includes the fields of research, development and demonstration. Deployment activities in support of the PV strategy are 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 way of an annex outlining the need of long term operational targets and support mechanisms for demonstration. A full update is expected by mid 2009.

Fig. 1 - A new 40 kWp PV-system will be sold in parts of 125 Wp as a co-operative installation to make PV available to people without access to their own roof or land.

PV has further been accepted as a technology input to the national Commission on Climate Change probing solutions up to 2050 and beyond.

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.

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. 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 have since received support, but the real extent to which PV really can benefit from this instrument with growing funding is not yet known.

A new support instrument has been introduced covering 2008 and 4 years ahead targeting demonstration of PV, wave power and other "emerging technologies". The first concrete PV related result of this new support instrument has been a grant of 22 MDKK for a project to demonstrate 1 MW PV on the buildings of the Skive municipality. This project is expected to have a significant replication potential.

By the end of 2008, about 3,2 MW had been installed in the context of various projects and demonstrations plants supported by various instruments.
A brief history of major initiatives since 2000: 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 EUR 4,40/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 the end of 2006, there are no longer any instruments in Denmark to bring down investment cost of PV systems in general, only the net-metering scheme supports PV deployment for private households and institutions.

Net-metering for privately owned PV systems was established mid 1998 for a pilot-period of four years. In late 2002, the net-metering scheme was extended another four years up to end of 2006. Net-metering has proved to be a cheap, easy to administrate and effective way of stimulating the deployment of PV in Denmark; however the relative short time window of the arrangement has so far prevented it from reaching its full potential. During the political negotiations in the fall of 2005 the net-metering for privately owned PV systems was made permanent, however net-metering alone - event at a present typical level of EUR 0,25/kWh - appears not on its own to be able significantly to stimulate PV installations.

RESEARCH & DEVELOPMENT, DEMONSTRATION

During 2003, the government 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 renewable. However, as the focus of the programme is on university research activities, it is so far only to a limited extent that PVs have benefitted 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 130 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 benefitted from support during 2008, with most of the funding going to basic R&D in organic and polymer cells. As previously mentioned, a new support instrument has been introduced covering 2008 and 4 years ahead with an annual funding level of 25 MDKK and targeting demonstration of PV, wave power and other "emerging technologies."

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. In April 2008 the government owned TSO Energinet.dk took over the role of representing Denmark in the PV-ERA-NET. Denmark has in the context of the PSO system in 2007 decided to enter the first 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 organic PEC cells are ongoing at the Danish Institute of Technology. This activity has been supported in 2002-04 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 2008 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.

In mid-1995, the Photovoltaic System Laboratory (PVSyslab) was established in collaboration between Risoe National Laboratory and the Danish Institute of Technology. The main function of PVSyslab is to certify the quality of PV systems and their installation including certification of installers and to help industry develop better products.

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.

Fig. 2 - The 6 kWp installation supplies free heat through a heat pump and in addition contributes to the other electricity consumption of the building. The mix of a PV system and a heat pump is becoming a popular mix in Denmark despite the lack of governmental support.

The SOL 1000 programme which had been run by the utility EnergiMidt, as mentioned above, intended to demonstrate low cost and architectural acceptable integration of PV technology primarily on existing single family houses. By the end of project ultimo 2006, it had 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-yourself" PV plants with a size of 250 Wp were also introduced and since 2005, about 200 of these systems 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.

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's are reported to be represented in this development.

Supported by Energinet.dk the utility EnergiMidt is running a data gathering project including 16 grid connected PV systems spread all over the country; each system is continuously monitored as to production and insolation (global and in plane with array). With time this project is expected to create a base for Danish operational data, a base which may be trasnferred to the PVSyslab.

INDUSTRY STATUS

A Danish PV industrial association (Dansk Solcelle Forening) was established in late 2008. With initially some 40 members, the association is expected to provide the emerging PV industry with a single voice.

R&D efforts are beginning to exhibit commercial results in terms of export. The company Topsil, which uses a float-zone technique, produces high purity Silicon (Si) ingots for the semiconductor industry, announced in 2002 their intention to develop a low-cost float-zone manufacturing technology that would enable the company to offer high purity Si to the PV industry. The first commercial results of its R&D into low-cost float-zone processing were seen in 2004 and it 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. Concerning the latter, a commercial breakthrough 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.

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

The total PV business volume in 2008 is very difficult to estimate with any degree of accuracy primo 2009, 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 45 MEUR in 2007 to 60 MEUR in 2008 is a "best guess," mostly due to exports.

The cumulative installed PV capacity in Denmark (including Greenland) was estimated to be about 3,2 MW by the end of 2008.

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 update 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.

The new previously mentioned Skive project targeting 1 MW on municipal buildings is expected to exhibit a high replication potential, stimulating other municipalities to similar initiatives.

However, it is regarded as obvious that without funding and a clear public support to large scale demonstration of PVs for yet some years to come, the sector risks will go on diminishing because of insufficient home market.

The trend towards commercial sustainability for PVs is seen as ongoing with steady improvements of the price/yield relation. Projections and scenarios completed during 2008 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 may emerge after 2015, given that the necessary demonstration activities can be continued in the period up to 2015. The source of funding for such a demonstration effort still has to be found, and the ongoing political climate and 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, EUROPEAN COMMISSION, DG ENERGY AND TRANSPORT
ANDREAS PIONTEK, EUROPEAN COMMISSION, DG RESEARCH

POLICY

On 17 December 2008, the European Parliament and the Council of the European Union have agreed to the package of measures on climate and energy aiming at reducing the EU greenhouse gas emissions by at least 20 % and to boost the share of renewable energy to 20 % of total consumption by 2020. The climate energy package, which will be adopted before the summer 2009, recognizes that the increased use of energy from renewable sources, together with energy savings and energy efficiency, constitute important steps to promote security of the energy supply, technological development and innovation, providing opportunities for employment and development, and reducing, at the same time, greenhouse gas emissions.

The commitments for the year 2020 are essential steps on the road to drastically reduce global greenhouse gas emissions levels by the year 2050, as a basic driver of our policies. The package of measures on climate and energy addresses renewable energy sources, greenhouse gas emission reduction policies (with a review of the European Trading System (ETS) and other measures outside of the ETS), carbon capture and storage, energy efficiency, and the new guidelines on state aid for environmental protection. A relevant piece of this package is the Directive on the "Promotion of the Use of Energy from Renewable Sources." The overall target of this Directive is to reach a 20 % renewable energy share in the European final energy consumption by 2020. It contains several elements which are important for the PV sector: the streamlining of administrative procedures, the consideration of renewable energy use in local and regional planning, the introduction of minimum renewable requirements for building codes, the improvement of information and training requirements and the reinforcement of electricity grid access provisions.

National Action Plans, to be adopted in 2010, will define the concrete Member State strategies to reach the 2020 national target and the contribution of each sector (electricity, transport and heating and cooling) to it.

DEPLOYMENT

The European market remains very heterogeneous. It is characterized by a dominant German market while other European countries are only recently increasing their importance. In 2007, the German PV industry had a turnover of about 5,7 BEUR and employed 42 600 people (47 % handicraft, 46 % industry and 7 % wholesale) [i]. The employment figure for the whole EU is about 70 000 [ii]. Although productivity in the PV industry progresses with automated production and reduced unit and system costs, the rapid market growth will further create new jobs in Europe. Depending on the system size, the lowest price for photovoltaic systems connected to the grid recorded in 2007 ranged between 4,5 EUR/W and 5,5 EUR/W; much the same as the corresponding price in 2006. It is assumed that the strong demand for modules determines the selling prices and the effects of cost reductions in production were not transferred to the consumers. An interesting trend emerges when observing the reported breakdown of the PV applications in the IEA countries. A three-fold increase in the cumulative capacity of large grid-connected centralized applications from 2006 to 2007 is recorded [iii]. Assuming that this trend is also reflected in the European PV market, new challenges are likely to emerge as large centralized PV systems, in the 10 to 100 MW range, may have more significant interactions with the grid than small, distributed systems.

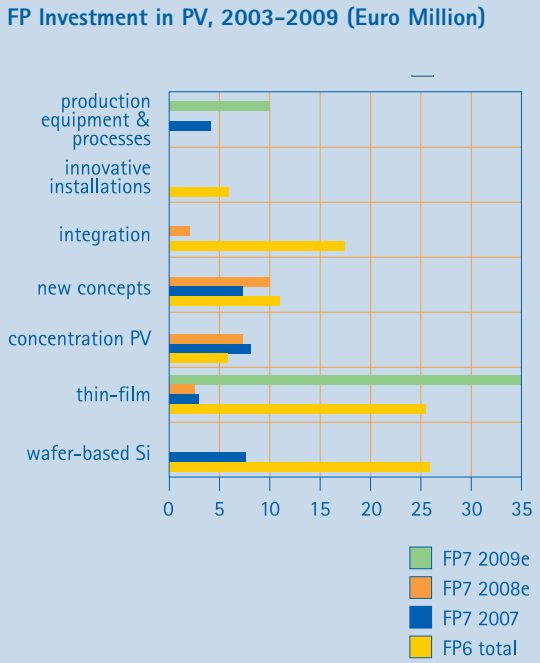

Fig. 1 - Framework Programme investment in PV. (2008 & 2009 figures are estimates and do not constitute an obligation on behalf of the European Commission.)

EUROPEAN SOLAR INDUSTRIAL INITIATIVE OF THE SET PLAN

The Strategic Energy Technology (SET) Plan has identified solar technology as particularly relevant to the European climate-energy policy objectives. The SET Plan proposes the setting-up of the European Solar Industrial Initiative (ESII) to accelerate the development and the market introduction process of the technology.

The European Commission, together with the PV Technology Platform and the European Photovoltaic Industry Association identified three main objectives for the European Solar Industrial Initiative:
i). Delivering an important share of the EU electricity consumption by 2020. ii). Reaching grid parity in most European countries by 2020; iii). Ensuring the leadership of European PV industry. The strong competition especially with China, USA and Japan creates a need for acceleration and strengthening of European PV research and its faster implementation into the market.

The European Solar Industrial Initiative will create the framework conditions to drive down the costs of PV technology and bring about a step change in its market take-up. Industry will play a leading role - identifying the activities and an appropriate governance structure.

RTD & DEMONSTRATION

The year 2008 marked the second year of the new 7-year European Framework Programme for research, technological development and demonstration. Photovoltaics is supported mainly under the Energy theme [iv] – which is jointly implemented by the Directorates General for Research (DG RTD) and for Energy & Transport (DG TREN). Two calls for proposals in 2007 led to seven successful proposals being selected for contract negotiation. The total costs of projects selected in 2007 are estimated at 43,6 MEUR, with an EC contribution of 29,5 MEUR. The FP7 2008 call for proposals with a predominant demonstration component, in the Energy theme, closed on 8 October 2008 and project proposals have been evaluated. Awarding procedure is not completed yet. An activity proposing a demonstration of the electrical benefits from photovoltaics on a large scale ranks the highest on the list. Such demonstration activity aims at measuring the active contribution of PV for increasing power quality and security of the system operation in a residential area, and the security of power supply and autonomous operation in an industrial zone.

Projects from the FP7 2008 calls for proposals addressing longer term research, in the same Energy theme, are currently under negotiation. Furthermore, a call launched jointly between the Energy and Nanomaterials themes of FP7 has received a number of PV proposals addressing new and emerging concepts, such as self-organized nano-structured injection solar cells, nano-rod based thin-film solar cells on glass, plasmon-generating nano-composite materials, and innovative materials for excitonic solar cells. Finally, two projects, - both concerning concentration PV, are also under negotiation. These projects aim to i) foster international cooperation with Mediterranean partner countries and ii) develop fixed solar panels with internal concentration and dynamic sun-tracking. The total EC contribution for projects already selected from the 2008 calls for proposals is estimated at around 20 MEUR.

The work programme for the FP7 2009 calls for proposals has been published on 3 September 2008. The 2009 work programme focuses on thin-film technologies (including material development, production equipment and process development). The call topics addressing longer term research have received high interest from the photovoltaic community and a high number of proposals have been submitted. The available investment for the successful proposals is about 20 MEUR. The FP7 2009 call topic addressing short term activities, with a relevant demonstration component, is open to receive proposals until 29 April 2009. Although the budget allocation will be very much dependent upon the quality of the proposals, an estimate of about 10 MEUR can be foreseen for this topic.

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S (EPIA) ACTIVITIES AND ROADMAP

BENJAMIN FONTAINE, JUNIOR COMMUNICATION OFFICER
DANIEL FRAILE, SCIENTIFIC OFFICER
SOPHIE LENOIR, MARKETING & COMMUNICATION MANAGER

Fig. 1 - IEA-PVPS Booth at the EPIA stand, 23rd EUPVSEC, Valencia, Spain, September 2008.

Fig. 2 - EPIA Team at the end of 2008.

With more than 200 members active along the whole value chain, from silicon producers, cells and module manufacturers to systems providers, EPIA is the world's largest photovoltaic (PV) industry association. It represents over 95 % of the European photovoltaic industry and 80 % on a global scale. EPIA's mission is to support the PV market deployment by giving the industry a unique and strong voice at European and international levels.

A REFERENCE IN THE PV SECTOR

In 2007, the European Commission launched the Strategic Energy Technology Plan (SET-Plan) in order to strengthen cooperation at the EU level and increase and improve investment in a broad portfolio of low-carbon energy technologies. Within frame of the SET-Plan, six European Industrial Initiatives were proposed, with a focus on the sectors where "Barriers, the scale of the investment and risk involved can be better tackled collectively". The Solar Europe Initiative is one of these initiatives and is being coordinated by EPIA. In this context, during 2008, EPIA organised a series of workshops and roundtables and worked with the EU PV Technology Platform to define the targets and priorities of the PV industry for the next decade.

In September 2008, EPIA gathered together the 50 top CEO's of the industry and redefined the PV industry's objectives in light of recent technological developments, the context of rising energy prices and the European Energy Framework SET-Plan. The association initiated an in-depth analysis of the potential and impact of PV, based on different deployment scenarios which take into account aspects such as the global economic context, PV technical development regulatory, economical and technical implications of high-penetration levels of PV into the electricity system and the energy market.

As the leading association in the PV sector, EPIA organized in 2008 top-level events in order to accelerate PV deployment and create privileged networking opportunities for the sector.

Some of these include:

- 2nd International Conference on Solar Photovoltaic Investments
- PV MED Conference
- European PV Industry Forum, within the frame of the 23rd EU PVSEC organised by WIP
- 1st International Thin Film Conference
- Market Workshop
- Workshop on Market Potential and Production Capacity
- Technical workshops (e.g. Building integration, grid-connection, standards)

EPIA is also a great source of knowledge and expertise for the entire PV sector. Thus, it published in 2008 many documents targeting different audiences (PV stakeholders, EU decision-makers, multipliers, general public, etc.). Some of them are well-known references in the sector. The following publications should be particularly mentioned:

- **"Solar Generation V":** 5th edition of the EPIA and Greenpeace joint-study on the future potentials of Photovoltaics
- **"Global Market Outlook for Photovoltaics until 2012":** Annual report presenting the most recent and upgraded data regarding PV market performance and short term forecast
- **"Building Integrated Photovoltaics – A New Design Opportunity for Architects":** brochure aimed at increasing awareness and understanding among architects and the construction sector
- **"Photovoltaic Energy – Electricity from the Sun":** publication dedicated to the widest audience explaining solar Photovoltaic electricity in a very educational and pleasant way

A MEMBER OF LEADING EUROPEAN AND GLOBAL INITIATIVES

EPIA is a founding member of:

- **EREC** – European Renewable Energy Council
- **PV CYCLE** – European association for the recovery of Photovoltaic modules
- **ARE** – Alliance for Rural Electrification

Fig. 3 - The European Parliament, Brussels.

EPIA is a member of:

- **EUFORES** – European Forum for Renewable Energy Sources
- **E2B JTI** – Energy Efficient Buildings Joint Technology Initiative
- **IEA-PVPS** – International Energy Agency Photovoltaic Power System

EPIA'S IMPLICATION IN THE ACTIVITIES OF THE IEA-PVPS

- ExCo Meetings
- EPIA regularly participates in the IEA PVPS ExCo meetings and is represented by Eleni Despotou, EPIA's IEA PVPS ExCo delegate.

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

Due to changes in EPIA staff, it was not possible to participate in the Task 1 meetings during 2008. However, EPIA supported the distribution and communication of the "Survey Report of selected IEA countries between 1992 and 2007, Trends in Photovoltaic Applications" issued in August 2008. EPIA will continue to exchange information on markets and industry, and data collection methodologies with Task 1 members during 2009.

Fig. 4 - 5th EPIA Industry Forum, 3rd September 2008, Valencia.

Task 12: PV Environmental Health and Safety Activities (EHS)

EPIA together with the Brookhaven National Laboratories coordinates this task which took-off during 2008 after its beginning in 2007. A Task 12 meeting during the 23rd EUPVSEC in Valencia was hosted by EPIA. Good progress has been made in the development of the "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" which are expected to be finalised early in 2009.

EPIA welcomed and supported the opening of the PV CYCLE association office in April 2008, at the Renewable Energy House, Brussels, after its foundation the previous year. The study "For the Development of a Recovery and Recycling System for Photovoltaic Products" co-funded by EPIA and BSW and sponsored by BMU was published in spring 2008 and is available in both German and English at http://www.pvcycle.org. This study set the basis for the implementation of a European take-back and recovery system of PV modules in Europe on which the association is currently working.

Potential Task 13 Creation: "PV Performance and Reliability"

EPIA supports the implementation of the next Task 13 which will serve as a continuation of the finalised Task 2. EPIA, represented by Daniel Fraile Montoro, attended the preparatory meeting in Milan 2007 and promoted the creation of the Task 13 among the EPIA industry network in order to involve the industry in the participation of the preparatory workshop which took place in Berlin on 25-26 September 2008 and for the future implementation of this invaluable Task.

General Support to IEA PVPS

The association hosted an IEA-PVPS island booth at the EPIA Industry Area during the 23rd EUPVSEC in Valencia, Spain in September 2008.

FRANCE

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

Fig. 1- Parking lot of a commercial centre in Saint-Aunès (Hérault department). 1,1 MW Aerial view and entry level view (photo Sunvie.eu concept).

GENERAL FRAMEWORK

The activity of photovoltaics (PV) increased steadily in France in 2008. According to the professional association SER (*Syndicat des Energies Renouvelables*) about 105 MW were installed during the year 2008, i.e. a tripling of the installation volume relative to the previous year. Eighty percent of installed power addresses individual dwellings. Total cumulative PV installed capacity in France is now about 180 MW.

The manufacturing industry is also developing in France with the implementation of a sector which includes photovoltaic actors at each stage of the silicon value chain: purification of feedstock silicon, ingots production, cells and modules manufacturing, distribution of products and systems, installation and operation of electric power generation systems. The feed-in tariff policy introduced in 2006 was a strong incentive, reinforced by the tax credit to stimulate private individual investments.

The major event for the future of renewable energy and photovoltaic industry in France is the "Grenelle of the Environment." This government initiative launched in late 2007 allowed, following public hearings, to prepare a bill. The committees comprising representatives of government and industry as well as public renewable energy stake-holders proposed significant progress for each renewable energy sources. Proposals of particular importance for photovoltaics were selected by the government:

- Objectives for PV cumulative installed capacity in France of 1 100 MW in 2012 and 5 400 MW in 2020;
- Confirmation until 2012 of the current feed-in tariffs and the creation of an additional one targeting installations on large buildings such as commercial and industrial sheds. This tariff is set at 0,45 EUR per kWh;
- A call for tenders for the construction by 2011 of at least one solar photovoltaic power plant in each French region, for a total installed capacity of 300 MW.

PHOTOVOLTAIC PROGRAMME

The Agency for the Environment and Energy Management (ADEME) is the institution that historically has the mission of supporting the development and promotion of photovoltaics in France. Since 2005, new initiatives, from national and regional authorities, have complemented ADEME'S work. The creation of the French National Research Agency (ANR) and the industrial development agency OSEO allowed an increase in leveraging money for PV R&D.

Indeed, ANR launched in 2008, a new research programme running for 3 years. This agency chose to combine in a programme called HABISOL R&D works on building and PV to underline the importance of BIPV.

Ten R&D photovoltaic projects were selected after the call for proposals launched in February 2008.

In parallel with the actions of ANR a major industrial project attracted the attention of the authorities in 2008. This is the R&D project Solar Nano Crystal (2008-2012). OSEO and ADEME associated funding to launch this ambitious project.

ADEME is now less involved in financial support for market implementation as favourable fiscal and financial measures were introduced such as the 50 % tax credit on photovoltaic equipment and preferential feed-in tariffs (see Table 1).

ADEME is always present in the training of project implementers (PHOTON and PHOTON RESEAU training), but to meet the professional demand, other initiatives have emerged in vocational training centres or in the National Institute for Solar Energy (INES). For instance, in October, TRANSENERGIE inaugurated its educational and demonstration solar photovoltaic QUALIPHOTON® platform (220 m^2), equipped with photovoltaic components illustrating the different technologies available on the market: sc-Si, mc-Si, a-Si, CIS and CdTe. The platform should be used for training project developers, specifiers, architects, electrical and roofing professionals.

With its partners, ADEME continues supporting cost-shared projects in the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS), particularly in Tasks 1, 2, 9, 10 and 11. The

TABLE 1 – FEED-IN TARIFFS FOR PHOTOVOLTAIC ELECTRICITY IN FRANCE (2008)

TARIFFS EUR/kWh	CONTINENTAL FRANCE	OVERSEAS DEPARTMENT AND CORSICA
Basic Tariff	0,31193	0,41591
Industrial/commercial buildings application (new tariff	0,45000	
Building integrated PV systems	0,57187	

International Electrotechnical Commission (IEC) is also receiving contributions from French teams supported by ADEME particularly in the field of technical specifications for rural electrification by renewable energy sources.

Regional councils are also very active in providing support for photovoltaics projects through targeted calls for tender in which energy efficiency and solar photovoltaic energy must be integrated as key elements of proposals. Finally, the involvement of competitiveness clusters, associating private and public bodies, in photovoltaic research activities is a fact worth mentioning.

RESEARCH AND TECHNOLOGICAL DEVELOPMENT

The R&D project Solar Nano Crystal, funded by OSEO and ADEME, is to establish a manufacturing pilot (Lab-Fab) for crystalline silicon photovoltaic cells/modules. This pilot will test technical innovations from public research laboratories. The overall objectives are the reduction of production costs, the increase in photovoltaic conversion efficiency and the reduction of environmental impacts from production processes. The work areas are targeting:

- The production of solar photovoltaic grade silicon feedstock for photovoltaic applications;
- A significant increase of the performance of cells and modules;
- The direct experimentation of research findings in a pilot production of cells.

The coordinator of the project is the PV-ALLIANCE associated companies (Photowatt, EDF Energies Nouvelles and CEA-Valorisation) in partnership with the silicon manufacturing specialists EMIX, SILPRO, PHOTOSIL, APOLLON SOLAR and the National Institute for Solar Energy (INES).

Regarding the call for projects in 2008 of the new ANR programme (HABISOL) dealing with intelligent living and solar photovoltaics, the three major research areas are:

- New methods for energy management in buildings;
- Energy efficiency and development of renewable energy use in buildings;
- Development of photovoltaic technologies for widespread use in buildings.

Ten new R&D projects have been identified on these topics. They added to the thirty R&D projects being supported by the ANR and ADEME since 2005. The teams presented preliminary results of their studies at the seminar for contractors on 16 and 17 December 2008 in Marseille. For ADEME, two major industrial R&D projects have been completed. The RÉDUCOP project led by Photowatt (multicrystalline silicon ingots, photovoltaic cells and modules) and PHOTOSIL project coordinated by Apollon Solar (solar PV grade silicon feedstock prepared through the metallurgical route). ADEME's Expert Committee on PV noted satisfactorily the projects results and made recommendations for the future.

INES, which involves researchers from CEA, CNRS and the University of Savoie, is an important centre for PV R&D and implementation located at Bourget-du-Lac in Savoie. It is continuing its development with a new research laboratory focusing on manufacturing technology for photovoltaic cells. The roof of the associated building is equipped with photovoltaic generators for testing purposes. Other initiatives should be noted in the reorganization of France PV R&D, in institutes such as IRDEP (Chatou), INESS (Strasbourg), INL (Lyon) and TECSEN (Marseille).

IMPLEMENTATION

As a result of the "Grenelle of the environment," fifty operational measures taken by the government for renewable energy sources were presented during the week of renewable energies, buildings and energy management in November 2008 in Paris.

For the photovoltaic industry, the Minister confirmed the purchase price of PV electricity established for building integrated photovoltaic systems and announced a new tariff of 0,45 EUR/kWh for installations on industrial and commercial buildings (Table 1). Tariffs will be applicable till 2012 and might be revised afterwards.

A supply contract is established for a period of 20 years between each producer and its local company (usually EDF). The financial act passed in December 2008 specifies that the proceeds from the sale of PV generated electricity will now be exempt from taxation through income tax when the associated system does not exceed 3 kW.

Finally, measures have been implemented to reduce the time for taking care of connection requests submitted to the authorities.

The necessary steps were reduced to two, instead of five.
Several demonstrations were held for professionals and the general public. During the Solar Event organised in June (about 10 000 participants) a symposium was held in Aix-les-Bains for French professionals in the field; this meeting which brought together nearly 500 participants was dedicated to discuss the market, industry and R&D development conditions for photovoltaics in France.

From 17 to 22 November 2008 was held in Paris the week of Renewable energy, Building and Energy Management initiated by ADEME in synergy with the SIREME (International exhibition on renewable energy and energy conservation), organized by the SER (*Syndicat des Energies Renouvelables*). The event attracted 15 000 visitors.

The international exhibition for renewables ENERGAIA, for trade visitors and general public (20 000 people) was held from 10 to 12 December in Montpellier.

In addition, associations behind the renewable energy sector (CLER, ENERPLAN for example) have held open days to allow thousands of people to visit facilities and meet photovoltaic professionals. Broadly speaking, there is a strong public interest for the exhibition and conferences, as the public is attracted by the opportunities to learn more about the area and seduced by the national and regional incentives.

Strongly supported by the profession and the public authorities, quality initiatives were put in place. Each installation company has the opportunity to be qualified as a PV installer "QualiPV" if complying with a ten-point charter established by the profession. In addition, discussions are under way to qualify the eligibility of land identified for ground based photovoltaic power plants.
In May 2008, the CSTB (the French approval body for equipments in the building sector) issued for the first time a new type of

Fig. 2 – Photovoltaic power plant in Narbonne (Aude department) – EDF EN – 7 MW.

Technical Assessment (ATEC) addressed to photovoltaic products. The ATEC evaluates the method of installation, the electrical safety, the suitability for use, the durability and the feasibility of the photovoltaic modules in the building.

INDUSTRY STATUS

The industrial production of materials, cells and modules continue to develop in line with market developments.

The company Photowatt International (a subsidiary of ATS), located in Bourgoin-Jallieu, produces multicrystalline silicon ingots, wafers and cells mainly dedicated to the manufacture of its own modules. Its production capacity is around 60 MW per year with targets of 100 MW. The company is also involved in the design and implementation of turnkey photovoltaic systems.

Emix is a company producing multicrystalline silicon ingots from the cold crucible electromagnetic casting technology (installed capacity of 360 tonnes).

Tenesol Technologies, a subsidiary of Tenesol, produces modules from imported cells (annual capacity of about 55 MW). As part of its development strategy in France Tenesol opened six regional offices in 2008 to sell to professionals and local communities.

The companies Invensil, Apollon Solar and Ferropem have set up a R&D pilot plant for solar photovoltaic grade silicon feedstock (metallurgical route). The project called PHOTOSIL is conducted in collaboration with CEA-INES and CNRS in Le Bourget-du-Lac. The construction of the plant SILPRO for the production of solar photovoltaic grade silicon feedstock for photovoltaic applications (chemical route) began in Saint-Auban in the Alpes-de-Haute-Provence department.

In addition to these PV industry players, many companies contribute to the development of equipment for the photovoltaic industry or the marketing of new products, namely: Air Liquide, Saint-Gobain, ECM, Vesuvius, Semco, Imerys-Roofing, Lafarge Roofing, Sunland21, Kawneer Europe, Arcelor, etc.

