IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS

annual report 2009

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2009

CHAIRMAN'S MESSAGE

Welcome to the 2009 Annual Report of the IEA Photovoltaic Power Systems Programme. Triggered by the situation of the global economy, 2009 has been a year with uncertainties and difficulties for some of the photovoltaic markets and industries. Prices for solar modules have seen strong reductions throughout the year. At the same time, photovoltaics is increasingly seen as a long term and significant option for a sustainable energy supply, keeping it as a promising sector for investment, an important part of various economic recovery plans throughout the world as well as a subject of increased and long term R&D strategies.

Important initiatives affecting both the technical and the market development of photovoltaics could thus be observed in the USA with the American Recovery and Reinvestment Act (ARRA) of 2009. In Europe, discussions have been ongoing in the context of the 2020 Strategic Energy Technology (SET) Plan and the launch of a Solar Europe Industry Initiative (SEII). Japan has introduced a new power purchase programme with increased purchase prices. The European Photovoltaic Industry Association (EPIA) has concluded a detailed study (SET for 2020) analysing the conditions for a 12 % share of the European electricity supply through photovoltaics by 2020.

As a leading international network of expertise, IEA PVPS has the mission and privilege to cooperate on a global level in this rapidly evolving 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 2009. The Solar Electric Power Association (SEPA) from the United States joined the PVPS Programme as the 24th member during the year. I welcome SEPA as the most recent IEA PVPS member and look forward to a long and fruitful cooperation. Contacts have been ongoing with China, Greece, India, New Zealand, Singapore, South Africa, and Thailand.

On the Task level, two new Tasks have been established within the PVPS programme in the year 2009: Task 13 on Performance and Reliability of Photovoltaic Systems and Task 14 on High Penetration of PV in Electricity Grids. Both projects have found broad support and interest from various PVPS members and will start their operational work in the year 2010.

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 24th European Photovoltaic Solar Energy Conference in Hamburg (Germany) and Solar Power International in Anaheim, CA (USA) attracted a large number of visitors and provided an excellent forum for dissemination purposes.

2009 was another productive year for PVPS with many new results from the various ongoing projects. With the conclusion of Task 10 on Urban Scale PV Applications, this project has seen a number of publications of high value. 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.

Stefan Nowak
Chairman

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its member countries. The European Union also participates in the work of the IEA. Collaboration in research, development and demonstration of new technologies has been an important part of the Agency's Programme. The IEA R&D activities are headed by the Committee on Research and Technology (CERT), supported by a small secretariat staff, with headquarters in Paris. In addition, four Working Parties on End Use, Renewable Energy, Fossil Fuels and Fusion, are charged with monitoring the various collaborative energy agreements, identifying new areas for co-operation and advising the CERT on policy matters. The Renewable Energy Working Party (REWP), chaired by the first PVPS chairman, Mr. Roberto Vigotti, oversees the work of ten renewable energy 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 late 2009, fourteen Tasks were established within the PVPS programme, of which seven are currently operational. The new Task 13 and Task 14 were endorsed in late 2009. The twenty-four PVPS members are: Australia, Austria, Canada, Denmark, EPIA, European Union, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, SEPA, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States. The European Photovoltaic Industry Association (EPIA) joined PVPS in 2005 and the Solar Electric Power Association (SEPA) joined PVPS in 2009.

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, Anaheim, California, USA, October 2009.

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. Begun in 1999.
- Task 9. PV Services for Developing Countries;
- Task 10. Urban Scale PV Applications. Begun in 2004. Follow-up of Task 7 (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.
- Task 13. Performance and Reliability. Endorsed in 2009.
- Task 14. High Penetration PV in Electricity Grids. Endorsed in 2009.

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

Fig. 1 - Towards a future of large-scale deployment of PV - joint Task 1 / Task 8 workshop held in Hamburg, Germany, 22nd September 2009, in conjunction with EUPVSEC.

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, are provided at selected conferences and meetings and can be downloaded from the website. *Trends* reports were initially produced every two years but are now produced annually to provide more timely information. From 1995 until the end of 2009 fourteen issues of *Trends* had been published.

SUBTASK 1.2: Newsletter

For many years a printed, colour newsletter, *PVPower*, was 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 is now published more often and 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. Thirty one issues of the newsletter had been compiled by the end of 2009.