MARKET DEVELOPMENT

The market is divided into four types of applications that leads to specialization of actors: the individual systems for homes (less than 3 kW), roofing systems for collective buildings (in the range from 10 kW to 100 kW), roofing systems for large industrial and tertiary roofs (for installed power in excess of 250 kW, see Figure 1) and PV power plants on the ground, above the MW.

The market for individual systems for homes increased significantly in 2008 because of tariff and tax incentives. The year 2008 also saw the implementation of the first ground based PV power plant in Continental France (see Figure 2).

The establishment at the end of 2008 of a feed-in tariff for systems installed on industrial and commercial buildings (0,45 EUR per kWh) should take effect in 2009.

An increasing number of regional councils are involved in financial support for the implementation of photovoltaic installations and training of professional bodies. They also work as contractors for the realization of their own administrative buildings or teaching in their charge.

Supported by favourable electricity purchasing prices, photovoltaics continue to attract venture capitalists. On the different market segments mentioned above, links are being tied between the industrial field and financial institutions, which embody the real development of a new business sector.

In addition to the historical actors already well established in the market (Photowatt, Tenesol, Apex BP Solar) new companies have developed, especially in the downstream part of the photovoltaic chain, installation and operation of photovoltaic systems. This ranges from the micro-enterprise of a person to large companies, such as EDF Energies Nouvelles active in the various segments.

Also, the arrival of new players in the business of producing electricity through photovoltaics is observed. Similarly, other operators, already heavily involved in wind energy are diversifying their investments in photovoltaics.

Finally, we see the emergence of new economic activities linked to the development of photovoltaics, for example the establishment of lease contracts for roofs suitable to photovoltaic systems.

CONCLUSION AND OUTLOOK

The progression of the French market is very strong. The electricity purchase tariff established in 2006 and the creation of the "sustainable development" tax credit were key elements. Such incentives have many positive effects on the dynamics of the market, including:

- The significant growth of applications for individuals;
- The diversification of the types of application (first ground based PV power plants);
- The evolving structure of industrial and commercial supply;
- The development of technological innovations from R&D to new products;
- The creation of skilled jobs.

The French photovoltaic industrial sector is now changing rapidly, with the involvement of major players from the French energy industry (EDF, Total, GDF-SUEZ, CEA, etc.).

With the initiative of the "Grenelle of the Environment," the French government has given a new impetus to photovoltaics development also supported by specific regional initiatives.
Businesses welcomed the approach taken and believe that the 2020 target to reach 5 400 MW of installed capacity is achievable.

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GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY – STATUS AND PROSPECTS

CHRISTOPH HÜNNEKES, PROJEKTTRÄGER JÜLICH (PTJ), FORSCHUNGSZENTRUM JÜLICH GMBH

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. Additionally, the aim is to ensure that all measures are affordable and keep pace with the economic development. With respect to these conditions, the German government adopted a package implementing an integrated energy and climate programme which comprises a number of proposals dealing for examples with energy efficiency and renewable energies in the electricity and heat sectors as well as transportation [1]. Among others, it is expected that 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.

Originally, for the electricity sector a national target for renewable energies of 12,5 % by 2010 and 20 % by 2020 was set. While in 2000 a share of 6,3 % for renewable energies was assessed, for 2008 a share of 15 % was estimated [2] which means exceeding the 2010 target already now. Therefore, the German Parliament agreed to increase the 2020 target to 30 %. Photovoltaic (PV) is part of this development. Meanwhile, a PV capacity of more than 5 GW is installed. Driven by the Renewable Energy Sources Act (EEG), PV shows an impressive development.

Fig. 1 - FLATCON ® concentrating PV system of Concentrix Solar (photo Fraunhofer ISE, Freiburg).

NATIONAL PROGRAMMES

In Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) takes the responsibility for the renewable energies within the Federal Government. The main driving force for the PV market in Germany is the Renewable Energy Sources Act (EEG) which guarantees favourable feed in tariffs for renewable energies [3].

Research and Development (R&D) is conducted under the 5th Programme on Energy Research and Energy Technology "Innovation and New Energy Technologies" [4]. The Programme was originally designed to be valid for the period from 2006 to 2008. It was now extended until 2010. Within this framework, the BMU as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. Both parts of the programme are administrated by the Project Management Organisation PtJ in Jülich.

RESEARCH AND DEVELOPMENT

Funding Activities of the BMU

In December 2008, the BMU released a new open call for tender [5]. Concerning PV, the call addresses five focal points:

- Silicon wafer technology, especially the production of solar silicon, reduced material consumption and the development of new cell and module concepts for future industrial productions.
- 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 and standardisation of island systems for global applications.
- Concentrated Solar Power (see Figure 1) and other 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 2008, the BMU support for R&D projects on PV amounted to about 39,9 MEUR shared by 130 projects in total. The distribution of the budget shows that the focal point still is on wafer based silicon technologies (59 % of the budget). The second centre of attention lies on thin-film technologies (32 %). The development of system technology (6 %) and alternative technologies like concentrating PV and crosscutting issues (4 %) are funded as well; see Figure 2.

In accordance with the German PV R&D strategy, 38 new grants were contracted in 2008. The funding for these projects amounts to 39,7 MEUR in total.

In 2008 the highlights of R&D were as follows:

- Since 2005, Q-Cells is working on high-efficiency silicon solar cells. To boost their own R&D capacities, Q-Cells opened its own research centre in August 2008. This centre will be home of two projects funded by BMU namely QUEBEC and Alba. In both projects, Q-Cells

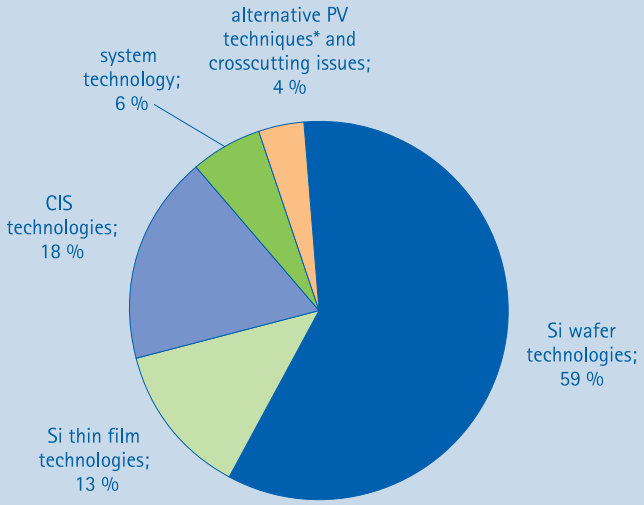

*Fig. 2 - BMU funding of R&D in 2008 (*concentrating PV, CdTe and crosscutting issues).*

relies on the expertise of the Fraunhofer ISE, Freiburg and the ISFH, Hameln. QUEBEC aims for 20 % efficiency on monocrystalline silicon while Alba addresses high efficiency cells on multicrystalline silicon. It is expected that both cell concepts will be transferred into pilot production in the near future.

- In December 2008, Concentrix Solar opened a 25 MW production facility for concentrating PV Systems (CPV – see figure 1) in Freiburg. Concentrix is a spin-off of the Fraunhofer ISE. The ISE itself published very recently a new world record of 41,1 % for a cell for CPV applications. The realisation of highly efficient CPV systems using this type of cell is currently funded by the BMU.
- Since April 2008 a German consortium of Solar World, University of Stuttgart and Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW) participates in the new IEA PVPS Task 12 - PV Environmental Health & Safety Activities.

Funding Activities of the BMBF

In 2008, the BMBF published its concept paper "Basic Energy Research 2020+" aiming for the support of long-term R&D on renewable energies [6]. Currently there are two focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells.
- Networks aiming for the development of thin-film solar cells were initiated in 2008. They place emphasis on topics such as 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 2008, 13 cooperative R&D projects were granted in total. The funds amount to a total of 47,7 MEUR.

Additionally, the BMBF funds the development of the "Solarvalley Mitteldeutschland" cluster as part of the Federal High-Tech Strategy. In early 2008, a competition to promote outstanding innovation-oriented alliances was launched. The "Solarvalley Mitteldeutschland" cluster which comprises most of Germany's PV industry was one of the five winners and will now be funded to boost its profile, eliminate impediments to its strategic development and grow into an internationally attractive centre. The BMBF allocated 200 MEUR grants in total for all five winners.

IMPLEMENTATION

Since 2004, Germany is the country with the highest annual PV installation worldwide. This remarkable development is based on the "Renewable Energy Sources Act (EEG)" [3]. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. In late 2008, an amendment of the EEG was decided. In order to stimulate a stronger price reduction, the degression rate of tariffs for new PV systems was raised from 5 % to 8 % in 2009 and 2010 (for systems smaller 100kW) [3,7]. Moreover, the degression rate will be adapted to the market growth. If the marked deviates form a predefined corridor, the degression rate will be increased or decreased by 1 % for the next year. For 2009 the corridor was set between 1 000 MW and 1 500 MW. Table 1 shows the development of the basic rooftop tariff. The rates are guaranteed for an operation period of 20 years. The bonus for façade integrated systems of 5 Ct/kWh was eliminated.

For small systems (< 30 kW) installed in 2009 there is now the possibility to obtain a reimbursement of 25 Ct/kWh for PV power consumed by the system operator or his neighbourhood. If one includes the savings on electricity delivery costs (approx. 20 Ct/kWh) this way of operating the PV system may become attractive as every kW PV power is worth 45 Ct under these conditions.

INDUSTRY STATUS

Based on the measures described above, the German PV industry still experiences a period of solid growth. 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 growing significantly taking advantage of the global silicon supply shortage of recent years. The figures given below are based on an analysis of the initiative "Germany Trade and Invest," the new German Foreign Trade and Inward Investment Agency, [8] and Photon magazine [9], see table 2. It must be mentioned that due to differences between both sources here only averaged numbers are given.

Silicon Wafer Technology: With Wacker, one of the world largest suppliers of silicon for the semiconductor and PV industry, Joint Solar Silicon, PV Silicon and Scheuten SolarWorld Solizium now at least four companies are in the silicon feedstock business in Germany. From 2009 on, a production capacity of more than 17 000 t equal to roughly 1 300 MW will be reached.
The total production capacity for wafers now amounts to around 2 000 MW. The main supplier of silicon wafers is still Deutsche Solar AG in Freiberg. Besides this company there are another five to six Germany based wafer manufacturers like PV Silicon at Erfurt or Ersol (formerly ASI) at Arnstadt. Silicon ribbons are produced by Wacker Schott Solar (EFG-ribbon) in Alzenau and Sovello (formerly EverQ - String-ribbon) in Thalheim.

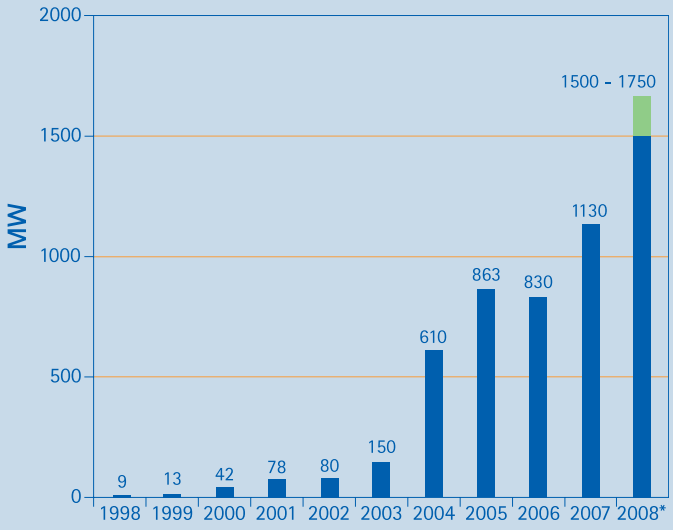

*Fig. 3 – Development of grid connected PV capacity in Germany after, [11] and [12], * first estimate; as of January 2008.*

The cell production in Germany shows a steady growth. Currently, twelve companies are engaged. Amongst these, Q-Cells in Thalheim is not only the biggest cell producer in Germany but also worldwide. The production of modules grew again. There are now more than fifteen companies with a production capacity of 1 MW and more listed. Amongst these, the biggest ones are Aleo Solar, Solar Factory, Solarwatt, and Solon, all with a production of 100 MW and more.

Thin-Film Technologies: In addition to the silicon wafer activities, there is an increasing number of companies investing in thin-film production lines. Eleven companies are operating or building production facilities for silicon thin film modules with a total capacity of 500 to 600 MW. CIS technologies are used by twelve companies resulting in a production capacity for 2009 of roughly 300 MW. CdTe modules are currently fabricated by two companies. In total, the production of thin-film modules amounts currently to roughly 290 MW a factor of 3 times more than 2007 and now 1/3 of the silicon wafer module production. From 2009 on, thin-film technologies will have a production capacity of more than 1 000 MW, half of the module production capacity of silicon wafer technologies.

Besides the above described manufacturing of feedstock, wafers, cells and modules, the fabrication of **concentrating PV** (CPV) is entering the scene. In 2009, the production capacity will be around 30 MW.
Another important business in Germany is the **inverter industry.** Besides SMA Solar, the world-leader producing around 1 000 MW alone, there are more than another 10 companies producing state-of-the-art inverters. For 2007 a production of 1 600 MW was reported [9].

TABLE 1 – DEVELOPMENT OF THE BASIC PV FEED-IN TARIFF OF THE EEG FOR ROOFTOP SYSTEMS SMALLER THAN 3 KW

	2003	2004	2005	2006	2007	2008	2009	2010*
Tariff* (Ct/kWh)	46,0	57,4	54,5	51,8	49,2	46,75	43,01	39,14 - 40,0

** Depending on the market size in 2009.*

In addition to the PV industry PV equipment manufacturers supply tools for every step of the PV value chain. The initiative "Germany Trade and Invest" currently lists 68 companies covering the range from equipment for ingot/wafer production to module turnkey lines [8].

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 worldwide.
Until end of 2007, around 10 000 companies employing 42 600 workers have been producing a turnover of 5,7 BEUR annually [10].

MARKET DEVELOPMENT

The EEG 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. First estimates for 2008 show a new capacity of grid connected systems between 1 500 and 1 750 MW [11, 12] resulting in a cumulated capacity between 5,3 and 5,6 GW at the end of the year.
With respect to the statistical difficulties, there is hope for improvement. Since the beginning of 2009 the owner of new PV systems are legally obliged to register their systems at the German Federal Network Agency. Only registered systems will receive the favourable feed-in tariff of the EEG.

In addition to the market of grid connected systems, there is a steadily growing request for stand alone systems. First estimates indicate that in 2008 around 5 MW were installed mainly for industrial applications like the automotive sector, traffic signals etc.

FUTURE OUTLOOK

In 2008 the German PV market again showed an impressive growth. The driving force for this development is the EEG which was amended in late 2008. Higher degression rates were introduced in order to stimulate additional price reductions. Moreover, through the use of renewable energies such as PV a lower consumption of coal and gas in the electricity sector and thus a reduction of Germany's dependence on energy imports will be accomplished. Therefore, it is expected that the German PV marked will stay at a high level.

The German PV industry intends to extend their production capacities further. An increasing share of the turnover will be earned form 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 for a standstill. Enhancement of production efficiency and at the same time lowered costs stay on the agenda. For this reason, high-level R&D together with sustainable market supporting mechanisms such as the EEG are still needed.

TABLE 2 – PV PRODUCTION IN 2007* AND 2008 AND THE PRODUCTION CAPACITY FOR 2009 AFTER [8], [9] – DUE TO DIFFERENCES BETRWEEN BOTH SOURCES, HERE ONLY AVERAGED NUMBERS ARE GIVEN

	PRODUCTION 2007*	PRODUCTION 2008	PRODUCTION CAPACITY 2009
Silicon Wafer Technologies			
Silicon feedstock	8 000 t	11 200 t	17 000 t
Wafer production	415 MW	710 MW	2 000 MW
Solar cell production	700 MW	1 200 MW	2 500 MW
Module production	680 MW	900 MW	2 000 MW
Thin-film technologies			
Silicon thin film	6 MW	57 MW	500-600 MW
CIS technologies	16 MW	30 MW	300 MW
CdTe	70 MW	200 MW	260 MW

** For comparison, see PVPS Annual Report 2007.*

FURTHER READING ABOUT GERMANY

The Internet portal on renewable energies of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is now also available in English, see www.erneuerbareenergien.de/english.

REFERENCES

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

[2] Press release "BEE Jahreszahlen 2008" of the German Renewable Energy Federation (BEE) of January 7th, 2009;
For an extensive analysis of data until 2007 see "Renewable energy sources in figures - national and international development", December 2008 update, http://www.erneuerbare-energien.de/inhalt/5996/4590/

[3] Renewable Energy Sources Act (EEG), http://www.erneuerbare-energien.de/inhalt/42934/40508/

[4] 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

[5] "Bekanntmachung über die Förderung von Forschung und Entwicklung im Bereich erneuerbare Energien", http://www.erneuerbare-energien.de/inhalt/37841/20028/

[6] "Basic Energy Research 2020+", http://www.energieforschung-bmbf.de/, also available in French and Spanish language.

[7] For systems bigger than 100 kW the degression rate rises from 5 % to 10 % in 2009 and 2010; for ground mounted systems from 6,5 % to 10 % in 2009 and 2010. From 2011 on the degression rate will be 9 % for all system sizes.

[8] Germany Trade and Invest – "Photovoltaics in Germany" and "Photovoltaic Equipment in Germany", January 2009, see http://www.gtai.com/homepage/industries/renewable-energies/photovoltaics/

[9] Photon, January 2009, p. 36 ff. and May 2008, p. 28 ff.

[10] BSW Fact sheet "Statistische Zahlen der deutschen Solarstrombranche", August 2008, see http://www.solarwirtschaft.de

[11] Press release of BSW form November 18th, 2008, see http://www.solarwirtschaft.de/

[12] see [8] and data of EuPD Research in pv magazine 01/2009, www.pv-magazine.com

ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE

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GENERAL FRAMEWORK

About 500 kWp of photovoltaic systems were installed during 2007, bringing the cumulative installed capacity to just over 1,8 MWp. As in previous years, the vast majority of systems installed were off-grid electrification applications (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).

However, considerable progress has been made recently 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, with an interim target of 5 % by 2014. At the present just about 0,1 % of the country's electricity supply comes from all sources of renewable energy.
- An international tender for a 15 MW PV power plant was issued by the Government in April 2008; an option exists for an additional similar one. A site for these power plants has been allocated in the Negev desert (2 x 0,5 km^2). Ten international consortia have answered the PQ tender.
- Feed-in tariffs for distributed PV systems entered into effect on July 1, 2008 (2,01 NIS/kWh ~ 0,52 USD/kWh ~ 0,40 EUR/kWh), with an installation cap of 50 MWp over seven years. The tariffs are for up to 15 kWp residential systems and up to 50 kWp commercial ones, and are guaranteed for 20 years. For systems starting operation from 2011 to 2015, the tariff will be reduced by 4 % every year.
- Additional tariffs are being considered by the Public Utility Authority-Electricity for systems between 50 kWp and 5 MWp.
- The National Council for Planning and Construction has recently approved rules to accelerate approval by local authorities and to exempt these systems from local fees.

It is expected that these actions will influence strongly the local PV market. 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 enacted, an increase in PV implementation is forecasted.

INDUSTRY INVOLVEMENT

The number of firms active in the PV field almost quadrupled during the past year, to about thirty. Most companies are small and deal mainly with system integration. However it is early to judge the pace of PV system installations triggered by the feed-in tariffs; it will depend much on the willingness of the banking sector to finance PV systems. Investments costs for private individuals for a 2 kWp installation would be almost USD 15 000. Payback period should be about ten years.

The cap of 50 MWp for the first seven years, although a modest one, will nevertheless generate a retail market for PV solar panels, inverters and controllers of almost 400 MUSD. Fully exhausting the cap will result in annual generation of 100 GWh at annual feed-in purchasing costs of 50 MUSD for the power utility. Considering the annual revenues of 4,5 BUSD of the power utility from sales of about 50 TWh, the required net tariff cross-subsidy will be about 1 %. The feed-in-tariff looks attractive, considering the fact that a PV installation in Israel could generate up to twice the amount of kWh as compared to German installations enjoying a 2008 tariff of 0,47 EUR/kWh.

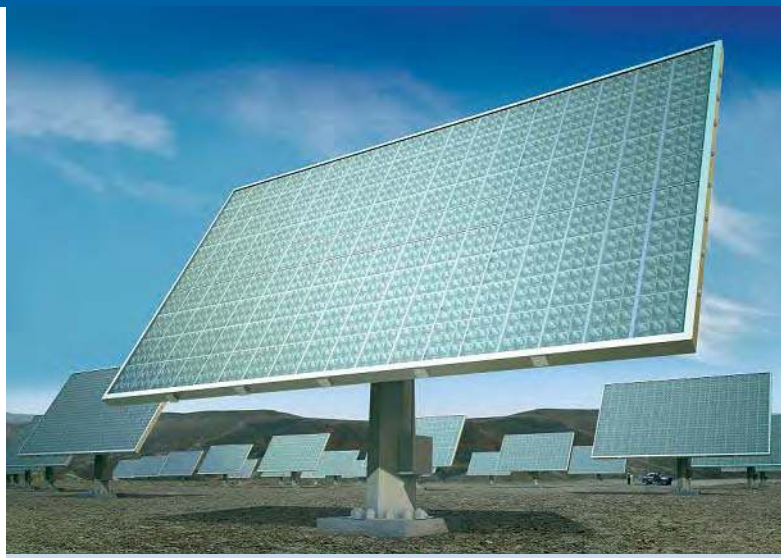

Fig. 1 - The MST basic unit (simulation).

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.

RESEARCH AND DEVELOPMENT

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

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

- MST Ltd. is developing a novel concentrating PV (CPV) technology. The basic unit is the solar tracker, with an output power of about 50 kWp (Figure 1). It has an area of 240 m^2 and a tracking accuracy exceeding 0,05 degrees. The system's lenses concentrate sunlight to 500 suns on multi-junction highly-efficient (37 %) solar cells. The projected costs of installation and maintenance are low and the planned lifespan of the system is 30 years. An additional significant advantage is the system's ability to be installed on hilly terrain. The high efficiency in converting light to electricity combined with a sophisticated tracker and panel system configuration results in a 50- 60 % reduction in the land area normally required for installation of solar power plants. MST plans to reach 10 MW production in early 2010.

Fig. 2 - Zenith Solar multi-dish system (simulation).

- DiSP Ltd. is developing a very high efficiency CPV 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. The heat can be provided at temperatures suitable for solar air conditioning, space and water heating, and process heat. The company has installed a working commercial pilot system and is preparing for large scale installations in 2009 and 2010.
- 3GSolar Ltd. in Jerusalem is developing novel dye-sensitized solar cell modules. According to the company's approach, an intrinsically corrosion-resistant, robust current-collecting grid has been developed that allows scale-up to large area dye cells having increased stability and with reduced wastage of cell active area.
- Ben-Gurion University's Blaustein Institutes for Desert Research (BGU-Blaustein) represents Israel within the framework of the IEA's Task 8 Photovoltaic Specialists Working Group Very Large-Scale Photovoltaic (VLS-PV) Power Plants. One of BGU's contributions to this working group was a paper, designated a "highlight" at the 23rd EUPVSEC, Valencia, 1-5 September, 2008, that shed new light on the problem of matching VLS-PV to the electricity grid. The paper showed quantitatively the extent to which appropriately designed buffer storage is critical for being able to inject the rapidly varying output of VLS-PV plants into the grid in a manner commensurate with the rate at which spinning reserve turbines can be ramped down. In the absence of such storage, the largest contribution possible by PV power is only a few percent of annual national electricity requirements.
- Toward the goal of quantifying the design of such storage, BGU-Blaustein scientists began work on a project involving the investigation of a 5 kW vanadium redox flow battery. The purpose of the project is to employ the battery as a laboratory, which, in the first place, will enable them to identify the optimal manner for charging from a PV array and discharging to the grid. In the second place, this research will enable them to identify the causes that limit round-trip efficiency, as a necessary first step to devising methods for overcoming them.
- HiConPV was an EU-funded project that ended in 2006. As a spin-off from this project, a start-up company, Zenith Solar, entered into an agreement with BGU-Blaustein (who developed the optics) and Germany's Fraunhofer ISE (who developed the PV cells) to commercialize an industrial-scale, dish-based, concentrator-photovoltaic (CPV) system. In its first generation, the basic 10 m^2 aperture Zenith Solar CPV unit will generate approximately 2 kWp of electrical power and 5 kWp of thermal power (in the form of hot water). A multi-dish pilot system is currently under construction at kibbutz Yavneh, just east of Ashdod (Figure 2).
- BGU-Blaustein are continuing their study of the degradation of conventional flat-panel PV modules under the aggressive desert conditions of Sde Boker. This work is performed partially within the framework of another EU-funded project, PERFORMANCE, and its spin-off project, OWT-1, with co-investigators from Fraunhofer ISE and TÜV Rhineland in Germany. Already, after only two years of data collection, the Israeli partners were able to quantify module degradation rates as small as 1 % per year. Such precision is only possible owing to the unique natural AM1,5 G spectral conditions at this outdoor test site (Figure 3).
- Researchers from BGU-Blaustein have this year extended their cooperation with the SolFocus Corporation of San Jose, California, and have continued to develop novel optics for photovoltaic concentrating systems and have tested, characterized and researched high-efficiency state-of-the art solar concentrator cells per research agreement with SolFocus.
- Other start-ups are developing new CPV systems, in addition to the ones mentioned above. Among them: SRS, SunAdd, and Solecta.

Fig. 3 - OWT-1 Project test module at Sde Boker.

Fig. 4 - 34 kWp grid-connected system at a farm in the Negev (photo SolarPower).

- Researchers at Tel Aviv University have isolated the principal protein that performs photosynthesis from genetically engineered bacteria, and arranged the protein molecules using sophisticated nano-technology methods to form a photovoltaic cell. This break-through technology could lead to solar cells that operate at high efficiency but can be produced at very low cost.

EDUCATIONAL ACTIVITIES

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

GOVERNMENT ACTIONS

It is expected that the Government activity described above (solar power plant tenders and tariffs for distributed PV) will influence favorably 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 (MNI) were only about 100 000 USD in 2007; however, additional funding is available in this area from other research foundations.
- Partial funding (up to 30 %) of innovative deployment-support projects - about 65 000 USD from MNI in 2007.

Fig. 5 - 16 kWp tracking system at a farm in the Negev (photo SolarPower).

ITALY

PV TECHNOLOGY STATUS AND PERSPECTIVES
S. CASTELLO AND S. LI CAUSI, ENEA
S. GUASTELLA AND F. PALETTA, CESI RICERCA

GENERAL FRAMEWORK

Photovoltaics is becoming more and more important in Italy.
The feed-in programme "Conto energia" seems to ensure a stable situation providing the basis for the expansion of PV market in Italy followed by an adequate growth of the national PV industry.
A preliminary evaluation of PV power installed in Italy during 2008 sums up to about 180 MWp, even if it is foreseen that additional power (i.e. 30-40 MWp) could be still counted. Then the total installed and operating power in Italy at the end of 2008 should result in about 300-330 MWp with an increase around 150- 180 % with respect to the previous year.
In this growing contest only public budget for research and demonstration initiatives remain essentially flat with respect to the previous years and not adequate to market stimulation resources.

Fig. 1 - Sun tracking 1 MW PV plant, Roccastrada (GR) (photo GSE).

NATIONAL PROGRAMME

The Italian feed-in programme started with a first phase, which has been defined through two governmental decrees issued in 2005 and in 2006 and has resulted at the end of 2008 in about 5 000 PV plant's installations (corresponding to about 120 MWp). This first phase is expected to obtain a further 20 MW PV installations by its end, stated in April 2009.
The second phase has been defined through a governmental decree issued in February 2007 and resulted in setting in operation about 18 000 plants, corresponding to about 110 MW.
More specifically, it is to highlight that both phases of "Conto energia" incentive have recorded a remarkable success among the citizens (which represent the greater part of feed in tariff beneficiary) as well as among the private companies (with a share in power of about 64 %).
According to data supplied by GSE (the institutional manager of "conto energia" programme), the geographical distribution of PV installations at the end of 2008 consists of about 50 % of the total power installed in the northern part of Italy and almost 30 % in the north-east area, while only the 23 % of PV installations has been counted in the south Italy (islands included), in spite of higher solar radiation availability in these areas.
An analysis of the kind of PV installations demonstrates that a large use of areas not differently utilisable (i.e. roof tops) has been done. In fact, the installation of small and medium size PV plants resulted, typically, on the roofs of industrial structures, private houses, as well as schools, public and company buildings, hotels and farmhouses), whereas large size PV plants resulted as usually installed on the ground by fixed or sun tracking module supporting structures. As a consequence of these plant locations, a low environmental impact has been obtained.
As far as module manufacturers, larger quantities have been supplied by Japanese, German and Chinese companies, while only 15 % of the installed modules have been fabricated in Italy, also due to a limited capacity in 2008 (about 350 kW) .
Concerning component and system costs, economic data highlighted that the turnkey cost of plants range from 4 EUR/W to 6 EUR/W, while the cost of medium and large size plants (>50 kW) decreases to 4-5 EUR/W. Moreover average share cost of modules is around 68 % of the total plant cost, while the share of inverters is only 10 %. The remaining 22 % is due to installation and engineering activities as well as cables and supporting structures.

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) and CESI RICERCA (a research company owned by ENEA and CESI, the Institute for Research and Certification of Electric Components and Systems). Additional contributions have been supplied by some Universities, CNR (the National Council for Scientific Research) and few private Laboratories.
ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest regard: crystalline silicon, Cu_2O solar cells, microcrystalline Si devices, micromorph tandem solar cell as well as concentrators technologies. In this last contest, ENEA is carrying out experimental activities on standard units of 5 kW, in order to assess the technical and economical feasibility of this application.
CESI RICERCA is carrying out activities in research and development on high efficiency single and triple junction solar cells (InGaP/InGaAs/Ge) for terrestrial and concentrator applications, in the frame of the Italian electric system research programme (RdS – Ricerca di Sistema) and in the European project (APOLLON).
Furthermore, CESI RICERCA is involved in components' characterization and performance evaluation of PV systems, as well as in research and demonstration activities for electrification of remote communities, in the frame of the RdS programme.
Public budget for R&D and market incentives totalled about 25 MEUR in the year 2008. In particular, expenditure on PV research and demonstration has been about 5 MEUR, remaining essentially flat with respect to the previous years.

Fig. 2 - Building integrated 13 kW PV plant, Gavardo (BS) (photo GSE).

IMPLEMENTATION OF SYSTEMS

As previously mentioned, a total capacity of about 300 MWp is installed and operating in Italy at the end of 2008, according to a preliminary evaluation. Taking into account that during this year about 180 MWp have been installed, the annual growth recoded has been more than 150 %.

This increase has been driven by the support mechanism of on-grid distributed systems market, that now account for about 95 % of the total photovoltaic installed. The installations in Italy in the four significant sectors of PV power system applications are as follows:

- off-grid domestic systems:
  amounting to 5 MW (mainly promoted in the eighties);
- off-grid non-domestic systems:
  amounting to 8 MW;
- on-grid centralized systems:
  amounting to about 88 MW (installed at the beginning of 1990's and
  increased due to the feed-in tariffs;
- on-grid distributed systems:
  amounting to about 200 MW (dominating Italy's cumulative installed photovoltaic power).

INDUSTRY STATUS AND MARKET DEVELOPMENT

At the industrial level, about 25 producers of crystalline silicon cells and finished PV products can be identified in Italy. Beyond the two historical companies, Enipower and Helios Technology, other emerging producers of solar cells are now operating (i.e. Omnia Solar and Xgroup) and are strongly determined to expand their production facilities in the next years. Further companies assembling and encapsulating standard, or tailor-made modules, can be found in Italy (i.e. Solon, Solarday, Xgroup, Solsonica).

On the whole, the total capacity sums up to about 300 MW at the end of 2008, while for the next year the production capacity could reach more than 450 MW, according to declarations from the operators.

During last year, neither ingots nor wafers have been produced in Italy, although three new companies (Estelux, Silfab, Italsilicon, Depasol Silicon and Xgroup) have announced an annual total capacity of about 10 000 t by the end of 2010. Finally, regarding thin films technology initiatives, the Italian Ministry of Environment, Land Protection and Sea and Regione Lombardia have promoted a project aimed at developing a pilot plant for CdTe module production. The production capacity will be around 18 MW/year and the manufacturing facility will be realised within 2009.

As far as BOS components, in Italy about 10 companies manufacture inverters for on-grid and off-grid applications. Some of these have experience in inverters for large PV power plants, while others have produced 1,5 -10 kVA inverters under Electric Utilities' specifications for the connection to the grid. About 45 % of the inverters installed in 2008 have been produced in Italy while the same figure has been exported. As a consequence, about 140 MW of inverters have been produced in Italy during 2008.

FUTURE OUTLOOK

The national initiatives and the increased participation of operators have made Italian people more and more aware of PV technology utilization. With the feed-in decree, the largest obstacles for the growing market seem to be smoothed out and the tariffs introduced seem to be adequate for small plants as well as for large plants, particularly in the sunny Southern Italian region. As a consequence, the current feed-in supporting scheme seems to ensure a stable PV situation in Italy, providing the basis for the expansion of PV market and, then, for an adequate growth of the national PV industry.

In this contest, counting on a growth of up to 180 MW in 2008 and of about 300-400 MW in the following year, Italian producers of crystalline-silicon cells and modules are planning to extend their capacities in the next year to up to 400-500 MW/year. Moreover, some initiatives have been announced to realize production lines of thin films modules, as well as production of silicon ingots.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

HITOSHI KAWANAMI, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)
OSAMU IKKI, RTS CORPORATION

Fig. 1 - Hokuto site of NEDO large-scale PV demonstration facility, 600kW, Total 2 MW by the end of FY 2009 (Natsuaki, Nagasaka-Cho, Hokuto City, Yamanashi Pref.) (photo RTS Corporation).

GENERAL FRAMEWORK

The general framework for Japan's energy policies and measures covering PV power generation is classified into the following in response to the purposes, based upon the legislations, measures and strategies of the Ministry of Economy, Trade and Industry (METI).

1) Energy policy: Basic Law on Energy Policy Making (enacted in 2002)
   With the three principles of i) "securing stable energy supply", ii) "conforming to environmental requirements", and iii) "utilizing market principles", promoting the use of PV power generation is clearly stated in the article of ii) "conforming to environmental requirements". Furthermore, the "Basic Energy Plan" was formulated in order to materialize the basic direction of Japan's energy policies.
2) Direction for dissemination of new and renewable energy: Law concerning Special Measures to Promote the Use of New Energy (New Energy Law, enacted in 1997)
   This law stipulates responsibilities of the national government, local governments, energy consumers and suppliers, as well as manufacturers of energy equipment for dissemination of new and renewable energy.
3) Enhancement of use of electricity generated from new and renewable energy: Act on Special Measures concerning New Energy Use by Electric Utilities (RPS Law) (enacted in 2002)
   Electric utilities are required to use more than a certain amount of electricity generated from new and renewable energy. The obligation amount of new and renewable energy use is increased on a yearly basis.
4) Fundamentals of energy strategy: New National Energy Strategy (formulated in 2006)
   Under the basic recognition of the current status, target figures to be achieved by 2030 were set on different types of energy. Dissemination of PV systems is described in the "New Energy Innovation Plan." The goal of reducing the cost of PV power generation to the level of that of thermal power generation by 2030 was set. Support measures to expand "demand" and "supply" have continued through introduction of subsidy programs and preferred tax treatments in response to each stage of growth. The aim is to create a group of PV-related industries.
5) Short- to mid-term strategy for technology development of PV systems: PV 2030 Roadmap (PV2030) for technology development of PV systems (formulated in 2004).
   Goals for technology development of PV cells and systems were set from a long-term perspective for the period up to 2030.
6) Long-term strategy for technology development of PV systems: Cool Earth Energy Innovative Technology Plan (formulated in 2007)
   "Innovative PV power generation" was selected as one of the twenty themes of the innovative technology development which will be emphasized for the future. The goal was set to increase the conversion efficiency of solar cells from the current levels of 10 - 15 % to over 40 % and reduce the power generation cost of solar cells from the current level of 46 Yen/kWh to 7 Yen/kWh.
7) Target installed capacity of PV systems: Action Plan for Achieving a Low-carbon Society (approved by the Cabinet in 2008)
   This action plan sets targets to increase the amount of installations of PV systems to 14 GW by 2020 and 53 GW by 2030.
8) Policies and measures for dissemination: Various subsidy programs by the Ministry of Economy, Trade and Industry (METI) and the Ministry of the Environment (MoE)
   Field test projects and technology development on PV power generation, Project for acceleration of renewable energy, etc.

Fig.2 - PV System in front of Osaka Dainichi Station, 11kW (Dainichi higashi-machi, Moriguchi City, Osaka) (photo RTS Corporation).

NATIONAL PROGRAM

The government has implemented research and development (R&D), demonstrative researches, model projects, dissemination measures and laws and regulations 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 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 cells and modules, new controlling methods, advanced system technologies and newly developed installation methods, etc. and enlarge the application area of PV systems. Projects for promoting the introduction of PV systems have been implemented to support local governments and private businesses.

MoE has been promoting measures against global warming putting priority on strengthening efforts for achieving a low-carbon society and continuously promoting support programs and technological development for introduction of new and renewable energy in residential and commercial sectors, as well as in local communities. The budgets for major national PV programs implemented in FY2008 are as follows;

i) Technology Development for New Energy: 7 700 MJPY
ii) Field Test Project on New Energy Technology: 8 590 MJPY
iii) Verification of Grid Stabilization with Large-scale PV Power Generation Systems: 3 580 MJPY
iv) Project for Supporting New Energy Operators: 33 580 MJPY
v) Project for Promoting the Local Introduction of New Energy: 4 150 MJPY
vi) Project for Establishing New Energy/Energy Conservation Visions at the Local Level: 900 MJPY
vii) Project for Promotion of Non-profit Activities on New Energy: 60 MJPY
viii) Project for Developing Technology to Prevent Global Warming: 3 709 MJPY
ix) Project for promoting dissemination of eco houses: 100 MJPY
x) Project for acceleration of renewable energy: 500 MJPY
xi) Project for promotion to develop model areas in low-carbon society: 1 100 MJPY
xii) Promotional project for environmental technology development using nano-technology: 453 MJPY
The budget except for item iii) includes those for PV and other types of new and renewable energy.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

R&D

Two Projects started in FY2006 under the "4-Year Plan for Photovoltaic Power Generation Technology Research and Development (FY2006 - FY2009)" have been continued in 2008; i) R&D of Next-Generation PV Generation System Technologies and ii) R&D of Common Fundamental Technologies for Photovoltaic Generation Systems, Phase II. In addition, Project for PV Systems Advanced Practical Technology Development was completed in FY2007. A new two-year subsidy program "Project for Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation Systems" started in FY2008, as well as a new project "Research and Development on Innovative Solar Cells" started.

1. R&D of Next-Generation PV Generation System Technologies

This project aims at establishing elemental technologies to achieve the target PV power generation cost set in the PV2030 roadmap: 14 JPY/kWh in 2020 and 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 five 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. Five 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. Interim evaluations were conducted at the end of FY2007 and some R&D projects were moved to either "Project for Development of Technologies to Accelerate the Practical Application of

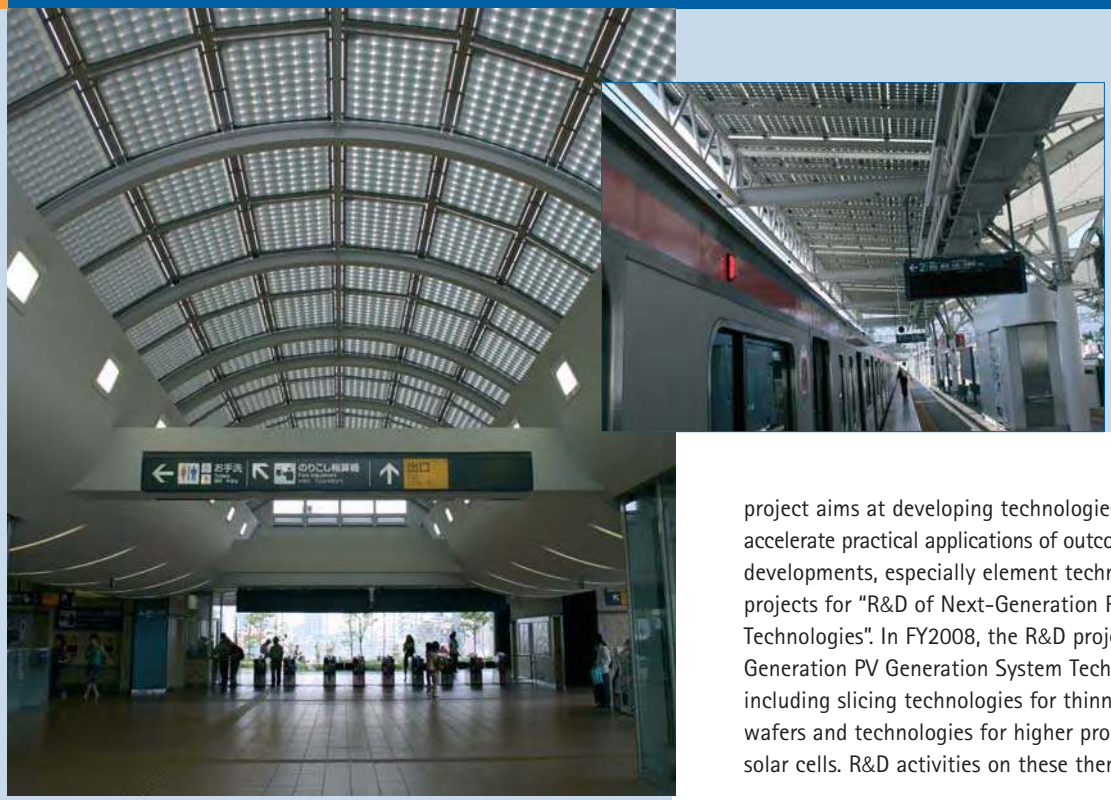

Fig. 3 - Tokyu Toyoko Line Motosumiyoshi Station, 140kW (Nakahara-ku, Kawasaki City, Kanagawa Prefecture) (photo RTS Corporation).

Photovoltaic Power Generation Systems" or "Research and Development on Innovative Solar Cells".

2. R&D of Common Fundamental Technologies for Photovoltaic Generation Systems, Phase II

This project is a successor of R&D of Common Fundamental Technologies for Photovoltaic Generation Systems in the previous term, aiming at developing technological infrastructure for supporting extensive utilization and mass deployment of PV systems. Under this project, research was continued to develop evaluation technologies for performance and reliability of PV cells/ modules and evaluation technologies for electricity output from PV systems. Research was also continued on technology trends of PV power generation and LCA, Life Cycle Assessment.

3. Project for Technological Development of Innovative PV Power Generation Technology

This project is a seeds-seeking research project aiming at drastically improving performances of solar cells (target conversion efficiency: 40 %) from a long-term perspective looking towards 2050. It also aims at establishing R&D centers for international joint researches. In FY2008, three themes and two R&D centers were selected and R&D activities started in such areas as development of multi-junction solar cells as well as structures of super-high efficiency solar cells using quantum dot materials and Multiple-Exciton-Generation materials.

4. Project for Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation Systems

All the research themes up to FY2007 have been completed and the project was switched to a two-year subsidy project in FY2008. This project aims at developing technologies for industrialization to accelerate practical applications of outcomes of preceding technological developments, especially element technologies developed under projects for "R&D of Next-Generation PV Generation System Technologies". In FY2008, the R&D projects conducted under Next-Generation PV Generation System Technologies moved to this project, including slicing technologies for thinner multicrystalline silicon wafers and technologies for higher productivity of thin-film silicon solar cells. R&D activities on these themes have been promoted.

5. Others

In regards to PV power generation system technologies, development of electricity storage technologies on grid connection of new and renewable energy have been promoted under the plan towards 2010.

DEMONSTRATION

Six major demonstration programs were implemented in FY2008: i) Field Test Project on New Photovoltaic Power Generation Technology, ii) Verification of Grid Stabilization with Large-scale PV Power Generation Systems, iii) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources, iv) R&D of Islanding Detection Testing Technology for Clustered Photovoltaic Power Generation Systems, v) International Cooperative Demonstration Projects for Stabilized and Advanced Grid-connection PV Systems and vi) International Cooperative Demonstration Projects on PV Power Generation System.

1. Field Test Project on New Photovoltaic Power Generation Technology

Since FY2007, the "Field Test Project on New Photovoltaic Power Generation Technology" has been implemented under New Energy Technology Field Test Project. This program aims at leading dissemination of medium-scale PV systems by installations 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 model technologies are defined: i) PV systems with new modules, ii) PV systems with building-integrated modules, iii) PV systems with new control systems, iv) PV systems aiming at higher efficiency and v) the application employing small-scale multiple grid-connected systems, a model newly added in FY 2008 with a view to introducing PV systems at housing complexes. The introduction of PV systems for public facilities and industrial uses are promoted under this program. 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, 662 projects, totaling 22 090 kW were completed. In FY2007, 374 projects, totaling 21,058 kW were installed. In FY2008, both the number of selected projects and the total capacity selected were largely decreased to 180 projects totaling 9 211 kW. Cumulative installed capacity of field tests conducted from FY1992 - to FY2008 exceeded 100 000 kW.

2. Verification of Grid Stabilization with Large-Scale PV Power Generation Systems

This demonstrative research project aims at establishing a system to stabilize power output of MW-scale PV systems without giving negative impacts on the quality of grid electricity and validating its effectiveness and usefulness. In addition to these objectives, the final goal of this research is the development of technologies to make the business of future MW-scale PV plants feasible. The term of this research project is from FY2006 to FY2010. The complete capacities of the demonstrative systems will be 5 MW in Wakkanai City of Hokkaido Prefecture and 2 MW in Hokuto City of Yamanashi Prefecture by the end of FY2009, of which 2 MW and 600 kW, respectively have been installed as of the end of 2008. Developments under this project include technologies to restrict voltage fluctuations, technologies to restrict frequencies (output fluctuations), technologies to control output of large-scale PV systems which enable planned operations, and development of power conditioners equipped with control functions for grid stabilization.

3. 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 fluctuations of power generation using new and renewable energy. Technological development covers three themes as follows: i) development of technologies for practical applications to establish an electric energy storage system with the capacity of around 1 MW, at the mass production cost of 40 000 JPY/kWh and the life span of 10 years, ii) development of next-generation technologies aiming at reaching 20 - 30 MW of capacity with mass production cost of 15 000 JPY/kWh and the lifespan of 20 years in 2030, iii) development of common fundamental technologies to select charge/ discharge patterns and development of evaluation methods.

Under these themes, developments of large-capacity lithium ion battery and nickel hydride battery have been conducted.

4. R&D of Islanding Detection Testing Technology for Clustered Photovoltaic Power Generation Systems

This project is associated with the Demonstrative Project on Grid-Interconnection of Clustered Photovoltaic Power Generation Systems which was conducted over the period from FY2002 to FY2007. Aimed at establishing testing technologies which contribute to certification of devices to detect islanding operations for grid connection of multiple PV systems, the project will be conducted from FY2008 to FY2009.

5. International Cooperative Demonstration Project for Stabilized and Advanced Grid-connection PV System

This program is an international program of demonstration and technological development using PV power generation, aiming at a stable electricity supply by mainly constructing micro-grids with a higher proportion of PV power generation.
Three overseas collaborative projects have been conducted as follows: i) "Demonstrative research on power supply systems to maximize the use of solar and other fluctuating renewable power sources" in Indonesia and Malaysia, ii) "Demonstrative research on advanced micro-grid stabilization systems" in Thailand, iii)"Demonstrative research on advanced micro-grid stabilization systems (high quality electricity supply)" in China

6. International Cooperative Demonstration Projects on PV Power Generation System

This program is an international program of demonstration and technological development using PV power generation, which started in FY1992 and is scheduled to be completed in FY2009. In partnerships with developing countries, the main goal of the program is to improve reliability and other features of PV systems under natural conditions and social systems which are usually not available in Japan.
Currently, the following projects are conducted: i) Demonstrative Research Project on Integrated Control Technology for Large-Scale Photovoltaic Systems," to comprehensively control large-scale PV systems and capacitors in Xining of Qinghai Province, China, ii) Demonstrative Research Project to Stabilize Output of Hybrid PV Power Generation Systems," using PV and small-scale hydraulic power generation and capacitors in May County of Phongsaly Province, Laos, iii) "Development of Design Support Tools for Photovoltaic Power Generation Systems," vi) "Support Projects to Improve Maintenance Skills for Application to Photovoltaic Power Generation Systems."

IMPLEMENTATION

The Ministry of Economy, Trade and Industry (METI)

1. Project for Promoting the Local Introduction of New Energy

This program aims at accelerating the introduction of new and renewable energy in local communities 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 public organizations 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, thermal energy conversion, biomass power generation, biomass heat utilization, biomass fuel production, utilization of snow and ice

energy, hydraulic power generation, geothermal power generation, natural gas co-generation, fuel cells and clean energy vehicles.
PV systems with the output capacity of 10 kW or more are qualified under the program. Qualified PV systems can receive the subsidy of the lower amount of either up to half of the installation cost, or 300 000 JPY/kW. Projects for awareness towards dissemination are subsidized with a fixed amount (or up to half of the installation cost). 1 334 systems in total were subsidized between FY1997 to FY2008, of which 598 systems were PV systems. In FY2008, 229 systems in total were newly qualified, of which 134 systems were PV systems with total installed capacity of 3 625 kW. Local governments and nonprofit institutions understand the benefits of introduction of new and renewable energy through this program and introduce PV systems to school buildings, public facilities and so on.

2. Project for Supporting New Energy Operators

This program aims at accelerating 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, thermal energy conversion, natural gas co-generation, utilization of snow and ice energy, biomass power generation, biomass heat utilization, biomass fuel production, hydraulic power generation and geothermal power generation. Amount of subsidy is up to one third of the installation cost, and 90 % of the debt is guaranteed. The output capacity of eligible PV systems was 50 kW or more (10 kW or more is also eligible in case of installations in remote islands). In the second term of applications in FY2008, however, the eligible capacity was lowered to "10 kW or more," in order to encourage installation of PV systems by small- and medium-sized enterprises (SMEs). 331 systems in total were qualified from FY1998 through FY2006, of which 14 systems were PV systems with the capacity of 986 kW in total. Three systems were qualified in FY2007 and 162 systems were selected for FY2008 program.
Besides these programs, METI has been supporting local governments for their projects to formulate their own visions for introduction of new and renewable energy, and nonprofit organizations (NPOs) for their awareness activities to introduce new and renewable energy. Through related organizations, METI also offers some programs such as low-interest loans and tax credits.
Furthermore, the four ministries, namely METI, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Land, Infrastructure and Transport (MLIT) and the Ministry of the Environment (MoE) jointly made an announcement on the "Action Plan for Dissemination of PV Power Generation" and declared that the four ministries will join hands for the dissemination of PV systems.

The Ministry of the Environment (MoE)

The Ministry of the Environment (MoE) is promoting projects to reduce CO_2 emissions by the use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming." In FY2008, based upon the "21st Century Environment Nation Strategy," MoE has been accelerating measures against global warming in various sectors including commercial and residential sectors, putting emphasis on making full-fledged efforts for achieving a low-carbon society. In the "Project to support active introduction of technological measures in business sectors" and the "Project for acceleration of renewable energy," MoE has been providing subsidy for the introduction of new and renewable energy including PV systems and enhancement of energy conservation. The "Model project for advanced installations of renewable energy" under the "Project for acceleration of renewable energy" has continued providing the existing subsidy for "Mega-solar PV power generation." The "Supporting project for installing renewable energy in residential area" provides subsidy for projects by local governments to support the introduction of renewable energy such as PV systems to residential houses. The "Project for promotion to develop model areas in low-carbon society," which integrated both the "Town-wide CO_2 20 % reduction project" and "Pilot Programs for Inventing Cool City," also provides subsidy for model projects which comprehensively develops installation of PV systems and other facilities. Other projects include the Project for dissemination of eco-houses, Eco-Renovation of Schools, Solar Mileage Club Program, and CDM/JI project survey which was newly established in FY2007 to roll out in the Asian region. MoE is also conducting projects such as the Project for developing technology to prevent global warming which implements development of practical use of PV systems and other renewable energy technologies, and the Promotional project for environmental technology development using nano-technology.

The Ministry of Land, Infrastructure and Transport (MLIT)

Under the "Guidelines for Assessment of Environmental Friendliness of Government Building Facilities and Renovation Plan" as well as Kyoko Protocol Target Achievement Plan, construction of green government buildings equipped with PV systems and other new and renewable energy systems has been promoted at buildings for central ministries and agencies and local government offices. In July 2008, MLIT formulated the "Environmental Load Reduction Program on Government Facilities (Government Buildings Green Program)". MLIT also formulated the "Model project to promote eco-CO_2 reduction at houses and buildings" and is providing subsidy for the introduction of technologies to reduce CO_2 emissions, such as PV systems. Under the "Model project for environmentally symbiotic residential areas", improvement of PV systems have been continuously supported.

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

In cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF), METI and MoE, MEXT has continued "Eco-school Promotion Pilot Model Project" and is promoting the introduction of new and renewable energy systems such as PV systems, facilities for energy conservation as well as using local building materials at elementary and junior high schools across the nation. By FY2008, MEXT certified 781 schools as Eco School Pilot Model Projects, of which 505 schools are promoting the installation of PV systems.

Fig.4 - AEON Laketown, 487kW (Higashi-cho, Koshigaya City, Saitama Prefecture) (photo RTS Corporation).

Local Governments and Municipalities

The movement to actively work on environmental issues has been spreading among local governments and municipalities year by year. Over 300 local governments and municipalities established subsidy programs for the installation of residential PV systems. While most of the programs provide subsidy ranging from 20 000JPY/kW to 50 000JPY/kW, the largest amount of subsidy is 200 000JPY/kW. The Tokyo Metropolitan Government (TMG) set a target to reduce CO_2 emissions by 25 % in 2020 compared to that of 2000 under the "Tokyo in 10 years" plan and announced a plan to introduce 1GW of solar energy. Accordingly, TMG decided to provide subsidy of 100 000JPY/kW in FY2009 and FY2010. This will provide support for the introduction of solar energy devices at 40 000 households in total over the period of two years. In parallel, environmental values of electricity which was generated by PV power generation and used for home consumption for the period of ten years will be converted into Green Power Certificates, to be owned by TMG.

Utilities

Electric utilities in Japan continue the introduction of PV systems into their own facilities and net-billing to buyback 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 disseminating PV systems and wind power generators. The utilities charge an additional rate of 500JPY/month on the bills as a contribution to the supporters of the fund among their customers, and contribute the same amount as their supporters' contributions as an endowment for the installation of PV systems and wind power generators. From FY2001 to FY2007, 897 public facilities including schools across Japan were subsidized by the fund and the total capacity installed reached 17 118,8 kW. In FY2008, 149 sites were selected, and a total 3 150,6 kW of PV systems received subsidy as of the end of 2008.

Electric utilities achieved the obligation amount of purchasing electricity generated from new and renewable energy for FY2007 designated under the RPS Law that was enforced in FY2003. Usage of electricity generated by new and renewable energy by utilities for FY2007 was 7 430,5 TWh in total, including 660,6 TWh from PV power generation. The accredited facilities for power generation using new and renewable energy under the RPS Law was 386 498 systems totaling 5 372 MW, of which PV systems accounted for 385 352 systems and 1 432 MW, respectively.
Electric utilities also made an announcement to accept grid connection of PV systems up to around 10 GW and strengthened efforts on PV power generation. Specifically, utilities announced a plan to construct 30 PV power plants with the total capacity of 140 MW across the nation by 2020, which represents their commitment to taking the initiative in introducing PV systems. Electric utilities are increasingly setting up specific plans to construct MW-scale PV power plants.

Financial Institutions

Some financial institutions such as banks provide loan programs for individual customers at low interest rates for the 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, there is a growing trend that financial institutions themselves install PV systems at their own branch offices and other facilities. There is also an emerging trend of expanding environmental financing for the projects actively working on environmental issues. Furthermore, with the aim of contributing to the society, local banks nationwide are planning to offer housing mortgage loans to customers, and part of the profits from the loans will be used to jointly purchase Green Power by local banks.

INDUSTRY STATUS

In the PV industry, PV players developed and enhanced activities focusing on the global market as follows, which was expanded to many related industries: i) increasing production capacity and overseas expansion by polysilicon manufacturers, ii) increasing production capacity and overseas expansion by silicon wafer manufacturers, iii) increasing production capacity, expanding overseas manufacturing bases, starting joint venture businesses overseas, improving solar cell performances by established PV cell/ module manufacturers, iv) increasing production volume and capacity by new thin-film PV manufacturers, v) emerging PV system integrators, vi) increasing production capacity by solar cell component manufacturers and an increasing number of new entrants, vii) enhancement of overseas development by manufacturers of full turnkey solar cell manufacturing equipment, and mushrooming new entries into the PV business by manufacturers of semiconductor manufacturing equipment, and viii) ballooning new entries by trading companies home and abroad into PV power generation businesses.

Highlights of PV cell/module manufacturers in 2008 are as follows.

Sharp announced a series of plans to increase production of thin-film silicon PV modules, starting from the completion of a new 160-MW production line for thin-film silicon PV modules at its Katsuragi Plant. Currently, a 1 000-MW/year thin-film silicon PV module plant is under construction, on the premises of a plant for large-sized liquid crystal display panels in Sakai City of Osaka Prefecture, scheduled to start operation in 2010. Sharp established a joint venture company with Tokyo Electron for the development of manufacturing equipment. Furthermore, Sharp announced a plan to construct a 480-MW/year plant to produce thin-film silicon PV modules through a joint venture with ENEL of Italy. Sharp also announced a plan to improve efficiency of crystalline silicon solar cells and expand businesses overseas.

Kyocera completed the expansion of its Mielse Plant and announced a plan to construct a new solar cell plant in Shiga Prefecture for the purpose of increasing the production capacity to 650 MW/year by FY2011.

SANYO Electric completed the construction of a 40-MW/year PV module plant in Shiga Prefecture and disclosed plans to increase the production capacity of a solar cell plant in Shimane Prefecture and a PV module plant in Mexico to 210 MW/year and 50 MW/year, respectively. SANYO also announced a plan to construct a plant in the USA for pulling single crystalline silicon ingot. As for production of thin-film silicon PV modules, SANYO agreed with Nippon Oil Corporation to establish a joint venture company. SANYO also agreed with Panasonic for the acquisition of SANYO by Panasonic.

Mitsubishi Electric plans to establish a production framework with the capacity of 600 MW/year by FY2011. Alongside that, Mitsubishi will enhance its global sales networks and is also considering the commercialization of thin-film silicon solar cells.

Kaneka revised up its plan to increase its domestic production capacity to 150 MW/year, along with construction of a new overseas production facility with the capacity of 200 MW/year. It has announced a plan to further increase production capacity to 1 GW/year by 2015.

Mitsubishi Heavy Industries (MHI) plans on increasing production capacity to 130 MW/year in 2010, and 250 MW/year in 2012.

Showa Shell Sekiyu is planning on construction of a facility with the production capacity of 1 GW/year. The company has tied up with **ULVAC** on the development of mass manufacturing equipment.

Hitachi withdrew from production of bifacial light-through crystalline silicon solar cells, and **Space Energy** has succeeded the business. Space Energy is preparing for full-scale production.

Fujipream has entered into a long-term supply agreement with **Schott Solar** of Germany in order to procure multicrystalline solar cells.

The production facilities of PV cell/module are now beginning to concentrate in 2 locations in Japan; the Kansai and Kyusyu regions. Related industries are also starting to announce the establishment of a stable supply framework of solar cells.

In the area of solar-grade silicon and wafers, manufacturers have been increasing production capacities and expecting growth of future demand for solar cells. In the area of silicon feedstock, **Tokuyama** has announced a plan to construct a production facility with the capacity of 3 000 t/year in Malaysia, and **OSAKA Titanium Technologies** and **Mitsubishi Materials** has also announced plans to construct new production facilities with capacities of 2 200 t/year and 1 000 t/year, respectively.

M. Setek, which entered into the business of polysilicon for solar cells, supplied for a Chinese solar cell manufacturer.

JFE Steel has announced a plan to enhance its production capacity of solar-grade silicon (SOG-Si) to 400 t/year.

Japan Solar Silicon is planning on producing 3 000 t/year of polysilicon, and through the future business merger of its parent company Nippon Mining Holdings, Inc. and Nippon Oil Corporation, is aiming at strengthening the business.

Due to an increase in thin-film silicon solar cell production, the demand for monosilane gas is also increasing. Accordingly, **Mitsui Chemicals** and **Tokuyama** will start a joint development project on manufacturing technologies.

Taiyo Nippon Sanso Corporation and **Evonik Degussa** of Germany are planning on constructing a joint production facility in Japan.

In the area of silicon wafers, **SUMCO** has constructed a new production facility aiming to achieve 1 GW/year production. **Space Energy** also increased production capacity to 8 million wafers/year.

Silicon wafer slicing companies such as **Ishii Hyoki, TKX** and **Shinko Manufacturing** are also enhancing production capacity, and **Kanematsu Corporation** has announced the establishment of a silicon wafer processing company.

Production equipment manufactures and related materials manufacturers backing up the PV industry are also enhancing their production facilities.

Ferrotec, in addition to entering the multicrystalline silicon furnace industry, has tied up with Tokyo **Rope MFG.** in the wire saw business in China.

In the area of BOS and production equipment for PV systems, many manufacturers have entered the PV industry, actively increasing production capacity and forming partnerships, as follows:

Fig.5 - Space Energy New Nagano Factory, 100kW (Shiga, Saku City, Nagano Prefecture) (photo RTS Corporation).

Glass: **Asahi Glass, Nippon Sheet Glass (NSG)**; EVA: **Bridgestone, Mitsui Chemicals Fabro, C.I. Kasei**; Back Sheets: **Mitsubishi Aluminum, Mitsubishi Plastics, Toray Industries, Toyo Aluminium, Toppan Printing, Lintec**; Electrodes: **Noritake**; Connectors for PV Modules: **Hosiden, Yamaichi Electronics, Honda Tsushin Kogyo**; Wiring Units: **Onamba**. These companies have entered the PV industry and are increasing production capacity of their products for PV applications.

In the manufacturing equipment industry, **Nisshimbo Industries** and **NPC** are enhancing the business of PV production lines, mainly for PV modules. **ULVAC, Tokyo Electron, Tokyo Ohka Kogyo** advanced its business to provide a thin-film silicon solar cell production line. Companies dealing with inspection and evaluation devices are also strengthening their operations.

In the PV system distribution industry, major pre-fabricated housing manufacturers strengthened partnerships with PV manufacturers and are committed to working on the full-fledged dissemination of residential PV systems. **Sekisui Chemical, Sekisui House, Daiwa House** and **Misawa Homes** offer energy-saving houses and condominiums equipped with PV systems. An increasing number of all-round trading companies have entered into introduction and power generation businesses using PV systems. **ITOCHU, Mitsui & Co.** and **Sumitomo Corporation** respectively announced plans to enter the PV business in Europe while **Mitsubishi Corporation** disclosed a plan to enter the PV business in Asia. Systematic introduction of PV systems by users has also been continuously promoted.

Backed by the government's strong message for a large-scale PV introduction and the eagerness of users for the introduction of PV systems for residential, industrial and electric utility sectors, a group of PV-related industries are strengthening their efforts for future growth.

MARKET DEVELOPMENT

Through the measures for introducing PV systems, implemented mainly by METI, the market development of residential PV systems and PV systems for public and industrial facilities has been advanced. Thanks to the government's 12-year support program for the dissemination of residential PV systems, the residential PV market has become the main PV market in Japan. Even after the support program was completed in FY2005, the number of installed PV systems has stayed at the level of around 50 000/year. In 2007, PV systems were installed on 49 425 houses with the total capacity of 177 MW, which increased the cumulative installations to about 400 000 houses and 1 458 MW, respectively at the end of FY2007. The number of installations as of the end of the second quarter of FY2008 is higher than that of the same period of FY2007. In the newly-built residential house market, pre-fabricated house manufacturers are enhancing efforts in the sale of houses that have environment-friendly functions with the introduction of measures for energy conservation and reduction of CO_2 emissions.

Consequently, housing manufacturers are promoting houses equipped with PV systems as standard equipment. In the PV market for existing houses, PV manufacturers are developing and establishing distribution channels consisting of local builders, electric contractors, electric appliances stores and roofers, etc., seeking for purchasers of residential PV systems all over Japan.

Under the field test projects, an increasing number of medium- to large-sized PV systems for non-residential use, such as for public and industrial facilities have been continuously installed. Opportunities for market expansion have been increasing in various areas such as applications, designs, installation sites, power generation capacity and introducers of PV systems, contributing to further market development of the non-residential sector. As for the installation sites, PV systems have been introduced to a wider variety of places including 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 more diversely installed at agricultural facilities (greenhouses), commercial facilities (shopping malls, family restaurants, large-scale retail stores), railway facilities (station buildings and platforms), road facilities (parking lots, expressway toll booths, interchanges), financial facilities (banks, etc.), transport

facilities (logistics centers, etc.) and resort facilities. 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. Under the NEDO's Field Test Project on New Photovoltaic Power Generation Technology in FY2008, a 22-kW PV system was installed at a housing complex as part of the application employing small-scale multiple grid-connected systems. A large-scale retail store company installed PV systems at six of its stores with the total capacity of 530 kW in Japan. As installations of several hundred kW-level PV systems on large roof areas of factories and warehouses are also on the rise, the market of large-scale commercial PV facilities started burgeoning. In terms of the size of installation, PV systems with the capacity of 100 kW or more account for 10 % of all the PV systems installed. In 2008, Electric Power Development (J-POWER) completed the construction of a 1-MW PV power plant. Electric utilities also plan to construct large-scale PV power plants with the capacity ranging from several MW to 20 MW. Further advancement of the large-scale PV power generation market is anticipated.

FUTURE OUTLOOK

The Japanese government made a cabinet decision on the "Action Plan for Achieving a Low-Carbon Society" based upon the "Fukuda Vision," a vision looking to the future of Japan, presented by the former Prime Minister Yasuo Fukuda. Under the action plan, the Japanese government set the national targets and measures for the innovative technology development, the dissemination of existing advanced technologies and for creating a framework to move the entire nation into a low-carbon society. For the PV power generation, the national target was set to increase the installed capacity of PV systems tenfold to 14 GW in 2020 and forty-fold to 53 GW in 2030 from the current levels. In order to achieve this target, the government announced its commitment to working on the following issues: i) drastic support measures for residential, industrial and public sectors, ii) development of innovative PV power generation technologies, iii) plans to construct mega-scale PV plants by electric utilities, iv) partnerships with local governments and promotion of collaboration between PV manufacturers and housing manufacturers, v) utilization of private funds such as Green Power Certificate and vi) development of technologies to stabilize grid connection. This cabinet decision is scheduled to be reflected in FY 2009 budget requests by each ministry and agency. Specifically, the Ministry of Economy, Trade and Industry (METI) decided to restart the subsidy program for residential PV systems which was terminated in 2005, with a commitment to getting re-engaged in achieving the full-fledged dissemination of residential PV systems as well as the cost reduction of PV systems starting in 2009. In this regard, METI started to accept application for a new subsidy program using the supplementary budget for FY 2008. The Ministry of the Environment (MoE) will also provide support for the dissemination of PV power generation though launching the following projects in FY2009: i) "Model project to create demand for Green Power Certificate in local communities" to achieve a low-carbon society, and the ii) "Project to promote the use of PV and other types of renewable energy." Moreover, the four ministries, namely the Ministry of Economy, Trade and Industry (METI), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Land, Infrastructure and Transport (MLIT) and the Ministry of the Environment (MoE) announced the "Action plan to disseminate PV power generation" to jointly promote the dissemination of PV power generation. Through these efforts, the Japanese government will further improve and strengthen the environment for the dissemination of PV power generation while developing measures for introduction and taking initiative in introducing PV power generation at their own facilities. The PV industry has been joined by various industries other than solar cell manufacturing industry. The materials industry dealing with silicon feedstock and other materials and component industries dealing with white reinforced sheet glasses, backsheets and other components for PV cells and modules started taking up technological developments and expanding their production capacities. The entire PV industry will actively promote activities to reduce costs of PV systems and develop applications. The housing industry, in cooperation with the PV industry, established the "Council on promoting solar housing" for full-fledged dissemination of residential PV systems for newly-built houses.

In addition, electric utility companies decided to promote the construction of PV power plants, including "mega-solar" MW-level PV power plants, in which Japan has been left behind by Europe and the USA.

As a result, the introduction of PV systems in Japan will get out of the stagnation of the past four years from 2005 to 2008. Starting from FY2009, the dissemination of PV systems will regain the momentum and a full-fledged dissemination will be promoted.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

JINSOO SONG, KOREA INSTITUTE OF ENERGY RESEARCH (KIER)

Fig. 1 - The 500 kW a-Si: H modules, produced by KISCO, installed in Haenam, the southern part of Korea.

GENERAL FRAMEWORK

Recently Korea's government has announced a long-term strategy with a motto of "Low Carbon, Green Growth" that will determine the direction of its national energy policy until 2030 and has also chosen 22 fields to be the focus of future growth engine projects, which can be categorized into 6 industrial sectors. Among them, the energy-environmental sector is including next generation PV cells, clean coal energy, ocean biofuel, carbon capture & storage, fuel cell power plant system and nuclear power plant. Under those programs by 2030, the use of renewable energy will increase to 11 percent from 2,4 percent in 2007. In 2008, an impressive progress has been made in the government budgets, PV dissemination, industry and R&D projects. The government renewable energy R&D budgets increased 119 % from the previous year. The new installed PV power systems have reached 42,9 MW in 2007 and the cumulatively 77 6 MW by the end of 2007. Under the 100,000 roof-top program, 7,313 systems with a total capacity of 9,245 kW were newly installed in 2007. The 119 new commercial PV power plants of 28,632 kW capacity were installed under the feed-in tariff (FIT) program. The many new companies have initiated business both in wafer based bulk silicon and in thin-film PV modules. The 25 new R&D projects have been initiated in 2008.

NATIONAL PROGRAM

Considering the Korea's current status in energy and environment and the importance of world's energy- and environment-related markets, Korea had announced a long-term strategy called "Green Growth" that would determine the direction of its national energy policy until 2030. According to this plan, Korea will reach its long-term energy goals by taking the following steps. (1) Improving energy efficiency and reducing energy consumption, (2) Increasing the supply of clean energy and reducing the use of fossil fuels, (3) Boosting the green energy industry, (4) Ensuring its citizens have access to an affordable energy. Under these steps for achieving the goals, renewable energy and its related industry will be taken an important part. By 2030, fossil fuel will account for only 61 percent of total energy consumption, down from the current 83 percent, while the use of renewable energy will increase to 11 percent from 2,4 percent in 2007.

In the renewable energy sector, the government will achieve a 44-fold increase in the use of photovoltaic energy, compared with the levels seen in 2007. The use of wind power will jump 37-fold, biofuels 19-fold, and geothermal power 51-fold. The government intends to achieve these milestones by stimulating domestic demand

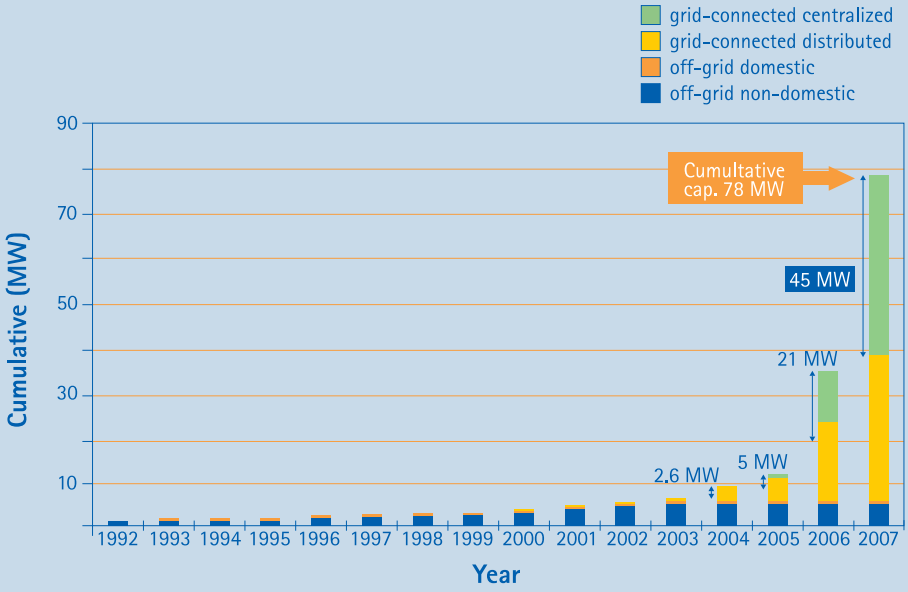

Fig. 2 - The cumulative installed PV power in 4 sub-markets.

and supporting the development of core technologies which include thin-film solar cells and large wind turbines. For domestic demand, the introduction of the Renewable Portfolio Standards and the enforcing increased use of renewable energy in public buildings will be included.

For boosting the green energy industry, the government will invest KRW 11,5 trillion in research and development into green technology. It will also establish a large-scale integrated test bed for green technologies and encourage energy-related national corporations to purchase green technologies. It is estimated that the green energy industry will create about 950,000 new jobs.

Besides establishing new long-term strategy for sustainable development, on Sept. 22 the new government has published the plans to develop new growth engines that will power the country's economy in five to ten years in the future. The plans include the visions for 22 industries in six area, including energy and environment, IT convergent industries and knowledge-based services. Among them, the energy-environmental sector is including next generation solar cells, clean coal energy, ocean biofuel, carbon capture & storage, fuel cell power plant system and nuclear power plant. The government confirmed to invest KRW 99,4 trillion in 22 tasks for new growth engines for the next five years.

In next generation solar cells, second and third generation solar cells such as Si, CIS thin films, dye-sensitize and quantum dot solar cells will be mainly developed and invested. Main tasks in solar cell sector are setting up large-scaled production system of thin film solar cells, developing the core technology of third generation solar cells and constructing the very large scale PV (VLS-PV) power plant. All tasks will be taken a lead by private companies coinciding with the government's active support to the R&D projects. After completing these tasks, it is hoped that $26 billion in exports, $7,4 billion added value and 300,000 new jobs will be created by 2018. In addition, carbon dioxide emissions will be reduced by 14,3 million tons and secure 4,5 million TOE of energy.

RESEARCH AND DEVELOPMENT

The government budgets in 2008 for renewable energy R&D were 241 billion KRW, which is a 119 % increase from previous year. The PV R&D budgets in the same year were 19 billion KRW. The 25 new projects have been initiated under the five R&D sub-program categorized into "Strategic R&D", "Basic & Innovative R&D", "Core Technologies Development", "Demonstration" and "International Joint Research". The 6 "Strategic R&D" projects are implemented with the subject of high efficiency and low cost bulk silicon solar cells and production equipments, poly-silicon production equipments, silicon and CIGS thin-film solar cells. For the short-term commercialization, the 6 "Core Technologies Development" projects have been initiated in the field of poly-silicon feedstock, AC modules, inverters and module materials. The 11 "Basic & Innovative R&D" projects have been supported to the university and research institutes in order to develop long-term breakthrough technologies especially focused on solar cells and materials. The 2nd generation thin-film and 3rd generation polymer and nano-based solar cells will be developed through this project.

INDUSTRY STATUS

Production of Feedstock and Wafer: After successful commercialization of poly-silicon feedstock in 2006, Dongyang Chemical Co., (DCC) has expanded their annual production capacity up to 5,000 ton in 2008. Many other companies, KCC corp., LG Chem. Co., Samsung Petrochemical Co., etc., have been considering production of poly-silicon feedstock. In the wafer area, more than 8 companies including Woongin Energy Co., Nexolon Co., has started production of single and multi crystalline silicon wafers. The annual production capacity reaches to 400 MW.

Fig. 3 - Asia's largest PV power plant with capacity of 23,95 MW in Shinan, the southern part of Korea. The systems are operated by horizontal axis tracking mode. It has started commercial operation from November, 2008.

Production of Photovoltaic Cells and Modules: In 2008, KPE completed their third manufacturing line of 50 MW and currently had largest production capacity of 96 MW in Korea. As a new company, Sinsung Holdings, STX Solar, Hyundai Heavy Industry and Millinet Solar have started production of multi crystalline silicon solar cells with capacity from 30 to 50 MW. The total annual production capacity in c-Si solar cells as of the end of 2008 reaches to 300 MW in Korea. The two new companies, KISCO and Alti-Solar, have successfully completed production line of a-Si thin-film modules with 20 MW capacity for the first time in Korea. Many other companies are concerned about thin-film PV including silicon and CuInGaSe2.

IMPLEMENTATION AND MARKET DEVELOPMENT

The cumulative installed power of PV systems in Korea tremendously increased to 77,6 MW by the end of 2007. Annual installed power in 2007 has reached 42,9 MW, which was more than two times higher than that achieved in the previous year. The share of grid-connected distributed system increased to 92 % of the total cumulative installed power form 83 % in the previous year. Whereas the grid-connected distributed system shows a sharp increase in the share of installation, the cumulative share of off-grid non- domestic and domestic system decreases to 8 % of the total cumulative installed power because there is no increase in annual installed PV power of the off-grid systems in 2007. Although the off-grid non-domestic sector has been major market in Korea until 2002, it is no longer an interesting area of major PV module manufacturers and system companies. In 2007, under 100,000 roof-top program, 7,313 systems with a total capacity of 9,245 kW were installed for single-family houses and public rental apartments. Under the feed-in tariff (FIT) scheme, 119 new commercial PV power plants of 28,632 kW in total ranging 3 kW – 3 MW were operating. Among them large scale-PV systems exceeding 1 MW were thirteen. In 2008, it is expected that the capacity of new installed PV power plant will increase significantly compared to the previous years due to the increased cap of FIT. Figure 2 shows the picture of Asia's largest tracking PV power plant with 23,95 MW in southern part of Korea beginning to operate on Nov. 2008.

FUTURE OUTLOOK

For the last two years, Korea has recorded rapid growth in the PV industry. The value chain in the 1st generation solar cell has been accomplished. The exiting and new companies have reported expansion plans of their production capacity of poly-silicon feedstock, ingots & wafers, solar cells & modules and production equipment.
The 2nd generation thin-film solar cells have been successfully commercialized in 2008. The many companies have been considering business entry in the field of silicon, CIGS and dye sensitized solar cells. Under the new government's long-term strategy with a motto of "Low Carbon, Green Growth", the solar cell industry will be nurtured as the new growth engine that can replace the semiconductor and display industries which are main export products of Korea.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS IN MALAYSIA

BADRIYAH ABDUL MALEK, MINISTRY OF ENERGY, WATER & COMMUNICATIONS (MEWC)
IR. AHMAD HADRI HARIS, MALAYSIA ENERGY CENTRE (PTM)

GENERAL FRAMEWORK

Under the 9th Malaysia Plan (development period of 2006 to 2010), the Government of Malaysia targeted renewable energy (RE) to contribute 350 MW of the total power generation capacity, which would mainly be from biomass wastes and biogas derived from palm oil mills. Solar photovoltaic (PV) was identified to provide electricity to the rural communities through solar hybrid technology while grid connected solar PV applications are to be promoted under the plan period. The national development on grid connected PV and BIPV applications are undertaken under the Malaysia Building Integrated PV (MBIPV) project. Under the National Budget 2008, companies are allowed to claim for Investment Tax Allowance (ITA) in addition to the normal Capital Allowance (CA) on their investments for PV systems at their own offices. In addition, the National Budget 2009 has extended import duty and sales tax exemption to PV systems for use by third parties.

The key stakeholders responsible for national PV development are the Ministry of Energy, Water and Communications (MEWC); the Malaysia Energy Centre (PTM); Energy Commission (ST); the Malaysian Industrial Development Authority (MIDA); the Economic Planning Unit (EPU); the Ministry of Finance (MOF); Tenaga Nasional Berhad (TNB - electricity utility); Sarawak Energy Berhad (SEB - electricity utility); and Sabah Electricity Sdn Bhd (SESB - electricity utility).

Public perception on grid connected PV systems has gained wider awareness since 2006 due to efforts implemented under the MBIPV project. However, the spread of awareness is not even throughout the country, where the greatest awareness concentration lies within the Kuala Lumpur Valley. The public perception of PV systems in general is still largely influenced by stand alone PV systems in rural applications which have existed long before grid connected PV systems. As a result, the public may still associate PV systems with the requirement for batteries, and they are also unaware of the potential for BIPV applications. For those who are familiar with grid connected PV systems, the high investment cost of the system is still the greatest barrier for widespread public adoption. The highly subsidized electricity tariff rates coupled with lack of environmental consciousness further add to the barriers for local PV investment.

NATIONAL PROGRAMME

The Government of Malaysia launched the MBIPV project in July 2005 in order to reduce the long-term cost of BIPV technology application through a widespread and sustainable BIPV market development. The MBIPV project targets to increase grid connected BIPV capacity by 330 % and reduce the system cost by 20 %, against the baseline set in 2005. The MBIPV Project is implemented under four main strategic thrusts: (i) awareness and capacity building (ii) market development (iii) policy development (iv) industry and technology development. 2008 is the third year of the MBIPV project where most of the implemented activities are beginning to show their results.

Fig. 1- Semi-transparent BIPV system at atrium of PTM-ZEO building.

Separately, the Government of Malaysia is also implementing several programmes on rural electrification using solar hybrid systems. This includes the SchoolNet project which provides electricity to power computers at rural schools, and allows rural schools and communities to be electrified for 24 hours daily. Overall, more than seventy schools in Sabah benefited from the solar hybrid programmes in 2008.

R&D, D

The five major areas of R&D in PV conducted by universities in Malaysia are inverters, PV concentrators, cells including thin films, hybrid systems and energy conversion tracking system. The inverter R&D is developed for tropical climate conditions with the objective for commercialisation. R&D on PV cells, thin films and concentrators by the universities are at the moment still at fundamental or applied research stage. The key six universities in Malaysia involved in PV are Universiti Teknologi Mara (UiTM), Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM), and Universiti Islam Antarabangsa (UIA). Most of the research is funded by the Ministry of Science, Technology and Industry (MOSTI) under the National Science and Techno Funds.

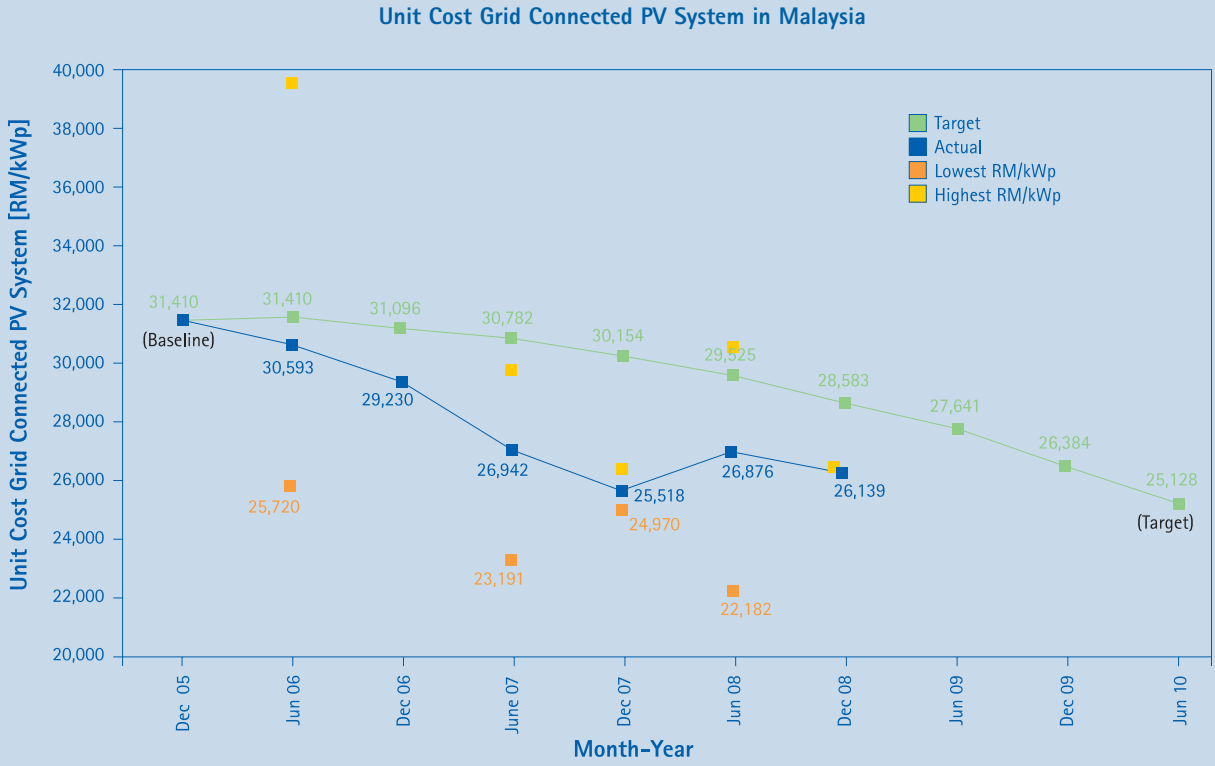

Fig. 2 - Trend of cost reduction of grid-connected PV systems.

IMPLEMENTATION

Malaysia Energy Centre (PTM) which administers the MBIPV project has taken and led on various initiatives to enhance PV deployment in Malaysia. For the grid connected PV application, PTM has enhanced public awareness on the BIPV added values, facilitated the interconnection procedure with the power utility, enhanced the PV system quality, and assisted the local PV industry. Currently, the grid connected PV systems are allowed to be connected to the utility distribution system at the low voltage level on a net-metering basis. The performances of all PV systems implemented under the MBIPV project are also being monitored to further promote public awareness and confidence, as well as improving the systems quality. Currently there is no special loan scheme available for the public to invest in PV systems. The feedback from the financing sector indicates that the local PV market is too miniscule to warrant formulating a special loan package for homeowners. Nonetheless, some local banks are willing to finance grid connected PV systems under a refinancing package of the respective home loans.

TABLE 1 – MAJOR PV FDIS IN MALAYSIA

COMPANY	PRODUCT	INVESTMENT (MYR)*	NAMEPLATE CAPACITY	JOBS CREATION	STATE	STATUS
First Solar	CdTe Modules	2 billion	704 MW	1 200	Kedah	In operation
Q-Cells	Solar cell, wafering & ingot	5 billion	350 MW	3 500	Selangor	Under construction
Sunpower	Solar cell, wafering	5 billion	1 000 MW	5 500	Malacca	Under construction
Tokuyama	Polysilicon	1.8 billion	3 000 tons	500	Sarawak	Planning
Renesola Malaysia	Reclaiming silicon through recycling		1 000 tons		Johor	In operation

** 1,0 MYR = 0,2051 EUR = 0,2887 USD (as at 31 December 2008, middle rate)*

Fig. 4 - Grid-connected PV housing community at Setia Eco-Park, Selangor.

INDUSTRY STATUS

The local PV service industry development is administered by PTM through a voluntary scheme called Approved PV Service Provider (APVSP), whereby the PV companies are required to fulfil various quality checks in order to be given an annual license and to be listed in PTM directory. By end of 2008, there were 8 companies registered as APVSP and they have collectively installed more than 125 kW of grid connected PV systems.

By the end of 2008, there were also five major foreign direct investments (FDIs) in PV manufacturing in Malaysia (see Table 1).

MARKET DEVELOPMENT

As at end of 2008, Malaysia has cumulative total installed grid connected PV capacity of approximately 740 kW and off grid PV capacity of about 8 MW. The off grid PV applications serve mainly rural electrification and non-building structures and are almost fully funded by the Government of Malaysia. Under the strategic thrust for market development in the MBIPV Project, financial incentives in the form of capital grants are provided for members of the public and companies to install grid connected PV systems at their houses and office buildings. The most significant of these incentives is the SURIA 1000 which provides capital grants on a bidding basis every six month starting from December 2006 to April 2010. SURIA 1000 incentives are awarded to those who require the least financial support from the Government on MYR per kW unit basis. Results and trends of the SURIA 1000 programme indicates that the public willingness to pay for the PV systems has increased from 38 % in 2007 to 58 % at the end of 2008.

FUTURE OUTLOOK

The Government of Malaysia has revised the gross domestic product (GDP) forecast to 3,5 % for 2009, which is down from a 5,5 % to 6,0 % of the past few years Malaysia due to the recent global economic crisis. The market outlook on consumer spending is predicted to reduce for 2009 and 2010 and this could potentially affect public's willingness to pay for PV systems and may affect the SURIA 1000 initiatives.

Fig. 3 - First Solar Inc manufacturing plant in Kulim, Kedah.

Currently, the local PV industry is still in its infancy and so far has not reached a size where the global credit crisis or other macro factors will cause an impact. For the local business communities and State investment agencies, PV is still a new and exciting industry, where many parties are identifying their respective opportunities as well as to benefit from the arrival of five global leading PV enterprises in Malaysia. These five companies offer significant business opportunities along the supply chain and have also created an attractive 'next-door' business environment to the local businesses.

MEXICO

PV TECHNOLOGY STATUS AND PROSPECTS IN MEXICO
JAIME AGREDANO, J. M. HUACUZ
ELECTRICAL RESEARCH INSTITUTE (IIE)

Fig. 1 - 174 kWp PV Grid-Connected system on the roof of a supermarket store (photo Wal-Mart Mexico).

GENERAL FRAMEWORK

As in many other economic activities around the world, the PV industry in Mexico is facing the global financial crisis. During 2008, the PV installed capacity continued with the same smooth growth trend shown in recent past years. The growth rate of the Mexican market remains steady at around 1 MW/year. In the same period, the implementation of government programs related with the use of renewable energies reported delays. Nevertheless, training activities in grid-connected PV were carried out regularly

NATIONAL PROGRAMME

After several months of discussions in the Mexican Congress, the long awaited 'Law of Use of Renewable Energy and Financing of the Energy Transition' was released. The objective of this law is to regulate the use of renewable energy and clean energy technologies for electricity generation, stating that the use of renewable energy is a public interest matter.

The next step to implement the law is to define and promulgate the corresponding rules. It is expected that specific criteria for all the renewable energy sources become incorporated in these rules, including those related with research promotion and technology development.

Regarding the program of rural electrification with renewable energy for communities located in southern Mexico no actions were undertaken during 2008. However, some relevant projects might be launched during the first semester of 2009. As a remark, the Agriculture Ministry continues supporting and financing projects related with productive uses of renewable energies mainly through PV systems.

RESEARCH AND DEVELOPMENT

Academic research activities related to PV materials continue in progress. Notably, more research efforts are being focused on thin film photovoltaics through collaborative actions between Mexican and European research groups. The Electrical Research Institute has recently finished the construction of a 1-kW prototype inverter for grid-connected PV systems.

In June 2008, Q-Cells announced the investment of up to 3 500 MUSD for the construction of a manufacturing plant in the northern border city of Mexicali. The plant production will supply PV modules for both the USA and the Mexican market. PV systems follow-up continued through data gathering and processing as well as system evaluation.

Particularly, in the Electrical Research Institute (IIE) PV-related research continues. In 2008 some studies were carried out to estimate the penetration limits for PV electricity in a distribution zone of northern Mexico. Also, studies on applications for provision of PV-energy-based services were developed for isolated communities.

Fig. 2 - 10 kWp Grid Connected System in a house (photo Cryplant).

Fig. 3 - Two 0.66 kWp Water pumping systems (photo Cryplant).

IMPLEMENTATION

The Mexican government launched a study to provide solar roofs for around 350 houses in the southern state of Chiapas. If the project is approved, 1-kW peak of PV electricity per house would be provided, representing the biggest PV solar roof cluster in the country. The project is at the planning stage and could be implemented within a short term.

The currently largest PV roof-mounted system in Mexico was installed at the end of 2008 in the city of Aguascalientes. The system was installed on the roof of a supermarket store and was designed to provide around 20 % of the electricity needs of the building. In April 2008, the first Workshop on Financing Mechanisms for Grid Connected PV Systems was held. The aim of the workshop was to bring together national financing and development agencies as well as international financial firms with major players of the PV industry in Mexico (mainly system integrators and installers). During the workshop some of the financial companies supporting projects in the California PV market shared their experiences and business vision.

The actions of the PV Grid Connected Project GEF/PNUD-IIE were focused on technology promotion, regulatory issues, and people training. Two diploma courses on PV grid-connected systems were offered during 2008 with an enrollment of more than 50 people. Course participants included project developers, members of PV industry associations, investors, industry professionals, and energy commission representatives of several Mexican states.

During November 2008, a workshop that focused on promoting the use solar energy, energy efficiency techniques, and roof mounted PV systems was held in the city of San Miguel de Allende in Guanajuato State. The workshop was organised by a group of enthusiastic solar energy practitioners and promoters. People from this town are pursuing to transform the city into the first Mexican solar city.

MARKET DEVELOPMENT

The Mexican Association for Renewable Energy Providers (AMPER, Spanish acronym) estimates that the Mexican PV market size was around 1 MWp for 2008. No precise information about market segmentation has been given, but it is estimated that the grid-connected PV systems share surpassed 20% of the total PV installed power. By the end of 2008, the cumulative PV capacity installed in Mexico was around 21,7 MWp.

Fig. 4 - Two 0.64 kWp Water pumping systems (photo Cryplant).

FUTURE OUTLOOK

Wal-Mart Mexico has plans to continue with the installation of more grid-connected PV systems in Mexican supermarket stores. The on-grid PV colloquiums and financing workshops will continue during the coming years in order to foster the technology, to disseminate key information, and to strengthen the PV industrial segment in Mexico. Grid-connected PV training activities will also continue under the umbrella of the GEF/UNDP-IIE project.

Once the application rules of the 'Law of Use of Renewable Energy and Financing of the Energy Transition' become promulgated, the number of PV systems will be increased both in number and installed capacity.

Activities of the new rural electrification effort of the Mexican government will begin in 2009 where PV technology will be playing the major role.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS
OTTO BERNSEN, SENTERNOVEM, WILLEM VAN DER HEUL, MINISTRY OF ECONOMIC AFFAIRS

Fig. 1 - Marnix ten Kortneaar researcher and founder of the company DR TEN which was granted a NEO project in 2008.

GENERAL FRAMEWORK

The goals of the Dutch government remained unchanged during this cabinet period and aim at an annual energy consumption reduction of 2 %, a reduction of CO_2 emissions of 30 % by 2020 (compared to 1990) and a contribution of 20 % of renewable energy to the total primary energy consumption in 2020. Following these ambitions, the government initiated the so called Clean and Efficient program, under which a new market implementation program, called SDE (Subsidy for Sustainable Energy) was launched in April 2008.

Within the existing Energy Transition Plan a specific paragraph is dedicated to sustainable electricity and to decentralized energy sources, including solar energy. In the Netherlands, the emphasis of the government effort still lies on biomass and wind generated energy and specifically wind at sea which will contribute relatively more to the policy goals in the short and mid term. The solar energy market is expected to pick up substantially after grid parity is reached in northern Europe. That moment depends also on energy prices and the development of new technologies. Until that time government subsidies like the SDE remain necessary to stimulate demand for solar power installations.

In July 2008, a new impulse to the energy transition was given by the Innovation Agenda for Energy. In the period 2008-2012, a total amount of 438 MEUR will be available for innovative investments which will have to be matched by corporate investments. About 9 MEUR of the first tranche (from about 200 MEUR) will go to photovoltaic demonstration projects on the integration of PV in the build environment.

NATIONAL PROGRAMMES

In April 2008 the SDE subsidy scheme for solar energy was launched for small scale PV installations with an initial subsidy tariff of 33 EURcent for every kWh (on top of the fossil electricity price) delivered to the national energy grid for a period of 15 years. This feed in premium will be adjusted every year according to changing energy market prices. The total new power to be installed in this Cabinet period (2008-2011) is expected to be 78 MW, on top of the 60 MW installed end 2008. The aim of the SDE is to promote roof top PV installations between 0,6 kWp and 3,5 kWp. Larger PV-installations (up to 100 kW) are expected to be subsidized in 2009. Another goal of the subsidy scheme is to prepare the different local market players for a larger domestic roll out in the future. Not only more efficient and cheaper solar systems contribute to the wide spread roll out of PV but also more efficient installation practices and standardization of products will lower the initial costs.

The government support scheme for R&D activities in future renewable energy technologies (PV, fuel cells, etc.) has also been unchanged. It is organized in four EOS (Energy Research Subsidy) programs, and one Transition Program, which together cover the full spectrum from fundamental new ideas and fundamental research to demonstration:

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

In 2008, new national R&D projects in solar energy were granted in all categories of the EOS program with the exception of the demonstration facility. Three additional projects have been granted in the joint European Eranet Polymol call. The total combined budget of EOS and ECN going to PV R&D activities in 2008 fell just short of 12 MEUR.

In 2008, a research program on "Thin Film Nanomanufacturing" also had its kick off. Although it is not focused on solar cells in particular it is relevant to the PV sector. The program is funded by the foundation for technical and scientific research (STW).

Fig. 2 – A new PV installation in the suburbs of Heerhugowaard, the Netherlands (photo Hans Pattist).

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2008, 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).
- Improving cell production processes, using new cell concepts and new or improved production technologies.
- Improving the efficiency of future generation cells through hetero-junctions and up- and down conversion of photons.

The main players in the fundamental Dutch research activities are the National Institute for Energy Research ECN, the universities of Utrecht, Eindhoven, Nijmegen, Wageningen, Groningen, Delft, the National Institute for Technology TNO and FOM-AMOLF. The following companies have their own research capacity in this field and projects going on:
Solland Solar, Scheuten Solar, NUON/Heliantos, Mastervolt, OM&T/Moserbaer, APA (advancedPhotovoltaicApplications) and subsidiary AST (Advanced Surface Technologies).
ECN and the Holst Center (open innovation initiative of TNO in the Netherlands and IMEC in Belgium) have signed an agreement in 2008 to offer a joint research program on roll-to-roll organic photovoltaics to the industry. The aim of the program is to transfer lab-scale processes to low-cost, large-area processes compatible with roll-to-roll production.

In 2008, the Solar Academy started offering courses and training for managers, engineers and operators working in solar cell manufacturing. The initiative was founded by ECN, Solland Solar, the Industry bank of Limburg (LIOF) and the Institute of Semiconductor Electronics RWTH at Aachen University in Germany.

The PV-ERA-NET Joint Call for Polymol solar cell research resulted in three granted research projects with Dutch participation with a modest total budget of 345,000 EUR. New research relations were established with Swiss, Swedish and British universities.

At the international level Dutch PV RTD centers and industries collaborate in several networks and ongoing projects. In 2008 there was a specific call in the European Seventh Framework Program for "Novel Materials for Energy Applications" with a strong Dutch participation of ECN and the other universities in international projects such as NanoPV (University of Groningen) and SolarDots (University of Eindhoven). However, not all results of the calls in 2008 are presently available. In the call for "future emerging technologies" the University of Leiden runs the project "Artificial Leaf" about artificial photosynthesis.

INDUSTRY STATUS

Business has been booming in the first part of 2008 for the PV industry. But with a strong down turn in demand at the end of the year due to the worldwide financial crisis. For fast growing and innovative companies in particular, it has become increasingly difficult to finance their expansion and maintain their research efforts. The government is looking for ways to minimize the effect on this emerging industry and on reaching the policy goals. Allthough the Dutch PV sector has not been spared the consequences of the crisis there are also a number of companies who have successfully expanded their business in the solar energy market in 2008. Examples are the engineering companies OTB and DHV who have set up specific divisions for solar energy and developed new products or services.
Both are strongly export oriented and have closed deals in emerging markets. E-Concern has successfully expanded its business in Italy during 2008.

The solar cell production in the Netherlands has been modest but steadily growing. Production data over 2008 is expected later this year. The major players also involved in R&D projects are Solland Solar, Scheuten Solar, NUON Heliantos, RGS Development and APA which has started a small CIS factory in the province of Frisia in 2008. Some of these production lines are experimental and most of the production is for export, especially for the German market.

Fig. 3 - PV facades on governmental building in Utrecht, project by Oskomera. http://www.oskomera.nl/projectpage.php?pid=114

DEMONSTRATION PROJECTS, IMPLEMENTATION AND MARKET DEVELOPMENT

After a promising start around 2000 the installation of PV dropped in the years 2006 and 2007 to an average growth of 1MW per year according to the CBS statistics http://statline.cbs.nl/statweb/.

That amount of PV installed in the Netherlands will rise again substantially from 2008 onward but how much exactly remains to be seen. The effects of the new SDE incentive in the Netherlands are not neccesarily immediate. The recipients have the option for installation of the PV systems during a limited number of years.
Therefore a considerable part of the budget granted in 2008 may not be spend in that same year. The budget granted in 2008 corresponds according to ECN to 18 MW. ECN advises the Ministry every year concerning the amounts and prices for the feed in tariff.

Large demonstration projects and implementation are ongoing in cities like Amersfoort and Heerhugowaard (see Fig. 2) for example.

FUTURE OUTLOOK

It is expected that the annual growth of PV installed in the Netherlands will rise structurally due to the SDE subsidy scheme. How much exactly and when remains to be seen. There are several factors in play and consumers have the option to use the grants in later years or not at all. After an evaluation of the SDE subsidy scheme in 2008 an expansion of the upper limit of the PV systems will most likely be allowed up to 100 kwp for a part of the total budget available each year.

The effects of the financial crises have a major impact on the sector but it is too early for an evaluation. There are several and sometimes contradictionary effects and every companies responds differently. There may even be newcomers to the solar energy field that look at sustainable energy sources as a way forward in times of crises.
The role of the government in this situation is under discussion also in an international context and several "recovery plans" are underway.

The research efforts in PV are expected to remain at the same basic level the coming years with possibly targeted actions on specific topics. In 2009 a call will open with funds from the "Innovation Agenda" that will target the integration of PV into the built environment.

The Netherland hope to maintain its excellent research position but that will be exceedingly hard with developments on other continents like Asia and North Americawhich are gearing up.

The market for PV will probably become more divers and in the coming years and more (university) spin offs are expected that will target niche markets for PV in mobility, consumer electronics and textiles.

Finally the bilateral collaboration with the neighbouring NordRhein-Westfalen (NRW) in Germany and Flanders in Belgium remains important and will be strengthened with photovoltaics as an important action line.

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
HARALD RIKHEIM, STATKRAFT AS

Fig. 1 - Production facility of Elkem Solar in Kristiansand under construction (photo Elkem Solar).

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 and heat pumps as substitutes to electric space heating.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001. With annual budgets of 150-200 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. Consequently, 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 (NRC) funds industry oriented research, basic research and socio-economic research within the energy field, including renewable energy sources. Another NRC programme within new materials and nano technology ("Nanomat" www.nanomat.no) also supports fundamental research tied to development of new materials of relevance for future PV solutions. The total funds for PV-related R&D projects were approx. 56 MNOK for 2008. 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.

RESEARCH AND DEVELOPMENT

Research activities on PV in Norway are focused on issues relating to silicon feedstock for crystalline cells and wafer- and cell-production technologies. Minor activities deal with system integration issues.

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

- **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. PV-systems activity is linked to research on distributed renewable energy hydrogen systems.
- **University of Oslo (UiO)**, Faculty of Mathematics and Natural Sciences: The Centre for Materials Science and Nanotechology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.
- **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 (UiA):** 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.

Institute for Energy Technology (IFE) is an autonomous research foundation with about 550 employees. (IFE), near Oslo, is working on R&D tied to solar cell production technology. This includes process development, characterization and optimization. The work is done in close relationship with the Norwegian industry. IFE also works

Fig. 2 – PV system above a fjord close to Geiranger. A large number of cruise ships visit here every summer. This PV system provides monitoring equipment with electricity; large cracks in the mountain may eventually lead to a gigantic landslide, and are consequently monitored. (photo GETEK AS).

Fig. 3 - A telecom installation (photo GETEK AS).

with PV applications, focusing on stand-alone systems. System technology and advanced storage systems are main parts of this activity. About 25 people are involved with PV activities at IFE, with an annual budget of 25-30 MNOK. IFE has a full inline solar cell processing line for crystalline silicon solar cells. IFE also has its own research production line for Si-based PV cells. IFE also has a fully equipped characterization laboratory, in which optical, electrical and structural properties for PV cells may be tested.

University of Oslo (UiO), The Centre for Materials Science and Nanotechology (SMN). New materials for solar cells and for utilization /transport of electricity, is a focus point for activities in photovoltaics and semiconductor physics. SMN holds relevant and high level expertise in semiconductor physics, Si-components, defect chemistry /physics, materials chemistry, thin film technology, theory and modeling. This competence will help developing Si-based solar cells of more conventional design towards higher energy efficiencies, and it provides the materials science basis for very high energy efficiencies in third generation solar cells. Among materials/components in focus are ZnO and SiC. The activity at SMN spans from synthesis by means of CVD to characterization, components and theory.

NTNU (Norwegian University of Science and Technology)
NTNU's solar cell research is mainly carried out by the PV-Solar Cell Materials Gemini Centre. Researchers are working on issues that range from quartz feedstock, to the production of metallurgical grade and solar cell grade silicon, to casting, wafer sawing and the characterization of materials, along with the development of third generation solar cells.

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 framework of Task 10 "Urban Scale PV Applications", Subtask 2: "Planning, design and development", Norway is responsible for developing a computer based tool for analysing the integration of PV in the built environment.

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, universitites and research institutes. Here can specifically be mentioned the strategic targeted project FoXy within the 6th framwork which is coordinated by SINTEF and has a wide range of participants from across Europe.

Agder University in southern Norway has a 20 kW photovoltaic array used for demonstration of an integrated energy system and long term measurements of different kinds of PV modules.
A PhD-programme in End Use of Photovoltaic Technology, is planned in partnership with Elkem Solar. The programme will be financed also 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.

Through the start-up of a bachelor programme in renewable Energy in 2008 also focused on PV-technology, the link between PV research and educational programmes is strengthened.

IMPLEMENTATION

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

In the 1990, 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,

Fig. 4 - A hydrogen filling station for automobiles, built by Norsk Hydro, now Statoil Hydro. It's located not far from the REC factory at Heroeya, near Porsgrunn in southern Norway (photo GETEK AS).

the Norwegian Coastal Administration made approximately 1840 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. The cumulative installed PV power capacity owned and operated by the Coastal Administration is approximately 230 kW.

Norway does not have any incentive schemes supporting the installation of PV systems. The absence of such schemes may explain why no large grid-connected PV-systems were built in 2008.

INDUSTRY STATUS

Elkem Solar (ES) 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 (Elkem Solar Silicon®) has been tested thoroughly by one of the main customers, Q-cells. The obtained solar cell efficiencies are similar to what is obtained with polysilicon and Q-cells has decided to use Elkem Solar Silicon® as a 100 % product. From being a research organisation, ES is now building up production capabilities. 4 000 MNOK is being invested in a industrial production plant. The plant started commissioning end of 2008 and will ramp up production during 2009. Total capacity will be about 6.000 tons Si and the plant has 259 employees.

Renewable Energy Corporation (REC) REC has business activities throughout the entire PV value chain. 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 and engages in project development activities in selected segments of the PV market.
In June 2008 REC decided to invest up to NOK 400 million to upgrade and extend the existing production capacity at the Herøya manufacturing complex by approx. 100 MW. That should ensure total wafer production out of Norway of around 1.75 GW in 2011. In addition to the capacity contribution, the investment will also cover an upgrade of the plants (referred to as Herøya I and II) to enable the implementation of next generation wafer and wire thickness levels. In 2007, REC Group had revenues of 6 642 MNOK and an operating profit of 2 588 MNOK.

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 opened it's wafer production facility in Aardal, in western Norway in June 2008. The annual 'phase one' capacity of approximately 130MW. Through an agreement with the Finnish company Okmetic, NorSun has secured access to key technology and expertise in mono-crystalline silicon ingot pulling, which will be utilized at the Aardal plant. Norsun also opened a manufacturing facility in Vanta, Finland. (Aug 2007), and has furthermore decided (March 2008) to build a third production facility in Singapore. In January 2008, NorSun signed a joint venture agreement with the Saudi Arabian companies Swicorp and CDC with the aim to establish a JV polysilicon manufacturing facility in Jubail, Saudi Arabia.

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. In 2008, the company's factory in Kristiansand, Norway has been upgraded, and at the end of 2008 the factory in Yangzhou comes on-line. This factory is a result of a contract with Jiangsu Shunda Semiconductor Development Co., Ltd. for SiC slurry recovery. In 2010 a major Metallkraft plant in Singapore starts serving REC ScanWafer with the Metallkraft recycling services.
In May 2008, Metallkraft and NorSun signed an agreement on recovery of spent cutting fluids from NorSun's solar wafer manufacturing plant in Årdal, Norway. The approximately 100 MNOK contract has an initial duration of four years.

Fesil Sunergy AS. Fesil Sunergy AS was established late in 2006 by Delta Sunergy BV, Delta N.V. and Fesil Venture AS. The company is planning a 150 MNOK pilot plant for production of solar grade silicon in Trondheim, based on its SOLSILC process. The plant will start production in third quarter 2009. Meanwhile, the company is also planning a full scale production plant at Orkanger near Trondheim. Initially, this plant will have an annual capacity of 3 000 tons of solar grade silicon per year.

PORTUGAL

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

Fig. 1 - DoubleSun Technology (photo WS Energia).

Fig. 2 - CPV with Fresnel concentrating optics (photo MagPower).

GENERAL FRAMEWORK

During 2008, there was no significant change on the general energy policy framework. Promoting Renewable Energies in Portugal is still a priority, 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 %. In 2008, the contribution of renewables was already 42 %. The 45 % target will be reached mainly through wind power (about 5 000 MW by 2010, currently 2 800 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).

A feed-in tariff mechanism is the main instrument for promoting renewable electricity. There are currently two different frameworks: the traditional Independent Power Producer (IPP) law, in force since 1988, and the micro-generation scheme, launched in November 2007.

Under the IPP framework, the feed-in tariff is applicable until a certain capacity target is reached (150 MW for PV), is guaranteed for 15 years and varies according to the installed power and type of system (BIPV or not) – see table 1. However, this framework is currently suspended.

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

The micro-generation framework, also known as "Renewables on Demand," was fully operational in March 2008. This system is specially designed for electricity consumers and consists of two regimes:

- The general regime, which is 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 is the same as the regulated tariff (true net metering), as defined annually by the national Energy Regulator.
- The special regime, which 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 benefits from 70 %, hydro and biomass from 30 %. The feed-in tariff is guaranteed for the first 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 according to the above described rule.

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 micro-generation management is supported on a web-based platform (www.renovaveisnahora.pt). Registrations are opened once per month. After registration, fee payment (250 EUR), system installation and technical audit, the micro-generator gets the permit to connect the system to the grid and start operation. The micro-generator has an export meter with remote telecoms, which sends the production figure to the electricity supply company on a monthly basis. This export figure, combined with the tariff rate for the micro-generation employed, establishes the export credit for the micro-generator. The customer receives a bill for the total of the import charges, less the export credit. Besides this schemes, other market development mechanisms for renewables include VAT rate of 12 % on renewable equipment, custom duties exemption and income tax reductions (up to about 800 EUR for solar equipment).

Fig. 3 - 45,6 MWp Moura power plant (photo Acciona Energy).

Fig. 4 - Moura PV assembling factory (photo Acciona Energy).

Fig. 5 - Martifer PV assembling factory (photo Martifer Solar).

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.

Applied research, demonstration and dissemination 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).

Associations such as SPES (National Solar Energy Society) and APISOLAR (solar manufacturers and installers association), INETI and energy agencies are also involved in dissemination activities.

European and international PV Standards are monitored by the national technical committee on Photovoltaic Systems (CTE 82).

A few R&D projects resulted in commercial products, namely those developed by WS Energy, S.A. and MagPower, Soluções de Energia, S.A., both portuguese companies.

WS Energia developed and patented the DoubleSun® Technology (Figure 1), which duplicates the annual energy yield of commercial PV modules by combining extremely light flat mirrors with easy-to-mount, quick-to-install tracking systems. The flat reflective optics has a concentration ratio of 1,85X, optimum to uniformly distribute radiation over the solar modules and increase annual energy yield, while maintaining module temperatures well below critical values. The concentration system can use off-the-shelf commercial mono-crystalline solar module, but it is recommended to use Mono-c-Si, HIT or back contact to increase system performance. The first commercial prototype was developed in 2006. The system price target of the pre-installation/BOS (including tracking structure, concentrators, inverter, mast, PV receiver, fixation clips) was 3,7 EUR/kW in 2008 and will be 2,9 EUR/W in 2010.

Magpower developed and industrialised an innovative solar power solution, consisting of a Concentrated Photovoltaic (CPV) system based on III-V triple junction cells and Fresnel concentrating optics (Figure 2). A patented high-precision tracking system ensures the system follows the sun throughout the year, receiving the maximum direct beam radiation possible, and delivering optimum electrical output. Magpower technology achieves a high level of efficiency, with a concentration ratio of x800, angular acceptance of more than 2 degrees, with less than half the temperature degradation of Si panels and with low ageing degradation. The cost per Wp is around 30 % less than traditional technologies of silicon.

A new industry-academic partnership was established to develop an innovative, fully-integrated PV ceramic tile based on thin films. The so-called Solar Tiles project is funded under the National Strategic Reference Framework, is headed by Revigres (Portuguese leading ceramic-cladding company) and has as partners 8 more institutions: Coelho da Silva (ceramic industry); Dominó (ceramic industry); the Technology Centre for Glass and Ceramics; CENIMAT (research centre of the School of Science and Technology of Universidade Nova de Lisboa); University of Minho; INETI; De Viris (system integrator) and ADENE (National Energy Agency). The project has already caught the attention of both generalist and specialised media and can soon be followed through the website www.solartiles.eu. The resulting functional prototypes are expected by the end of 2010.

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 and received construction permits. Since then, the scheme was suspended and no more power had been allocated under this scheme.

A few of those formerly licensed systems, totalling 48 MWp, started operation in 2008, of which the Moura power plant, one of the world largest centralised PV plants, with 45,6 MWp installed power.

The Moura PV plant (Figure 3) is located in Amareleja, east Alentejo and is owned and operated by Acciona Energy. The plant was built in about 13 months and comprises:

- 262 080 PV modules
- 2 520 Buskil solar trackers (azimuthal)
- Area occupied: 250 ha

TABLE 2- CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (1999-2008)

YEAR	OFF-GRID (MWp)	ON-GRID (MWp)	TOTAL ANNUAL POWER (MWp)	CUMULATIVE POWER (MWp)
Up to 1999	0,66	0,18		0,84
2000	0,22	0,08	0,30	1,14
2001	0,12	0,05	0,17	1,31
2002	0,29	0,07	0,36	1,67
2003	0,40	0,01	0,40	2,07
2004	0,55	0,08	0,63	2,70
2005	0,22	0,07	0,29	2,99
2006*	0,20	0,23	0,43	3,42
2007*	0,20	14,25	14,45	17,87
2008*	0,10	49,98	50,08	67,95

*Data for off-grid installation are estimated.

The estimated annual output is 93 GWh, i.e., a final yield slightly over 2 000 kWh/kWp.

The micro-generation scheme is experiencing a tremendous success. Since its start in April 2008, a total of 5 768 registrations were received, corresponding to a capacity of approximately 20 MW, but only about half paid the registration fee and went on with the licensing process. Of these, 615 systems were concluded in 2008 (2,23 MW) and about 2 000 (6,6 MW) are still under construction.

INDUSTRY STATUS

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

- Open Renewables, S.A.: A high quality crystalline PV modules facility, located in Évora and with a maximum annual manufacturing capacity of 35 MWp.
- Solar Plus: A 6,2 MWp per year thin-film (amorphous silicon tandem junction) PV module manufacturing facility in Oliveira do Bairro (north of Portugal).
- Moura c-Si module assembling factory, owned by Acciona Energy and operated by Fluitecnik, with a maximum annual manufacturing capacity of 20 MWp. The plant entered into service in June 2008 (Figure 4).
- Martifer Solar Facility: Built in Oliveira de Frades (North Portugal), the factory will start operation in January 2009. The maximum annual capacity is 50 MWp (mono and multi-crystalline Si modules), expandable to 100 MWp (Figure 5).

At the system level:

- WS Energy: concentration systems based on the Double-Sun® technology, manufactured in Oeiras. The manufacturing capacity by the end of 2008 was 6 MW. This figure is expected to increase to 12 MW and 15 MW by 2009 and 2010.
- MagPower: CPV systems based on III-V triple junction cells and Fresnel concentrating optics. MagPower is in the process of up-scaling the production capacity to 54 MWp/year until the end of 2009 to satisfy more than 60 MW secured under signed contracts.

MARKET DEVELOPMENT

With the newly installed capacity under the IPP framework together with the micro-generators, the Portuguese PV market increased again strongly in 2008, from a cumulative power of 17,9 MWp to 68,0 MWp.

The market structure is clearly dominated by on-grid systems, with a share of 96 % to the total installed power (Table 2).

FUTURE OUTLOOK

The world financial crisis may influence negatively and slow down the PV market development in the near future, either in what concerns implementation of large power plants, which require important capital expense, or at the industrial level. Additionally, there is still no positive sign from the government regarding the continuation of the IPP scheme as far as PV is concerned, although some rumours exist that a scheme for installations under 150 kW in industrial buildings may be in force still in 2009. Also important is the fact that legislative elections are taking place during 2009, which may delay the decision-making process.

Although falling short of the 10 MW 2008 grid-connection objective, expectations exist that the micro-generation scheme will provide a stable market for the substantially enlarged base of PV market actors, especially in what concerns installers and system integrators. Some market consolidation actions are currently under way, namely a voluntary installers training and certification programme and an improved Installation Guide, two initiatives of a partnership established between APISOLAR and the Portuguese subsidiary of TÜV Reinhland that will be submitted to the Directorate-general of Energy and Geology. Although investing in micro-generation PV is cost-effective, with payback times in the order of 8-9 years, there is nevertheless the risk that consumers (microgenerators) will prefer not to increase their debts until the financial situation stabilises. This risk may be aggravated by the 5 % downward revision of the base tariff, upon interconnection of the first 10 MW, and alleviated by already observed reduction of system prices, essentially steaming from global PV market trends and local learning effects.

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

FERNANDO SANCHEZ SUDON, CENTRO NACIONAL DE ENERGIAS RENOVABLES, CENER

Fig. 1 – 20 MW PV Power Plant. Almaraz Solar Farm (photo ASIF).

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

GENERAL FRAMEWORK

2008 has been a very critical year due to the fact that a new regulatory framework has been established by the government, in order to introduce new rules, to rationalize the extraordinary increase of the PV market that the previous framework created, due to the very favourable feed in tariff: 44c per kWh.

In fact in 2007, the target that the National Renewable Energy Plan has established for the year 2010 was surpassed. The target for 2010 was 400 MW and at the end of 2007 the installed capacity was 680 MW. A limit date of 30th September 2008 was established to include projects in the old feed-in tariff scheme. This means that the projects on line after that date will be under a new and quite less favourable feed-in tariff system. This situation has provoked the fact that in 2008 the market in Spain was the biggest worldwide and 2008 finished with an installed capacity over 3 500 MW, of which 2 700 MW has been installed in the year 2008.

Solar PV has been deployed in so called "solar farms." This implies very large scale installations, and in many cases, between 10 MW and 30 MW, as well as in many cases with tracking systems.

The new regulatory framework has been established in the Royal Decree 1578/2008, which implies changes in two main lines. On one hand, there is a reduction of the feed-in tariff in the order of 30 % with better figures for the PV installation in roofs and façades. On the other hand, and in order to control the impact of the feed-in tariff in the national economic situation, a quota of 500 MW in 2009 and similar for the next three years has been established. This will imply a strong reduction in the Spanish market, compared to the extraordinary figures of 2008.

NATIONAL PROGRAMME

At this moment, the government is working on the elaboration of a new National Renewable Energy Plan, with a time frame of up to the year 2020, in order to comply with the compromises established at European level of having 20 % of the primary energy supply in the EU covered by renewable energy.

For Spain, the target will also be 20 % of its domestic supply from renewable energy and there will be specific targets for each of the renewable energy technologies.
According to the new Royal Decree 1578/2008, it is expected to have a market of 500 MW per year during the years 2009, 2010, and 2011. The new feed-in tariff is 32 c per kWh for ground installations and 34 c per kWh for roof and building installations.
For now, it is not yet officially established what will be the target for PV in 2020, but in the event that the existing regulation will be prolonged up to 2020, this will imply a target of 10 GW of PV for that year.

R, D & D

No changes in the main lines for R&D have occurred since the last year, with quite relevant activity from public and private centres.
The national R&D Plan 2008-2011 has a Strategic Action dealing with Energy and Climate Change, where PV has a specific line.
The main lines of R&D cover the improvement of efficiency on the crystalline silicon technologies, including automation of processes, solar grade silicon processes, thin film materials and cells, integration of PV in the building sector, concentration PV and new materials, such as organic cells.

The main actors in R&D are:

- Instituto de Energía Solar from the Polytechnic University of Madrid
- CIEMAT
- CENER
- Institute of Microelectronics
- Other Universities, private centres and companies

Fig. 3 – 6,5 MW PV Power Plant. La Solana Solar Farm (photo ASIF).

Fig. 4 – 9,55 MW PV Power Plant. Milagro Solar Farm with the owners (photo ASIF).

It is also worth mentioning the creation of the Institute of Concentration Photovoltaic Systems ISFOC, with the purpose to test different technologies of concentration PV systems at the industrial scale.

IMPLEMENTATION

The very favourable framework, with the high feed-in tariff system, has created a very big market for the private initiative that has built many solar farms. Some of them are very big in size, and PV installations are very well distributed over the country, with close to 28 000 installations. There are 16 installations bigger than 1 MW. 63 % of the installations are with fixed structures and 37 % with tracking.

The projects are built on the Project Financed scheme with a very high participation from the financial sector, and with very wide participation from private small investors.

In 2008, there has also been an increase in the national manufacturing industry.

Fig. 5 – 23 MW PV Power Plant. La Magascona Solar Farm (photo ASIF).

INDUSTRY STATUS

The industrial production capacity in 2008 was in the order of 1 000 MW, with more that 20 companies active in the cells and modules production chain. This has implied almost doubling the production capacity, when compared to 2007. According to ASIF, the PV Industry Association, there are more than 500 companies active in the PV sector in Spain.

MARKET DEVELOPMENT

According to ASIF, the PV Industry Association, the estimated accumulated PV capacity installed in Spain at the end of 2008 was in the order of 3 500 MW; of which 2 700 MW has been installed in the year 2008, the biggest market worldwide.

The new regulatory framework approved at the end of 2008 has established a quota of 500 MW for 2009 and similar for the following years. According to this new situation, it is expected to reach 10 000 MW for the year 2020.

FUTURE OUTLOOK

Spain has a very important PV industry and the government is very much engaged with compromises of reaching 20 % of energy demand covered by renewable energy by 2020.

Although the present regulation will imply a decrease in the activity compared to 2008, it also will help to rationalize the market growth, and create a more stable and accepted framework.

The continuous decrease of the cost of PV, together with the expected increase of the energy price in the near future will help in reaching the grid parity cost.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

LINUS PALMBLAD, SWEDISH ENERGY AGENCY; BERTIL WAHLUND, ELFORSK AB AND ADAM HULTQVIST, UPPSALA UNIVERSITY

GENERAL FRAMEWORK

The Swedish PV market has experienced a significant growth over the last couple of years, although from a very low level. The growth rate levelled out during 2008, with about as much installed capacity as 2007. The reason for the market growth is the investment subsidy for PV systems on public buildings that was introduced in 2005. The support programme ended on December 31, 2008, with an estimated total installed PV capacity of 7 MW. The results of this first support programme for PV installations in Sweden is that it 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. In the budget for 2009 the Swedish government has announced plans for a new support for installation of PV systems.

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.

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). Wind power is growing rapidly at the moment and there are ambitious targets for the expansion over the coming years. Although, the total contribution of wind power to national electricity supply is still only about 1 %.

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. The budget was increased for 2009 to about 100 MEUR. 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 R&D in Sweden can be received from e.g. the Swedish Research Council, the Nordic Energy Research programme, the Agency for Innovation Systems and private foundations.

Fig. 1 – A total of 109 kWp has been installed on the roof and on the facade, as well as above the windows as sunscreens at the House of Ecology, Lund University. The different parts of the system demonstrate different ways of PV architectural integration.

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. 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 spin-off company, Solibro AB, was launched in 2003 and the technology resulted in commercial production during 2008 (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.

There are several research projects in Sweden around 3rd generation PV concepts. Many of these projects receive funding through the Swedish Research Council's call for basic research. One specific field that stands out is polymer solar cells, where research is conducted at several Universities in Sweden.

Fig. 2 - 64 kWp PV system on the roof of Andersberg Centrum and on the triangular roof of the nearby Andreas' Chruch in Gävle (photo Anders Holmsten, Gavlegårdarna).

Another field with world class research is molecular solar cells, where different research groups from Uppsala University, the Royal Institute of Technology and the public-private partnership company Swerea IVF AB are connected through The Center of Molecular Devices (www.moleculardevices.se). 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.

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. A new period of the programme started during 2008 and will continue until 2011 with a budget of approximately 0,4 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.

A first call of the new period was held during 2008. Examples of projects funded by the programme are studies regarding grid connection and new electricity meters, new ways of implementing PV systems, various activities for raising the awareness of PV, as well as monitoring of the performance of grid-connected systems (www.elforsk.se/solenergi).

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), and also because of a general trend to profile themselves as environmental friendly companies. 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 telecommunication 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, whereof 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 support programme was active until the end of 2008. It was an investment support of 70 % subsidy and limited to a total amount of about 15 MEUR. The interest for the subsidy has been good and the cap was reached early 2008, the cap was then lifted but that have not resulted in a large increase of additional systems due to the time constraint that the systems had to be completed by the end of 2008. The subsidy scheme has jump-started the domestic market for PV in Sweden and resulting in about 3 MW of installed capacity since the start. Hence the total installed PV capacity in Sweden almost doubled in three years time and the installed capacity of grid-connected BIPV applications increased more than tenfold. Many new actors have come in contact with the PV technology as a result of the subsidy and this is important since an important motive for the programme was to promote the development of professional know-how among installers, architects, project developers, etc. An important result is also that PV advocacy groups are beginning to form. The Scandinavian Photovoltaic Industry Association (SPIA) was formed much as a consequence of the support programme and during 2008 SPIA merged with the Swedish industry association for solar heating, Svensk Solenergi (www.svensksolenergi.se), to create a common industry association for solar energy in Sweden.

During the autumn of 2008, the Swedish Government presented the budget proposition for 2009 and it included a new support for installation of PV systems with about 5 MEUR per year for another three year period. The decree for the new subsidy was not finished at the end of 2008, but it will probably be similar to the previous support programme but with the major difference that it will be available for all applicants.

Fig. 3 - The system is the first in Sweden with CIGS modules from Solibro, a company that was founded as a spin-off from thin film research at Uppsala University. The system is installed at the Swedish University of Agricultural Sciences in Uppsala (photo Julio Gonzalez, SLU).

There are still very few grid-connected residential systems in Sweden, mainly due to the high prices of PV systems, the high cost of 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 and delivered early 2008. Among the recommendations related to PV are for example to waive the demand to measure energy delivered by the hour for systems with an output of up to 63 A and also to allow net-billing on a monthly basis for these systems. The recommendations from this assessment are at the moment being processed by the government.

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. GPV was earlier owned by the German company Solarworld, but in early 2008 a majority of the shares were sold to the Swedish renewable energy investment company Borevind AB. 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. This has been possible thanks to the supply of cells from the sister company **REC ScanCell AS** in Norway. The expansion to 100 MW production capacity during 2007 continued during 2008 to a total of 150 MW per year.

Total production capacity in Swedish module factories was about 190 MW for 2007, with only 70 MW actually being produced. Despite the new investment subsidy, the annually installed PV capacity in Sweden only constitutes a small fraction of the produced modules. 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 Research AB** conducts development of large scale processing and module integration of CIGS thin-film solar cells. Solibro was originally founded as a spinn-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 and Solibro Research AB was founded as a result to continue the R&D activities in Sweden. A full-scale manufacturing facility was constructed in Thalheim, Germany and operation was commenced in the beginning of the summer 2008. The construction of a second factory at the same location was initiated during the autumn 2008. Q-Cells also provided funding for investments at the research facilities 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 2009.

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 suggest improvements in the conditions for grid-connection of PV systems in Sweden. These improvements are crucial for the development of a market for residential systems in Sweden and would be an important complement to the new support programme that is planned. However, changes are not likely to be implemented before July 2009.

2008 was a year of uncertainty for the Swedish PV market since it was unclear, until very late, if there would be a continuation of the support programme after the year. The new programme will secure the market for another three years and with about the same amount of money dedicated for each year as in the earlier subsidy it is likely that there will be a sustained but limited growth of the market. Activities will probably be low in the beginning of 2009 until the new decree is finalised. In the long run it is very important with long term plans from the Swedish government for the development of the PV market.

2009 will also be an interesting year for Midsummer AB, that will start with their first deliveries of CIGS solar cells to customers during the coming year.

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
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ON BEHALF OF THE SWISS FEDERAL OFFICE OF ENERGY (SFOE)

Fig. 1 - La Ferme des Trois Epis, Aigle (VD). This chicken farm has an integrated system with 160 kWp solar tiles "oryon" (Solar Fabrik cells) and Swiss inverter SolarMax 80C (2 units); by Solstis, Switzerland (photo Solstis, Switzerland).

GENERAL FRAMEWORK

Concerning energy research, the Swiss framework as a whole has basically remained unchanged in 2008: The energy research strategy is defined by a 4 year energy RTD master plan, with 2008 as the first year of the present period 2008 – 2011. 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) (www.energieforschung.ch). It confirms the important position of photovoltaic RTD in the Swiss energy RTD landscape.

The framework for photovoltaic technology development in the public sector experienced a number of changes: Research and development were considerably increased compared to the level of previous years where as support for new pilot and demonstration systems continued to be very limited. Industry development continued to be strong with new entrants and production facilities being ramped up.

Turning to energy policy, 2008 saw the introduction of the new feed-in tariff scheme for new renewable energy technologies. In the course of the year, the scheme became operational as far as the application of projects for the new support scheme is concerned. A large number of projects was announced and photovoltaics constituted by far the largest amount of projects (~ 80 %). First actual payments of the feed-in tariff will start in 2009.

To support the deployment of renewable electricity through the feed-in tariff model, a levy up to 0,6 cCHF per kWh consumed electricity is being perceived; yielding a total annual amount of about 320 Mio. CHF. This amount is divided into maximum contributions from each of the renewable energy technologies. Concerning photovoltaics, these maximum contributions begin with 5 % of the available financial envelope and can increase over time, as the PV generation costs come down, up to a maximum of 30 %. Both the total envelope, as well as the possible contribution by photovoltaics are thus capped. This has resulted in a long waiting list of the filed applications. This cap and its possible future change are presently the subject of an ongoing political debate in the Swiss government and parliament.

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 accompanying measures for market stimulation. As indicated above, activities in pilot and demonstration projects continued to be limited during 2008. 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 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, up to 2006, deployment has mainly been driven by voluntary green power

Fig. 2 - Gründenmoos Stadium. Switzerland's largest solar power plant with an installed capacity of 56 kWp made of roofing membrane with integrated thin-film photovoltaic cells. The Gründenmoos Stadium in St.Gallen is the venue of the international CSIO horse riding competition in Switzerland. Surface: 1 200 m². Owner: Sankt Galler Stadtwerke (photo energiebüro, Switzerland).

marketing programmes of utilities. This will now change to the feed-in tariff scheme as explained above and market is expected to increase. 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 2008, the interdepartmental platform for the promotion of renewable energy and energy efficiency in international co-operation – REPIC – started a new 3-year term (www.repic.ch). This platform supported different photovoltaic projects of Swiss entities in developing countries.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

During the year 2008, a detailed photovoltaic research plan for 2008 - 2011 was approved by the Federal Commission for Energy Research (CORE). In the first year of this new period, overall 57 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.

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2007 (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	16,6	12 000	810
2003	75	1 600	17,9	15 100	875
2004	100	1 700	19,5	15 200	815
2005	200	1 900	23,6	18 200	850
2006	250	2 150	26,1	21 000	845
2007	525	2 675	32,6	25 700	875

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 2008, emphasis on transfer from R&D to industrial processes, manufacturing 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 oc oerlikon continued. During 2008, the equipment manufacturer oc oerlikon extended its activities as a leading supplier of manufacturing systems of thin film silicon solar cells on glass and increased the staff to some 1 000 workplaces. 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 metal foils. During 2008, 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. An increasing interest for photovoltaic technology can be observed for various research institutions as well as from industry. In line with the international trend to a broader scientific and technological base, increased activities take place in the fields of chemistry and numerical modelling.

On the part of application oriented research, emphasis continues to be given to building integrated photovoltaics (BIPV), both for new solutions involving thin film solar cells as well as for new mounting systems and structures for sloped roofs and facades. A dedicated website deals with the topic of BIPV (www.bipv.ch) and includes information about available products.

With the ongoing market development, quality assurance and reliability of products and systems, as well as standardisation, continue to be of high priority. The Swiss centres of competence at the Technical Universities of Burgdorf and Lugano carefully evaluate products such as PV modules, inverters and new systems. The test infrastructure is continuously expanded and recently includes the

Fig. 3 - Bifacial Photovoltaic Noise Barrier Münsingen. The world's first bifacial PV system along a railroad has a surface of 115 m². It has an installed capacity of 7,25 kWp on the front side and an additional 5,6 kWp on the back side, with the PV modules facing east and west (photo TNC Consulting, Switzerland).

largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf) as well as new laboratory equipment for IEC module certification (Lugano). 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 well positioned in the export market.

Visionary projects such as the solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard and the solar powered boat PlanetSolar (www.planetsolar.org), both of which plan to travel around the world by air respectively on water in the coming years, have entered their component testing and construction phase.

International co-operation continues to form a strong pillar of the R&D activities with 12 projects running in the 6th and 7th framework RTD programmes of the European Union during 2008, of which three are integrated projects. During 2008, a first joint call was conducted together with other European PV RTD programmes in the field of polymer and molecular solar cells. Two projects with Swiss participation emerged out of this initiative. 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-City as well as Geneva, the Mont-Soleil Association and SWISSOLAR contributed to the Swiss expert participation in IEA PVPS.

On the programme level, international co-operation is also taking place through the European 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 new feed-in tariff scheme, interest for photovoltaic projects strongly increased since 2007. As the new promotion scheme includes a retroactive clause for projects realised back to 2006, many new projects were initiated in 2007 and 2008. The Swiss legislation foresees the possibility of switching between the feed-in tariff and the voluntary green power marketing approach. The respective roles and contributions of these two instruments in the future photovoltaic market mix remains to be seen.

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. More recently, industrial activities in the area of solar cells, solar modules and manufacturing equipment for both of these areas have considerably increased. The Swiss PV industry is thus active along the full value chain starting from materials and manufacturing, over diverse components and products all the way to system planning and implementation.

In the inverter area, some products have achieved a high export rate. The Sputnik Company produces grid-connected inverters at a capacity of 275 MW/year and presently ranges as number 3 in the European market. The Studer Company produces stand-alone inverters and is also very successful in exporting. On the PV industry supply side, different products count among the world leaders, e.g. for wire-sawing machines from Applied Materials Switzerland (formerly HCT) as well as from Meyer Burger; and measuring equipment for PV module manufacturers from Pasan (now a part of Swiss Solar Systems – 3S). 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, which has developed a flexible, watertight flat roof PV system based on thin film silicon solar cells, is taking part in a joint venture with the American company Solar Integrated Technologies (SIT).

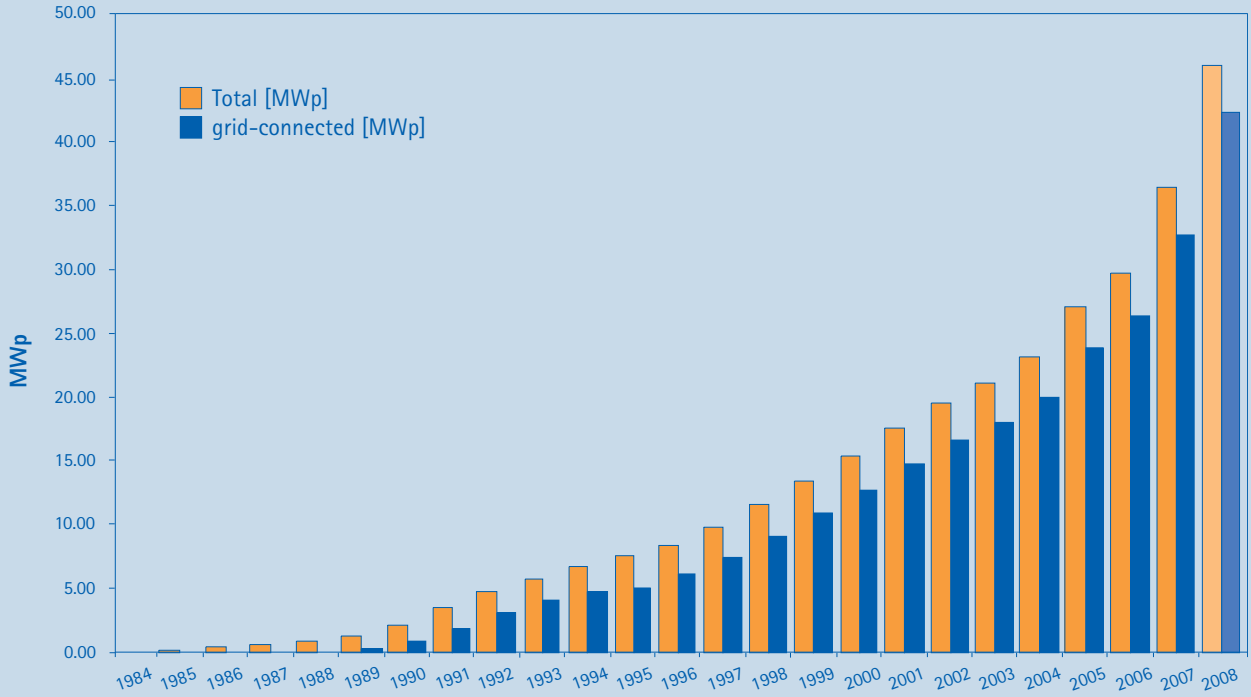

Fig. 4 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2008 (total and grid-connected, estimated values for 2008).

As indicated above, industrial activities evolve in the field of process equipment (oc oerlikon) and products based on thin-film technology (Flexcell® from VHF-Technologies, FLISOM). In 2008, oc oerlikon received a number of large orders for industrial production equipment of amorphous silicon solar cells and further developed the production equipment for micromorphous solar cells. Using oc oerlikon's technology, the project of a 30 MW production line by the Pramac company is being implemented in the southern part of Switzerland near Locarno. During 2008, VHF-Technologies built their production facility for a 25 MW production line of thin film silicon solar cells on flexible substrates. Furthermore, Swiss Solar Systems (3S) is building some of the world's largest PV module laminators.

Based on the long term experience and the large number of installed systems, considerable know-how is available amongst engineering companies for the design, construction and operation of a large variety of different applications, ranging from small scale, stand alone systems for non-domestic, professional applications and remote locations, over small domestic grid-connected systems to medium and large size grid-connected systems in various types of advanced building integration. The export volume of Swiss photovoltaic products is rapidly growing and is estimated to more than 1 500 MCHF in 2008.

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, which was formerly mainly driven by green power marketing schemes from utilities, has experienced a strong development in expectation of the new feed-in tariff support scheme. The annual market volume for grid-connected systems is estimated to a value around 10 MWp, considerably higher than the previous year (6,5 MWp). The total installed capacity has thus risen to about 46 MWp (Figure 4), corresponding to 9,5 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 2007 is thus approaching 26 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue and further increase with a focus on rapid technology transfer, 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 short to medium term market oriented approaches and continuous quality assurance. In parallel, the more basic and longer term research activities are being increased. 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 further 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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Fig. 1 - The development of organic solar cells in 2008 by the Solar Energy Institute of Ege University.

Fig. 2 - The silicon based PV module production from the unit cells in 2008 by the Solar Energy Institute of Ege University.

Fig. 3 - 40 kWp BIPV PV power system in Mugla by Mugla University.

GENERAL FRAMEWORK

Photovoltaic power systems are considered as an important renewable energy source for Turkey since the country is geographically well situated with respect to solar energy potential and lies in a sunny belt. Throughout 2008, public interest in climate change and photovoltaic technology was quite high. A draft law foreseeing Turkey's adoption of a participation in the Kyoto Protocol has been approved by the Turkish Parliamentary General Assembly on 05 February 2009. The Republic of Turkey Ministry of Energy and Natural Resources has announced that the government will add some support mechanisms to the existing renewable energy law for solar electricity in the first half of 2009 and the government will apply feed-in tariffs for grid-connected PV power systems.

The other important development is that TUBITAK (The Scientific & Research Council of Turkey) has provided project support to Ege University Solar Energy Institute to form a national PV technology platform with the participation of the universities, research institutes and the industrial companies. The project titled "Formation of National PV Technology Platform" has begun on 01.09.2008. The project will continue for the next three years with the support of TUBITAK. The aim of the project is to form the national PV technology platform for defining effective PV technology programs and plans in Turkey. The platform is also responsible for IEA-PVPS (International Energy Agency Photovoltaic Power Systems) membership on behalf of the Turkish government. The founding members of the platform are Ege University Solar Energy Institute, the General Directorate of Electrical Power Resources Survey and Development Administration (EIE), Mugla University, Bilkent University, Sisecam Co., Aneltech Co., Girasolar Energy Systems Ltd., Motif Project and Construct Ltd., Antalya Chamber of Commerce and Industry. New members continue to join to the platform (http://www.trpvplatform.org/).

The electricity gross generation was reported as 198 567,1 GWh in 2008 by TEIAS (Turkish Electricity Transmission Co.) and it was mainly produced by thermal power plants accounted for 166 399,6 GWh (82,8 % of the total) while hydropower energy was 33 271,9 GWh (16,75 % of the total) and the rest (geothermal + wind power energy) was 895,6 GWh (0,45 % of the total). The electricity requirement, which is called gross demand, was reported as 198 294,5 GWh in 2008 by TEIAS (TEIAS web page, 2009). TEIAS reports the annual electricity generation-transmission statistics of Turkey regularly. The installed electricity capacity of Turkey was announced as 40 835,7 MW in 2007. The total installed photovoltaic power system in Turkey is estimated over 3 MWp (2008). Because a certain statistical research was not concluded by an official department, one of the work packages of the National PV Technology Platform was formed to list the installed PV power systems in Turkey. According to the preliminary works, the main off-grid photovoltaic applications include power systems for telecommunications, signaling, water pumping, lighting and the electrification of remote regions without a regular supply of electricity. There are also some grid-connected photovoltaic power systems (1 – 94 kWp) at some research

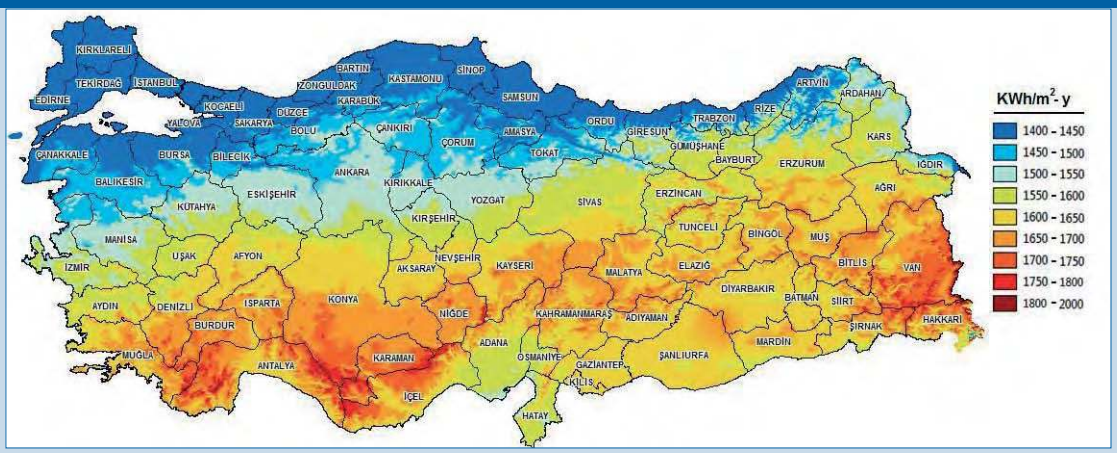

Fig. 4 - Solar Map of Turkey (kWh/(m².year)) (ref.: EIE, General Directorate Of Electrical Power Resources Survey And Development Administration).

institutes/universities, municipalities and department stores. Following the revision of the renewable energy law to support solar electricity, the number of PV installations is expected to increase significantly.

NATIONAL PROGRAMME

The main difficulties of the energy policy in Turkey are still the increasing demand and the import dependency. It is announced in the development plans the main objectives of Turkey's 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 government has declared to increase the share of wind and solar power capacities in the total installed capacity from its current value of 0,5 % to over 10 % by 2020. The amendments to the related law in 2008 allow the utilization of the utility grid as an energy reserve until 500 kW power for renewable energy sources without any permission. Turkey has also ratified the Kyoto Protocol following an overwhelming vote in the national parliament on 05 February 2009.

The Republic of Turkey Ministry of Energy and Natural Resources plans to make the General Directorate of Electrical Power Resources Survey and Development Administration (EIE) responsible for defining the technical sufficiency criteria and the Energy Market Regulatory Authority (EPDK) for evaluating the license applications over 500 kW plants for solar electricity production. Several grid-connected solar power plants are expected to be installed after the support mechanisms for PV power systems are defined by the amendment to renewable energy law in the first half of 2009.

R&D, D

Photovoltaic research and development activities are undertaken across a range of university, government and industry facilities and the projects are mainly financed by the research programmes of State Planning Organization of Turkey (DPT) and TUBITAK (The Scientific & Research Council of Turkey).

In addition to a few energy research institutes concentrated on the general energy R&D activities, the Solar Energy Institute of Ege University (SEI) is still the only research institute which mainly works on solar energy research (http://eusolar.ege.edu.tr/). The main PV related studies in SEI are the development of organic dye-sensitized solar cells (Fig. 1) and the lamination of silicon solar cells (Fig. 2). In 2008, SEI has increased its PV power capacity exceeding 24 kWp by producing its own PV modules. 10 kWp of the system continues to operate as grid-connected PV system and the remaining capacity is used as a stand-alone renewable hybrid power system. The system includes also a 6 kW wind turbine and 48 V 2000 Ah battery capacity. Mugla University has installed a 40 kWp BIPV grid-connected power system in 2008 and the total PV power capacity of the university campus has reached to 94 kWp (Fig. 3). The Middle East Technical University has begun to do silicon based wafer production research with the Nurol Corporation. The Institute of Materials Science and Nanotechnology (UNAM) of Bilkent University is another important research institute which has increased its PV research and development activities in 2008. All of these research institutes came together on the National PV Technology Platform under the leadership of SEI to define the Turkish PV road map for next decades. The number of researchers working on PV technology at the Turkish universities increases continually.

IMPLEMENTATION

The General Directorate of Electrical Power Resources Survey and Development Administration (EIE) prepared the Solar Energy Potential Atlas (GEPA) in 2008. The Solar Energy Potential Atlas is published on their website and gives the planners/investors the ability to reach the required parameters for the potential of solar electricity production (Fig. 4). (www.eie.gov.tr). 4 600 km² area of Turkey was calculated as having a solar energy potential of over 1 650 kWh/(m² .y) and is expected to produce 380 000 GWh energy per year by EIE.

Aneltech Corp. has installed over 300 kWp photovoltaic power systems for telecommunication power systems in different locations of Turk Telekom (Turkish Telecom Corporation) in 2008 (Fig. 5). The first PV-wind-diesel generator hybrid power system installed in an island by Girasolar Ltd. with the collaboration of Ege University Solar Energy Institute hosted many visitors in summer 2008 (Fig. 6). Some attractive small PV applications were also installed by several companies (Fig. 7). Some of the PV applications can be summarized as the following: Kocaeli Municipality has installed a 31 kWp grid-connected PV system. Gazi University has also installed a 2,5 kWp pilot PV system in 2008.

Fig. 5 - Photovoltaic power systems for telecommunication systems by ANEL-TECH Co. in different locations in Turkey.

Fig. 6 - PV-wind-diesel generator hybrid power system in an island in Fethiye-MUGLA by Girasolar Ltd.

Fig.7 - A small solar tracker project by Ekosolar Ltd.

Fig. 8 - The National PV Technology Platform Meeting in Izmir, Turkey, 19.12.2008.

INDUSTRY STATUS

Although the companies operating in the PV sector have increased recently, the photovoltaic sector in Turkey is still fairly small; providing work for only a small number of employees. The main business types are importers, wholesale suppliers, system integrators and retail sales. The companies serve in the installation, engineering and project development sectors. There are a few domestic battery manufacturers whose products can be used for off-grid PV applications. Aneltech Corp. and Girasolar Ltd. finalized plans for module production lines and both companies plan to produce crystalline based solar modules from the unit cells in 2009. Many investors can begin to plan the previous production lines after the support mechanisms with feed-in tariffs are initialized by the government.

MARKET DEVELOPMENT

The potential of Turkey in the photovoltaic market is very strong, since the country lies in a high solar radiation belt and has available large lands for solar farms. The total installed photovoltaic power system in Turkey is estimated over 3 MWp (2008). National PV Technology Platform tries to define the exact installed capacity with a general questionnaire. The platform also brings companies together to define the market requirements and works with the participation of the universities, research institutes and the industrial companies (http://www.trpvplatform.org/). (Fig. 8).

FUTURE OUTLOOK

The energy policy objectives of Turkey essentially require diversifying the energy sources, using domestic energy resources, increasing efficiency in electricity generation, transmission and consumption and creating an environment-friendly power system. The current value of wind and solar power capacities in the total installed capacity is still 0,5 %. Upon Parliament's sanction of Kyoto Protocol on 05 February 2009, the share of renewable are expected to increase substantially. Government statements are also in favour of PV as a renewable. If the Ministry of Energy and Natural Resources keeps their promise for supporting PV power systems with feed-in tariffs in 2009, the Turkish PV market will begin to reach its real potential in the coming years. Throughout 2008, public interest in climate change and photovoltaic technology was quite high and most of the Turkish society is now aware of solar electricity and its potential.

The Ministry of Energy and Natural Resources is about to establish a department named ENAR (R&D Support Projects for Energy Sector) aiming to support the innovation based energy projects, especially in renewable energy areas. The supports will also include some demonstration and technology transfer projects to improve the level of understanding PV systems.

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UNITED KINGDOM

PV TECHNOLOGY AND PROSPECTS
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GENERAL FRAMEWORK

Climate Change and carbon reduction are at the top of the political agenda with the demanding EU target to reduce carbon emissions by 80 % by 2050. In 2008 a new governmental department was formed; the Department of Energy and Climate Change (DECC), which brings together the Climate Change Group and the Energy Group. The two long term challenges identified by the DECC are tackling climate change by reducing carbon emissions both within the UK and abroad and ensuring secure, clean and affordable energy as the UK becomes increasingly dependent on imported fuel. Policy such as the Energy Act, Code for Sustainable Homes, Microgeneration Strategy and local planning policy work towards these aims and impact PV.

The Energy White Paper, published in May 2007, sets out the Government's strategy to tackle climate change and ensure a secure, clean and affordable energy supply. The legislative aspects of the white paper will be implemented through the Energy Act which was given Royal Assent in November 2008 (prior to this it was known as the Energy Bill). Important aspects of the Energy Act for the PV sector are plans to introduce banding of the renewables obligation and a renewable electricity tariff. A new Renewable Energy Strategy for the UK will be published in spring 2009 following a 3 month consultation period which ended in September 2008. The aim of the strategy is to identify how the UK will meet its target under the Renewable Energy Directive; ensuring that 15 % of its energy comes from renewables by 2020. This is equivalent to an almost ten-fold increase in renewable energy consumption from current levels so considerable effort will be required to achieve this target.

In 2006 the Government launched its Microgeneration Strategy with the objective of creating conditions under which microgeneration becomes a realistic alternative or supplementary energy generation source for the householder, communities and small businesses. A number of these actions supported the PV sector including; a certification scheme for microgeneration system installers and products, permitted development rights for homeowners, extension of the Low Carbon Buildings Programme (LCBP) grant and clearer information for consumers, for example a scheme run by the Energy Saving Trust 'Act on CO_2'.

The Code for Sustainable Homes which was launched as a voluntary initiative in December 2006 became mandatory in England in May 2008. The code uses a 1 to 6 star rating system to mark the sustainability performance of a new home against nine categories of sustainable design including energy. All new homes must attain at least a level 3 rating and the higher levels of the code require the installation of microgeneration technologies such as PV. The 'Building a Greener Future Policy Statement' published in 2007 confirmed the Government's intention for all new homes to be zero carbon by 2016. In addition the government has committed to zero carbon targets for other building categories; all new schools to be carbon zero by 2016, new public sector buildings by 2018 and new non domestic buildings by 2019. PV is ideally suited to building integrated applications and therefore provides an option for meeting zero carbon and other targets.

Fig. 1 – 8,4 kWp PV façade at Derby Quad Arts Centre (photo Solarcentury).

Local planning policies requiring new developments or refurbishments to include on-site renewables have become increasingly important in encouraging PV as well as other small scale renewables. The 'Merton Rule' pioneered by the London Borough of Merton in 2005 requires all new major developments to use onsite renewable energy to reduce annual CO_2 emissions by a set percentage, typically 10-30 %. This policy has been adopted by numerous other local authorities and

Fig. 2 – 73 kWp PV Canopy at Woking Station (photo PV Systems).

boroughs, in total at least 70 local authorities have either included or are looking to include similar policies in their plans.

Photovoltaics, like other environmental and low carbon technologies, are gaining increasing popularity and attention in the UK. Research conducted by the Energy Saving's Trust shows that half of UK home-owners believe homes with greener features are easier to sell in the current market with 53 % of all householders willing to pay extra for them. In addition many businesses are choosing renewables to improve their green credentials. For the public sector 50 % grants available from the LCBP and additional match funding have resulted in virtually free PV systems for schools and other community buildings. Although PV is still a relatively expensive technology, grants, subsidies and its building integrated nature make it a popular option for meeting carbon reduction targets.

PV is increasingly being used as a feature in a buildings architectural design for example in facades, louvres and intricate design as seen on the London City Hall. Solar Tiles which take the place of traditional roofing tiles, allowing PV systems to be completed integrated into the roof are becoming increasingly popular and are available from a number of UK companies.

In the UK most PV systems are grid connected distributed systems (accounting for 96 % of systems installed in 2008), on homes, public and commercial buildings. There has been a particular focus on microgeneration technologies for schools; both through the LCBP and an immediate Government target to reduce carbon emissions from all new school buildings by 60 %. The UK's largest PV system to date is the 391 kWp PV building façade on the CIS tower in Manchester; however the majority of PV systems in the UK are smaller and fall into the microgeneration category (50 kWp and below).

IMPLEMENTATION

At present the major government support measure for renewables is the Renewables Obligation (RO) which was introduced in 2002. The RO requires licensed electricity suppliers to source a specific and annually increasing percentage of their sales from eligible renewable sources. For 2008/09 the level of the RO is 9,1 %, rising to 15,4 % by 2015/16. Suppliers can meet their obligation by either presenting Renewable Obligation Certificates (ROCs); paying a buyout price (35,76 GBP per MWh in 2008/09 rising each year with inflation); or a combination of the two. ROCs are issued to generators for every 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 distributed amongst the suppliers who presented ROCs on a pro rata basis.

Minor changes to the RO introduced in April 2007 include measures to make it easier for small generators such as photovoltaic systems to access the benefits of the RO. From April 2009 banding will be introduced; providing differentiated levels of support to different technologies in order to encourage a larger contribution from emerging renewable technologies. PV will receive two ROCs per MWh generated from this time. During 2008 the Renewables Obligation was extended by 10 years to 2037.

In addition to the Renewables Obligation there are a number of funding options available to both homeowners and community buildings.

The Low Carbon Buildings Programme has been running for 3 years, providing grants for the installation of microgeneration technologies to homeowners, community organisations, public, private and non-profit sectors. Phase 1 household stream and Phase 2 of the programme are still open:

- Phase 1 Householders: Householders can apply for grants of up to 2500 GBP per property towards the cost of installing microgeneration technologies. Nearly 6 MGBP has been committed to 1404 PV projects under the scheme.

Fig.3 – Intricate design at London City Hall, 67 kWp PV system, Solar Technologies (photo GLA).

- Phase 2 Public Sector and Charitable bodies: Up to 50 % funding is available for new PV projects, subject to maximum levels per kW. Over 17,5 MGBP has been committed to 814 solar PV projects, representing the vast majority of the total 24 MGBP committed to all microgeneration technologies.

Homeowners based in Scotland can also apply for grants through the Scottish Community and Householder and Renewables Initiative (SCHRI). From June 2008 PV grants were eligible under the homeowner stream, providing grants of up to 30 % of the costs, up to a maximum of 4000 GBP. In Northern Ireland the Reconnect scheme which included funding of 8 MGBP over two years for householders installing renewable energy systems closed in March 2008. Although there are at present no plans for further schemes homeowners are still eligible for LCBP funding.

In April 2008 the Community Sustainable Energy Programme was launched, providing grants towards the cost of microgeneration technologies and energy efficiency measures. A total of 8 MGBP is available from the Big Lottery Fund. Community organisations can apply for up to 50 KGBP or 50 % of the project cost (whichever is the lower). This funding is typically used in conjunction with a grant from the LCBP or equivalent to meet the full costs of a microgeneration installation.

Other organisations including EDF, EoN and Scottish Power award grants for renewable energy projects. There are also local initiatives supporting PV installations, for example in the County of Gloucester residents can apply for a grant of up to 1000 GBP for microgeneration technologies.

CERT 2008-2011 is the third phase of a scheme (originally known as the Energy Efficiency Commitment) which obligates energy suppliers to achieve reductions in carbon emissions in the household sector. CERT obligates electricity and gas suppliers to promote energy efficiency improvements and renewable energy generation with homeowners through grants and offers. There is a ring fence of no more than 6 % of the suppliers obligation for demonstration and market transformation. This rises to 8 % if microgeneration measures account for at least 2 % of the market transformation action. Through this 6-8 % of the target CERT aims to demonstrate the potential of microgeneration technologies and to stimulate the market by driving up demand, leading to price reductions and greater accessibility. With CERT expected to deliver 3 700 MGBP of investment over three years, 2 % of this would mean 74 MGBP for the microgeneration technologies. However there are concerns that CERT will not provide support to a number of microgeneration technologies, in particular Wind and PV and support will not be equivalent to that provided by the Low Carbon Buildings Programme.

Measures which have made it easier for consumers wishing to install a PV system include permitted development rights and the Microgeneration Certification Scheme. From April 2008 microgeneration installations which have little or no impact beyond the host property were classified as permitted development. This removes the need for specific planning consent, reducing the cost and speeding up the process of a PV system installation.

The Microgeneration Certification Scheme (MSC) assesses microgeneration products and installers against robust standards with the aim of creating a rapidly growing and sustainable microgeneration industry, based on quality and reliability. From March 2009 the grant programmes will only be accessible to installers registered with the scheme.

MARKET DEVELOPMENTS

Figures for the PV capacity installed during 2008 are not yet available but early indications point to similar growth to that experienced in 2007 with around 3 MW being installed during the year. This brings the cumulative total installed capacity to approximately 21 MW. Rapid expansion will be required in the PV sector as well as other renewable technologies to meet the EU target of 15 % of total UK energy production from renewables by 2020.

R&D, D

Research in the UK is largely funded by the Engineering and Physical Sciences Research Council (EPSRC), the Department for Business Enterprise and Regulatory Reform (BERR) and the Carbon Trust. The UK Energy Research Centre (UKERC) Research Atlas provides details of publicly funded past and ongoing research activities in the solar sector, available at http://ukerc.rl.ac.uk

The Sustainable Power Generation and Supply Initiative (SUPERGEN), funded by the EPSRC aims to radically improve the sustainability of power generation and supply. In 2008 the Photovoltaic Materials for the 21st Century (PV-21) project was launched, building on an initial four year project. This 6,3 MGBP project, led by the University of Durham with support from 7 other universities and 9 industrial partners has the ultimate goal of making solar energy more competitive and affordable. The major focus is to develop thin-film light absorbing cells for solar panels from sustainable and affordable materials.

Since 2001, the Carbon Trust has committed over 18,5 MGBP to supporting Applied Research in Business and Academia. The grant funding aims to support the development and commercialisation of technologies which have the potential to reduce UK carbon emissions. In 2008 the size of grant available from the Carbon Trust was doubled to 500 KGBP with the aim of enabling more ambitious projects to be developed. In the PV Sector recently funded projects include Imperial College London's research to improve the power conversion efficiency of polymer based solar cells, research by Microsharp Corporation Ltd to develop ultra low cost solar concentrators and the development of an innovative nanotechnology route to solar grade silicon by IntrinsiQ Ltd.

The Carbon Trust is also funding the Advanced PV Research Accelerator for which Cambridge University, in collaboration with The Technology Partnership, has been announced as the preferred bidder. A core aim of this research is to create modules with 5 % efficiency and a lifetime of five years that can be manufactured on a roll-to-roll web up to one meter wide.

INDUSTRY STATUS

A number of UK PV companies including G24i, Solarcentury, QuantaSol and Whitfield Solar were listed in the Guardian/Library House Clean Tech 100 List 2008. The list aims to highlight a group of the most promising private companies in Europe focusing on clean technology; companies on the list are selected on the basis of their potential for future growth and beneficial environmental impact.

Some of the recent developments within the UK PV industry are summarised below;

Whitfield Solar, a spin out from Reading University, has developed a low-cost dual-axis solar concentrator PV system. QuantaSol, based in Surrey, design solar cells for use in concentrating PV systems, reporting 27 % efficiency and is aiming to increase this to greater than 40 %. Cardiff based G24 works on products using Dye Sensitised Thin Film (DSTF) technology.

PV Crystalox Solar manufactures multicrystalline silicon ingots in Oxfordshire. The company has grown to become one of the world's largest producers of multicrystalline silicon ingots, production in 2008 was expected to reach 225 MW equivalent per annum.

Sharp's module assembly plant in Wrexham increased production to around 220 MW in 2007.

Romag in Consett uses crystalline silicon PV cells and produces glass/glass and glass/tedlar laminates for showcase projects such as London City Hall, Arsenal Emirates stadium and the Eden Project in Cornwall.

FUTURE OUTLOOK

In October 2008 the UK parliament published amendments to the Energy Bill to enable two renewable tariffs; one for electricity and one for heat and biogas with an upper threshold of 5 MW per plant. The aim is to introduce the tariffs in April 2010 working alongside the existing Renewables Obligation. Negotiations over the coming year will establish the details of the tariffs and the timescale for introduction.

As discussed there are a number of policies and strategies helping to implement microgeneration including the Code for Sustainable Homes, Merton rule and EU directive. The amendments to the Renewables Obligation, with the extension to 2037 and double ROCs available for PV also support the PV industry. Further measures include plans to improve the grid network so this will not become an obstacle to microgeneration technologies in the future.
The Low Carbon Buildings Programme and the Carbon Emissions Reduction Target (CERT) will remain the main source of financial support for domestic scale renewables leading up to the tariffs for heat and electricity generation.

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND FUTURE OUTLOOK

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GENERAL FRAMEWORK

The U.S. Federal Investment Tax Credit (ITC) legislation had a great impact on the photovoltaics (PV) power industry during 2008. First, anxiety over the possible expiration of the ITC on 1 January 2009 encouraged a rush by businesses and consumers to install systems using the existing credits. Then, on 3 October 2008, the Emergency Economic Stabilization Act of 2008 was passed. The new Act extends the 30 % commercial ITC, eliminates the monetary cap for residential solar electric installations, and allows utilities and alternative minimum tax filers to take the credit through December 2016. However, the contraction of the global economy has cast uncertainty on the effect of the ITC in a time of tight lending and limited tax equity. The year concluded with legislators and lobbyists looking at modifications to the ITC to increase its immediate effectiveness.

Meanwhile, the U.S. Department of Energy (DOE) partnered with national laboratories, universities, and private industry to advance PV technology by financing research and development (R&D) and market transformation activities. Specifically, DOE launched funding programs aimed at developing pilot production of innovative cell technologies, bringing cross-cutting PV products to market and promoting advanced grid developments to accommodate high capacities of PV generation. Important utility-scale PV projects were completed in response to incentives, and new industry programs — power purchase agreements (PPAs), discounts on employee PV purchases, leasing plans, and community group purchases — also boosted the market.

NATIONAL PROGRAMME

The DOE Solar Energy Technologies Program (SETP) supports R&D and market transformation activities to develop cost-competitive solar energy systems. In 2008, DOE invested nearly 170 MUSD in U.S. companies, universities, and national laboratories. At the National Renewable Energy Laboratory (NREL), funding was ramped up to complete the Process Development & Integration Laboratory. This cluster of research tools will allow industry and universities to work with NREL R&D scientists on large-area solar devices to figure out how to scale manufacturing processes when moving from laboratory devices to commercial products. DOE funds companies to move prototype PV components and systems through the commercialization process. The PV Incubator project invested 17,6 MUSD (matched by company cost share) in six company-led, early-stage projects in 2008. Technology Partnership Pathways and university partnerships are some of the other innovative R&D funding approaches used by the DOE programme.

DOE market transformation activities, designed to remove barriers to the acceptance of new solar technologies in the marketplace, often make use of experts in the DOE R&D Programme at NREL, Oakridge National Laboratory, Sandia National Laboratories, the Southeast and Southwest Regional Experiment Stations, and private firms. Under this effort, DOE selected 25 "Solar America Cities" to receive shares of 5 MUSD and important technical assistance from programme experts to help create sustainable solar market infrastructures in their areas. Other market transformation activities included the creation of the Solar America Board of Codes and Standards (SolarABCs), which is designed to improve the development of codes and standards that facilitate the installation of safe, high-quality PV systems. In related work, programme experts also contributed to the first international concentrator qualification document, the International Electro-technical Commission standard 62108: Concentrator Photovoltaic Modules and Assemblies — Design Qualification and Type Approval. Technical assistance to states and utilities is also provided by other organizations, including the Interstate Renewable Energy Council, the Clean Energy Group, the National Association of Regulatory Utility Commissioners, and the Solar Electric Power Association. The Solar Energy Industry Association in the U.S. represents solar companies, providing policy and other analysis and information to the industry, and lobbying Congress on behalf of the industry.

Fig. 1 - NREL developed a new solar cell that was recognized by R&D Magazine as one of the year's most revolutionary technologies. The research team (pictured here) achieved 40,8 % efficiency.

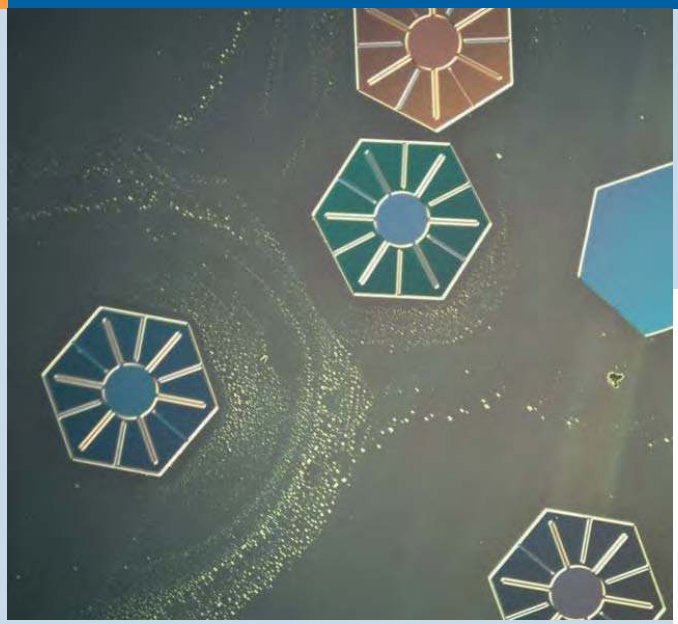

Fig. 2 - Sandia developed a crystalline silicon solar cell that is 20 microns thick and 500 microns across.

Recognizing that market transformation is affected by issues of interconnection to the grid, DOE sponsored the Renewable Systems Interconnection (RSI) study, which resulted in 14 published reports. Following recommendations from the RSI study, DOE began to invest up to 24 MUSD (plus company cost share) in Solar Energy Grid Integration Systems projects.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

R&D Programme efforts in 2008 focused on novel device architectures and production-relevant processes with the goal of improving performance while reducing costs. Results of the R&D Programme recognized in 2008 ranged from new, highly efficient solar cell designs to new processes for high-volume manufacturing of solar materials. R&D Magazine awarded two of its four Editors' Choice awards to PV technology advances.

Solar Cell and Module Efficiency Progress

- NREL—Achieved 40,8 % conversion efficiency for its inverted metamorphic triple-junction solar cell; achieved 19,9 % efficiency for a copper indium gallium diselenide (CIGS) solar cell and 19,2 % for a 1 cm^2 cell.
- IBM—Achieved 30 % efficiency for a concentrating PV cell using a thin liquid metal layer of gallium and indium to enhance the heat transfer properties of a 1 cm^2 silicon solar cell.
- SunPower—Announced a 23,4 % efficient thin-film silicon cell (12,7 cm).
- CaliSolar—Achieved greater than 15 % efficiency for crystalline silicon cells made from upgraded metallurgical-grade silicon feedstock.
- First Solar—Achieved 12,5 % aperture-area conversion efficiency for a cadmium telluride (CdTe) module.
- HelioVolt—Achieved 12,2 % CIGS efficiency with its process technology.
- Ascent Solar Technologies, Inc.—Achieved greater than 9,5 % efficiency for its production-line flexible CIGS monolithically integrated modules.
- Sencera International Corporation—Achieved 7 % sunlight-to-electricity conversion efficiencies under standard test conditions for single-junction silicon solar cells made using plasma-enhanced chemical vapor deposition.
- University of Washington—Achieved 5,1 % efficient plastic solar cells using alkanedithiols additives to dye-sensitized solar cells.

Other Achievements

- Pacific Northwest Laboratory in collaboration with NREL—Developed a flexible barrier coating for CIGS modules that passed stress tests for temperature and humidity equivalent to certification standards.
- NREL— Installed four new environmental test chambers to provide enhanced PV module testing.
- Sandia—Demonstrated prototype crystalline silicon PV cells that are only 20 microns thick; compared PV performance models using a full year of data; demonstrated a draft version of a predictive reliability model; completed first two years of Long-Term Inverter Performance Characterization effort.

IMPLEMENTATION

State and local government initiatives and policies, combined with the federal ITC, have encouraged installation of more than 330 MW of new PV generation capacity in 2008 (270 MW grid-tied and 60 MW off-grid).

New State and Local Initiatives

Rebate programmes supported installation of many PV systems nationwide. For example, California's Self-Generation Incentive Program and the California Solar Initiative provided a 7,9 MUSD rebate check to the Contra Costa Community College District for 3,2 MW of solar systems installed at three locations by Chevron Energy Solutions. New rebate programmes were instituted in four states so that by the end of 2008, 19 states offered PV rebate programs. However, some states have had trouble balancing rebate levels with consumer demand. Nevada and New Jersey stopped accepting rebate applications (for most types of systems), while Connecticut, Florida, Maine, Maryland, and Minnesota ran out of rebate funding. Existing rebate programmes were reduced in California and Connecticut. In Colorado, Xcel Energy (a public utility) lowered its incentive from 4,50 USD/W to 3,50 USD/W in late October because the company will soon reach its Renewable Energy Standard requirements dictated by Colorado law. Several states have lowered (or are likely to lower) PV rebate levels to coincide with the lifting (on 1 January 2009) of the 2 000 USD cap of the federal ITC for residential PV.

New Renewable Portfolio Standards (RPS) were established in Ohio, Michigan, and Missouri, raising the total number of U.S. states with such policies to 28. The RPS policies in Ohio and Missouri include a "solar carve-out," which requires a specific portion of electricity (or energy) to be generated using solar resources. RPS policies were

Fig. 3 - High-efficiency solar cells are used in utility-scale "concentrator PV" systems such as this one made by SolFocus in California.

significantly expanded in the District of Columbia, Maryland, and Massachusetts. In addition, two states—South Dakota and Utah—established renewable energy goals, which are not legally binding.

Net metering remains a very popular policy tool for promoting PV and other renewables. In 2008, 13 states and the District of Columbia enhanced existing net-metering policies, Michigan established a new net-metering policy, and Texas abandoned net metering. In addition, eight states adopted new or expanded comprehensive interconnection standards.

Feed-in tariff incentives were offered for the first time at the state and city government level in 2008. California is considering changes that would expand applications of its feed-in tariff, and other states, including Hawaii and Wisconsin, are considering feed-in tariffs to promote solar installations. The first city feed-in tariff was approved by Gainesville, Florida, to take effect in 2009. The city-owned Gainesville Regional Utilities proposed paying 0,32 USD/kWh for solar power, which could provide a 3 % to 5 % return on investment for residential or business customers participating in the programme. Other cities, including Los Angeles, California, have proposed feed-in tariffs for 2009.

Two other new government initiatives include the Connecticut Solar Leasing Program and the Property Tax Financing Districts being set up by municipalities in California, including Berkeley, San Diego, and Palm Desert. The Berkeley FIRST program allows property owners to borrow money from the city's Sustainable Energy Financing District to install PV systems. The property owners repay the cost of the system over 20 years through an annual assessment on their property tax bills.

New Utility and Industry Programmes

Utilities are expected to play a much bigger part in building PV power plants in 2009. This is because the extension of the ITC removed language prohibiting utilities from applying for the 30 % tax credit. Even in the uncertain economy of early 2009, many utilities were actively planning large PV power projects to meet their generation needs and take advantage of the ITC.

Third-party financing and PPAs contributed to about 72 % of nonresidential PV installation in 2008, according to the AltaTerra Research Network. With PPA financing, commercial customers supply a rooftop or other property to host the PV system and agree to purchase the electricity generated at a specified rate (usually at or below current retail electricity rates) for a long term (20 years). The energy company covers all aspects of the PV installation: finance, design, purchase, maintenance, and monitoring. With this arrangement, the customer can buy solar electricity with no up-front investment, and the energy company and investors can apply available tax credits and incentives to the project.

Large retailers also installed commercial PV systems in 2008, and several big corporations announced plans to purchase or lease solar systems in 2009. Residential installations also benefited from third-party and PPA financing. Companies offering residential leasing programmes for solar power systems in 2008 helped reduce the homeowner's up-front costs for a PV system. For example, a typical 2,5 kW system of 25 000 USD can be reduced in price to 2 000 USD. In addition, residential PPA financing resulted in monthly payments that vary with the electricity production of the system.

Residential customers can own shares of PV power plants through the Sacramento Municipal Utility District (SMUD) SolarShares program. SMUD buys electricity from PV power plants and sells it to customers who subscribe to the program. For a fixed monthly price based on each customer's usage, the pilot programme gives a credit on subscribers' monthly bills for the electricity produced by the PV plant. Subscribers are expected to pay about 10 % more for electricity over the year. SMUD also owns its own solar generating plants. Similar green pricing programs have been announced in other cities, including Los Angeles, to increase generation and reduce greenhouse gas emissions.

Community group purchases by the company 1 Block Off the Grid (1BOG) negotiated up to 48 % off of the market price of 2-kW PV systems for its participants in San Francisco during 2008. Other programs like Go Solar Michigan of the Great Lakes Renewable Energy Association and Go Solar Marin have offered group purchases for several years. Partnerships between PV suppliers and large employers are offering as an employee benefit the option to buy discounted residential solar systems.

INDUSTRY STATUS

According to the Solar Electric Power Association (SEPA), by the end of 2008, there were over 60 000 distributed solar electric systems interconnected across the United States. SEPA estimates that grid-tied PV installations are conservatively expected to exceed 100 000 by 2010 and 250 000 by 2015. Other analyses classify

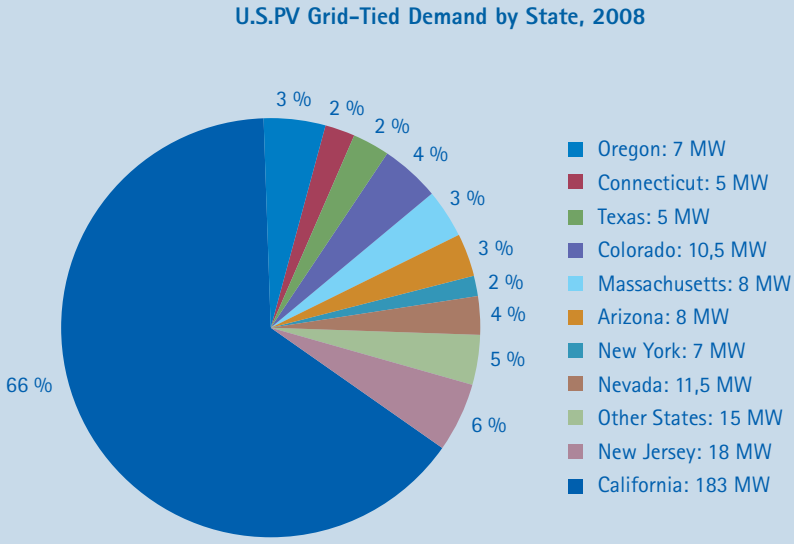

Fig. 4 - More than 65 % of 2008 U.S. grid-tied PV installations were in California (photo GTM Research, Prometheus Institute).

about 100 companies as active PV cell and module manufacturers in North America. Of these companies, 72 are seen as start-ups that are bringing innovative technologies to market. Venture capitalists invested almost 1 600 MUSD in solar companies in the third quarter of 2008 alone, compared to more than the 1 050 MUSD total venture capital investment in 2007. Companies developing thin-film modules using CIGS or CdTe received some of the largest rounds of investments. SoloPower and AVA Solar each raised more than 100 MUSD this year, while Solyndra reported raising more than 219 MUSD USD from 23 investors. Nanosolar took in 300 MUSD in investments.

Expanding Production

In addition to expansion of existing facilities, the following PV companies opened new manufacturing facilities in 2008: EPV Solar, 20-MW capacity, Robbinsville, New Jersey; Global Solar Energy, 40-MW capacity, Tucson, Arizona; HelioVolt, 20 MW capacity, Austin, Texas; Konarka Technologies, 10 million m² per year of flexible solar film, Lowell, Massachusetts; Miasolé, 40 MW capacity, Santa Clara, California; Nanosolar, up to 1 GW capacity per year, San Jose, California; SolarWorld, 500 MW capacity by 2011, Hillsboro, Oregon; Solon AG, 60 MW capacity, Tucson, Arizona; Suniva Inc., 32 MW capacity by 2010, Norcross, Georgia.

Underwriters Laboratories (UL) announced the opening of its 1 858 m² PV Technology Center of Excellence certification facility in San Jose, California. It is the largest commercial laboratory for PV testing and certification in the United States, with 14 test chambers and two solar simulators.

Utility-Scale PV Projects

Important utility-scale projects came on line in 2008, generating green power for many Americans.

- A 10-MW thin-film (CdTe) PV installation called the El Dorado Solar Energy (a subsidiary of Sempra Energy) project was completed near Boulder City, Nevada, in fewer than six months. Pacific Gas and Electric Company signed a 20 year agreement to buy the electricity from the project.
- A 3-MW PV project was completed outside of Philadelphia, Pennsylvania, to provide power and renewable energy credits to Exelon Generation LLC. The crystalline silicon PV project is located on the 61 512 m² Waste Management G.R.O.W.S. landfill site.
- A 2,3-MW single-roof PV system was installed at Toyota's North America Parts Center in Ontario, California. Toyota will purchase the generated electricity from GE Energy Financial under the SunPower Access™ power purchase agreement program.
- A 2,1-MW solar power system was installed at Applied Materials Inc. corporate campus in Sunnyvale, California.
- A 2-MW PV power plant completed on the rooftop of a commercial building in Fontana, California, is the first project in the three-year, 250 MW rooftop initiative of the Southern California Edison utility.
- A 1,1-MW solar power system supplies electricity to Valley Center Water District, a public water agency and one of the top 20 power purchasers in the San Diego Gas & Electric Company service area.

Several large PV projects were installed this year at busy airports. The most visible was dedicated at Colorado's Denver International Airport, which serves nearly 50 million passengers each year. The 2 MW system spans 51 512 m². Another 2-MW system was installed at Fresno airport in California.

MARKET DEVELOPMENT

According to preliminary estimates, total U.S. PV capacity (grid-tied and off-grid included) increased by 330 MW in 2008, for a total of 1 106 MW PV installed capacity at the close of 2008. California accounted for nearly 66 % of all PV installations in the country, but other top states for installations included Arizona, Colorado, Hawaii, Nevada, and New Jersey.

The United States provided more than 7 % of PV module shipments worldwide from early estimates, or nearly 376 MW. Nearly 54 % of this total was in the form of thin-film modules. (EPV Solar, First Solar,

Fig. 5 - Many U.S. homebuilders are using roof-integrated PV systems such as the "solar tiles" shown on the rooftops of this 77-unit solar condo housing development in California. Each system provides owners with about 1 kW of solar energy.

Global Solar, and United Solar). On the demand side, the U.S. consumed an estimated 7 % of the global demand for module products, or 313 MW.

FUTURE OUTLOOK

The stronger dollar could hurt exports of U.S. products, and the economic slump has caused some companies to reduce their sales forecasts. There are some concerns of module oversupply, demand uncertainty, and falling prices and, hence, industry profits. PV module prices are expected to fall up to 12 %. Related prices for silicon and thin-film materials are expected to fall up to 30 %. On the positive side, the Federal ITC was extended, the cap on the amount of ITC allowed for residential installations was removed, and utilities are now allowed to benefit from the ITC. With increased production, transmission construction, and incentives, PV is poised to become a contributor to economic recovery in 2009 and beyond.

Acknowledgements: The following people reviewed and contributed to this report: Katie Bolcar, Hannah Muller, Selya Price, Scott Stevens, and Sarah Truitt, U.S. Department of Energy; Carol Anna and Lauren Poole, National Renewable Energy Laboratory; Charles Hanley, Sandia National Laboratories; Travis Bradford, Prometheus Institute; Larry Sherwood, Sherwood Associates; Rusty Haynes, University of North Carolina; and Patricia Weis-Taylor, PWT Communications.

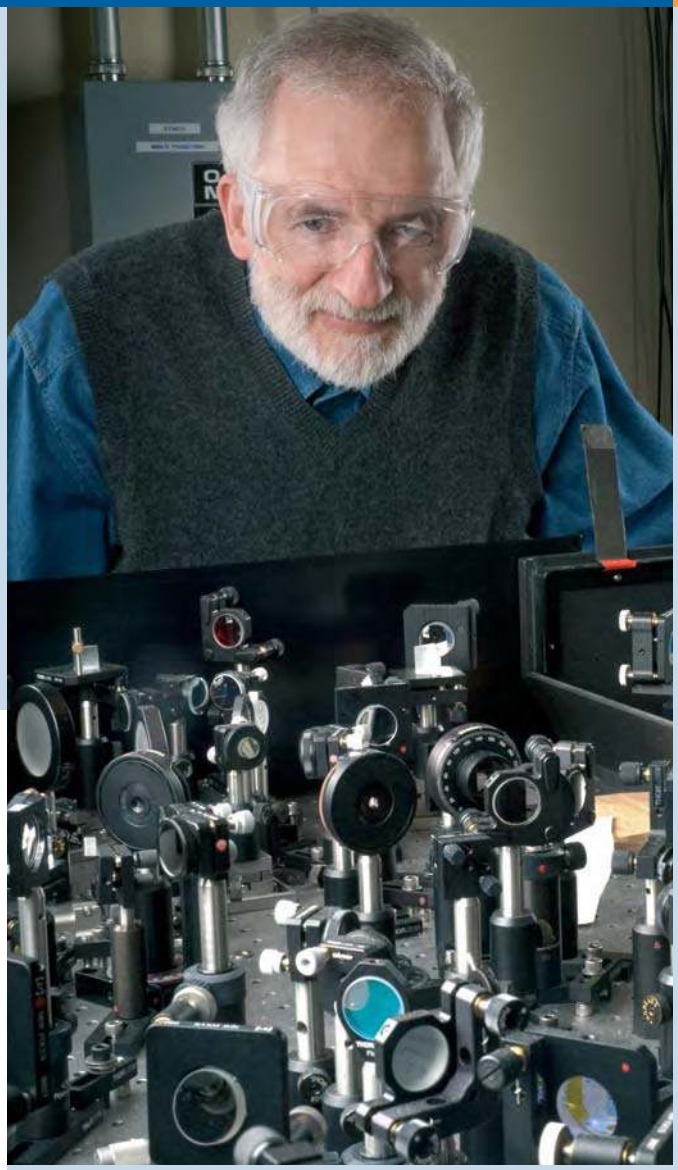

Fig. 6 - NREL's senior research fellow Dr. Arthur Nozik (pictured) received an International Eni Award for his work with quantum dots and more efficient solar conversion. The Eni is touted as the Nobel Prize of energy research.

COMPLETED TASKS
TASK 2 - PERFORMANCE, RELIABILITY AND ANALYSIS OF PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 2 was to provide technical information on PV operational performance, long-term reliability and costs of PV systems, which is very important for an emerging technology. This service was given to a diverse target audience including PV industry, research laboratories, utilities and manufacturers, system designers, installers, standardisation organisations and the educational sector. Task 2 aimed to provide performance data for both general assessments of PV system technologies and improvements of system design and operation.

MEANS

Task 2 work was structured into seven subtasks in order to achieve the objectives.
These were achieved through the development and continuous update of the PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV power systems and subsystems. Task 2 also analysed performance and reliability data for PV systems and components in their respective countries. Activities included the work on the availability of irradiation data, performance prediction for PV systems, shading effects and temperature effects as well as long-term performance and reliability analysis, monitoring techniques, normalised evaluation of PV systems, user's awareness and quality aspects of PV system performance.

Subtasks 1, 5, 6 and 7 were terminated at the end of 2007, while Subtask 3 was concluded in 1999 and Subtasks 2 and 4 were terminated in 2004. Task 2 was officially concluded in 2007.

SUBTASK 1: PV PERFORMANCE DATABASE

Participants worked on the development and update of a PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV systems and subsystems located worldwide. The information was gathered and presented by means of standard data collection formats and definitions. The database allows the comparison of components' quality, long-term operational results, analysis of performance and yields, long-term operational results, analytical calculations, yield prediction and checking of design programmes. A collection of such a variety of high quality operational data presents a unique tool for PV system performance analysis. The performance data are available at the IEA PVPS website: www.iea-pvps.org. In addition, the complete database programme can be downloaded from the same website.

SUBTASK 2: ANALYSIS OF PV POWER SYSTEMS (FROM 1999 TO 2004)

Participants analysed performance and maintenance data for PV power systems and components in their respective countries, both in order to ensure the quality and comparability of data entered in the database under Subtask 1 and to develop analytical reports on key issues such as operational performance, reliability and sizing of PV systems. Participants also compared existing data on operational reliability and developed recommendations on maintenance aspects.

SUBTASK 3: MEASURING AND MONITORING APPROACHES (FROM 1995 TO 1999)

Participants worked on a handbook covering PV system monitoring techniques, normalised analysis of PV systems and national monitoring procedures in the IEA member countries. This document covered measuring and monitoring in the context of PV systems and expanded in breadth and details the issue of monitoring. It helped orientating and relating technical explanations and details of existing experiences and guidelines. Available documentation on measuring and monitoring approaches was brought together and assessed for their scope and contents.

SUBTASK 4: IMPROVING PV SYSTEMS PERFORMANCE (FROM 1999 TO 2004)

Participants worked on recommendations on sizing of PV power systems and suggested improvements for better PV system performance. Participants identified tools to process and analyse data for performance prediction and sizing purposes. Applied energy management schemes were analyzed from the energy and operating cost points of view. Participants took account of the work performed in other Subtasks and worked in collaboration with Task 3.

SUBTASK 5: TECHNICAL ASSESSMENTS AND TECHNOLOGY TRENDS OF PV SYSTEMS

Participants analysed and validated expertise and performance results from grid-connected (GCS), stand-alone (SAS) and PV-based hybrid systems. The aims of this subtask were to demonstrate up-to-date performance validation criteria for a qualitative ranking of PV grid-connected, stand-alone and PV-based hybrid systems. It also identified high performance products, technologies and design methodology in order to foster the development of maximum conversion efficiency and optimum integration of PV. Activities included evaluating PV performance over time and failure statistics, analysing the end-user's consciousness on PV system performance and the use of satellite images for PV performance prediction.

SUBTASK 6: PV SYSTEM COST OVER TIME

Task 2 identified and evaluated 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. Participants worked on national case studies on performance and costs in their countries to provide a good insight of performance and cost trends of PV systems for a 10-year-period.

SUBTASK 7: DISSEMINATION ACTIVITIES

Task 2 put enhanced efforts to disseminate Task 2 results & deliverables to target audiences on the national and international level using websites, workshops & symposia as well as presentations at conferences and seminars. Task 2 deliverables range from the PV Performance Database to technical reports and conference papers. The public PVPS and Task websites enabled downloads and technical information to be provided quickly and cost-effectively to the users. The Task 2 website is available in eight different languages spoken by the Task delegates. For gaining information on the user profile and

customers of Task 2 deliverables, monthly download statistics were prepared on a regular, biannual basis.

Activities included seminar presentations, training courses for system designers and installers (Italy), European master course and university seminars to advanced students (France, Germany), conference contributions for national and international audiences as well as presentations and distributions of the Performance Database programme and other Task 2 deliverables.

Task 2 developed a web based educational tool in close cooperation with Task 10 that is available at www.bipvtool.com. This tool represents a detailed, practical source of information on building integrated PV from the idea to the long-term operation of PV systems.

TASK 2 REPORTS AND DATABASE

Task 2 produced the following technical reports, workshop proceedings and database programme from 1997 to 2007:

Database

IEA PVPS Database Task 2, T2-02:2001 http://www.iea-pvps-task2.org

Task 2 Technical Reports

1. ANALYSIS OF PHOTOVOLTAIC SYSTEMS, T2-01:2000, April 2000
2. OPERATIONAL PERFORMANCE, RELIABILITY AND PROMOTION OF PHOTOVOLTAIC SYSTEMS, T2-03:2002, May 2002
3. THE AVAILABILITY OF IRRADIATION DATA, T2-04:2004, April 2004
4. COUNTRY REPORTS ON PV SYSTEM PERFORMANCE, T2-05:2008, December 2004
5. COST AND PERFORMANCE TRENDS IN GRID-CONNECTED PHOTOVOLTAIC SYSTEMS AND CASE STUDIES, T2-06:2007, December 2007
6. PERFORMANCE PREDICTION OF GRID-CONNECTED PHOTOVOLTAIC SYSTEMS USING REMOTE SENSING, T2-07:2008, March 2008

Task 2 Internal Reports

1. HANDBOOK ON MONITORING AND MONITORING APPROACHES, ECN, Netherlands, November 1998
2. PROCEEDINGS OF WORKSHOP "PV SYSTEM PERFORMANCE, TECHNOLOGY, RELIABILITY AND ECONOMICAL FACTORS OF THE PV INDUSTRY", ISFH, Germany, October 2005
3. REPORT ON USERS' AWARENESS OF PV SYSTEM PERFORMANCE, AIST, Japan, September 2007.

DELIVERABLES – WHERE TO GET THEM?

All technical reports are available for download at the IEA PVPS website:
http://www.iea-pvps.org and the Task 2 website: http://www.iea-pvps-task2.org/

PARTICIPANTS

Thirteen countries supported Task 2 activities:
Austria, Canada, European Union, EPIA, France, Germany, Italy, Japan, Poland, Sweden, Switzerland, United Kingdom, United States.

Participants represented the following sectors: research & development, system engineering, PV industry and utility.

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COMPLETED TASKS
TASK 3 - USE OF PHOTOVOLTAIC POWER SYSTEMS IN STAND-ALONE AND ISLAND APPLICATIONS

OVERALL OBJECTIVE

Task 3 was established in 1993 to stimulate collaboration between IEA countries in order to improve the technical quality and cost-effectiveness of photovoltaic systems in stand-alone and island applications.
When the **first programme (1993-1999)** was approved, the stand-alone photovoltaic sector was largely comprised of solar home systems for rural electrification, remote 'off-grid' homes in industrialised countries and PV consumer goods. PV hybrid systems and niche off grid applications such as PV powered bus shelters were also being introduced in certain countries.
As part of this programme, a number of documents were published as information about installed stand-alone PV systems worldwide. These included a **lessons learned book** featuring case studies from each country, as well as a survey of **PV programmes in developing countries**.

Task 3's **second programme (1999-2004)** was initiated against this background with the following overall objectives:

Considering all types of stand-alone photovoltaic systems, ranging from small PV kits to power stations supplying micro-grids, the main objective of Task 3 is to improve the technical quality and cost-effectiveness of PV systems in stand-alone and island applications.

TASK 3 Aimed:

- To collect, analyse and disseminate information on the technical performance and cost structure of PV systems in these applications
- To share the knowledge and experience gained in monitoring selected national and international projects
- To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems
- To contribute to the development of improved photovoltaic systems and subsystems"

The main target audience of Task 3 activities were technical groups such as project developers, system designers, industrial manufacturers, installers, utilities, Quality organisations, training providers, end users.

The 1999-2004 work programme included the following subtasks and activities:

SUBTASK 1: QUALITY ASSURANCE

Activity 11: Critical Review of Implementation of Quality Assurance Schemes

To develop quality assurance schemes that will lead to a warranty for all system installations at reasonable cost.

Activity 12: Technical Aspects of Performance Assessment on Field - Quality Management

To identify and establish practical performance assessment guidelines.

SUBTASK 2: TECHNICAL ISSUES

Activity 21: Hybrid Systems

To contribute to cost reduction through standardisation and modularity in order to facilitate large scale dissemination of PV hybrid systems.

Activity 22: Storage Function

To provide recommendations to decrease the cost of storage in PV and PV hybrid systems.

Activity 23: Load/Appliances : Load Management and New Applications

To provide a technical contribution to cost reduction by showing the cost efficiencies associated with effective load management and efficient appliance selection.

Collaborative activities had to develop knowledge based on project implementations, technological improvements from the equipment manufacturers, R&D programmes results, and feed-back coming from the field.

PUBLICATIONS

Task 3 publications can be downloaded from the IEA PVPS website www.iea-pvps.org and are listed below:

TECHNICAL REPORTS PUBLISHED BY TASK 3 DURING THE PERIOD 1999-2004

TITLE	REFERENCE NUMBER
Survey of National and International Standards, Guidelines and Quality Assurance Procedures for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-07:2000
Recommended Practices for Charge Controllers	IEA-PVPS T3-08:2000
Use of Appliances in Stand-Alone Photovoltaic Systems: Problems and Solutions	IEA-PVPS T3-09:2002
Management of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems	IEA-PVPS T3-10:2002
Testing of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-11:2002
Selecting Stand-Alone Photovoltaic Systems - Guidelines	IEA-PVPS T3-12:2002
Monitoring Stand-Alone Photovoltaic Systems: Methodology and Equipment - Recommended Practices	IEA-PVPS T3-13:2003
Protection Against the Effects of Lightning on Stand-Alone Photovoltaic Systems - Common Practices	IEA-PVPS T3-14:2003
Managing the Quality of Stand-Alone Photovoltaic Systems - Recommended Practices	IEA-PVPS T3-15:2003
Demand Side Management for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-16:2003
Selecting Lead-Acid Batteries Used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-17:2004
Alternative to Lead-Acid Batteries in Stand-Alone Photovoltaic Systems	IEA-PVPS T3-18:2004

SCOPE FOR FUTURE ACTIVITIES

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, "PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website:
www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities:
Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

CONTACT INFORMATION

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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
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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

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