Fig. 2 - Task 1 members and other PVPS colleagues disseminated national PV and PVPS Programme information at a workshop held on Jeju Island, Korea, 10th November 2009, in conjunction with PVSEC-19.

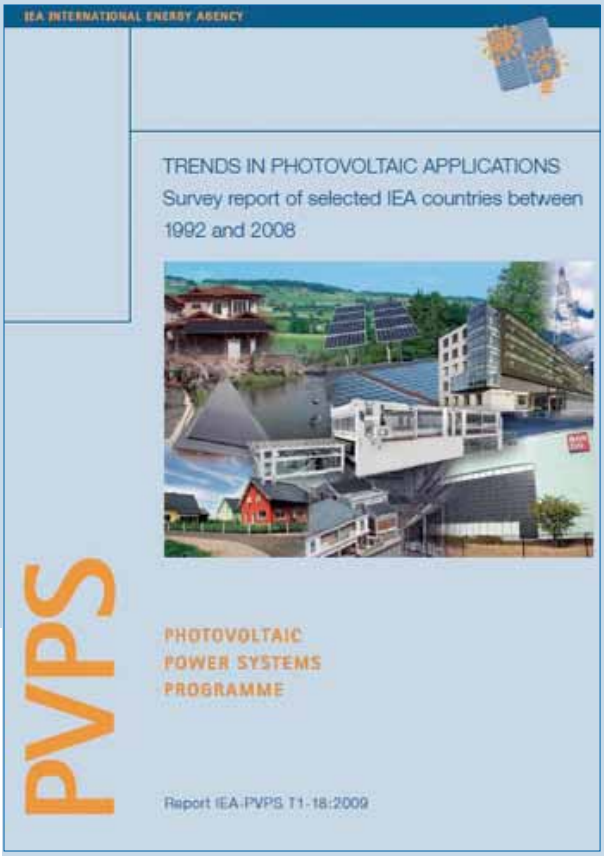

Fig. 3 - The Trends in Photovoltaic Applications report is produced annually and contains a useful snapshot of the world's PV markets, industry value chain and relevant public policies.

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 (several workshops), Grid parity and beyond, and Towards a future of large-scale deployment of PV. 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.

SUMMARY OF TASK 1 ACCOMPLISHMENTS FOR 2009

The key Task 1 priority is meeting the information needs of the various stakeholders and target audiences, in support 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 and other stake-holders. Also, Task 1 endeavors where possible to be an active contributor to other related workshops / events.

SUBTASK 1.1: Status Survey Reports

Full national survey reports for calendar year 2008 were received from more than 75 % of participating countries during 2009. Less than one quarter of participating countries still need to address the quality of their information provision. Timing remains problematic for a small number of countries.

The fourteenth *Trends* report was published in September 2009 and outlined a number of significant developments in both member and non-member countries during calendar year 2008. About 5,56 GW of PV capacity were installed in the IEA PVPS countries during 2008 (an increase of about 150 % over the previous year) which brought the total installed capacity to 13,4 GW. By far the greatest proportion (75 %) was installed in Spain and Germany alone. The growth of the annual PV market was staggering in a number of countries during that year. The Korean annual PV market increased six-fold. The Spanish annual market increased almost five-fold, as did the Italian market. The French annual PV market more than tripled as did the Portuguese market. There was a dramatic (five-fold) increase in silicon feedstock production in the US, with four active manufacturers, exporting about 85 % of production. The total PV cell production volume for 2008 in the IEA PVPS countries increased by 56 %. Germany replaced Japan as the leading producer of photovoltaic cells. Countries not part of the IEA PVPS reporting process accounted for close to 50 % of world PV cell production. Total module production increased by almost 50 % from 2007, following similar growth the previous year.

Conference papers / posters were developed for EUPVSEC and PVSEC-19 based on the information developed for the Trends report.

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. The first two issues of the e-newsletter (e-PVPower) were produced and disseminated, in July and September. Current and back issues of *PVPower* are available on the public website.

SUBTASK 1.3: Special Information Activities

Task 1 and Task 8 organized and held a combined, integrated workshop, “Towards a future of large-scale deployment of PV”, at

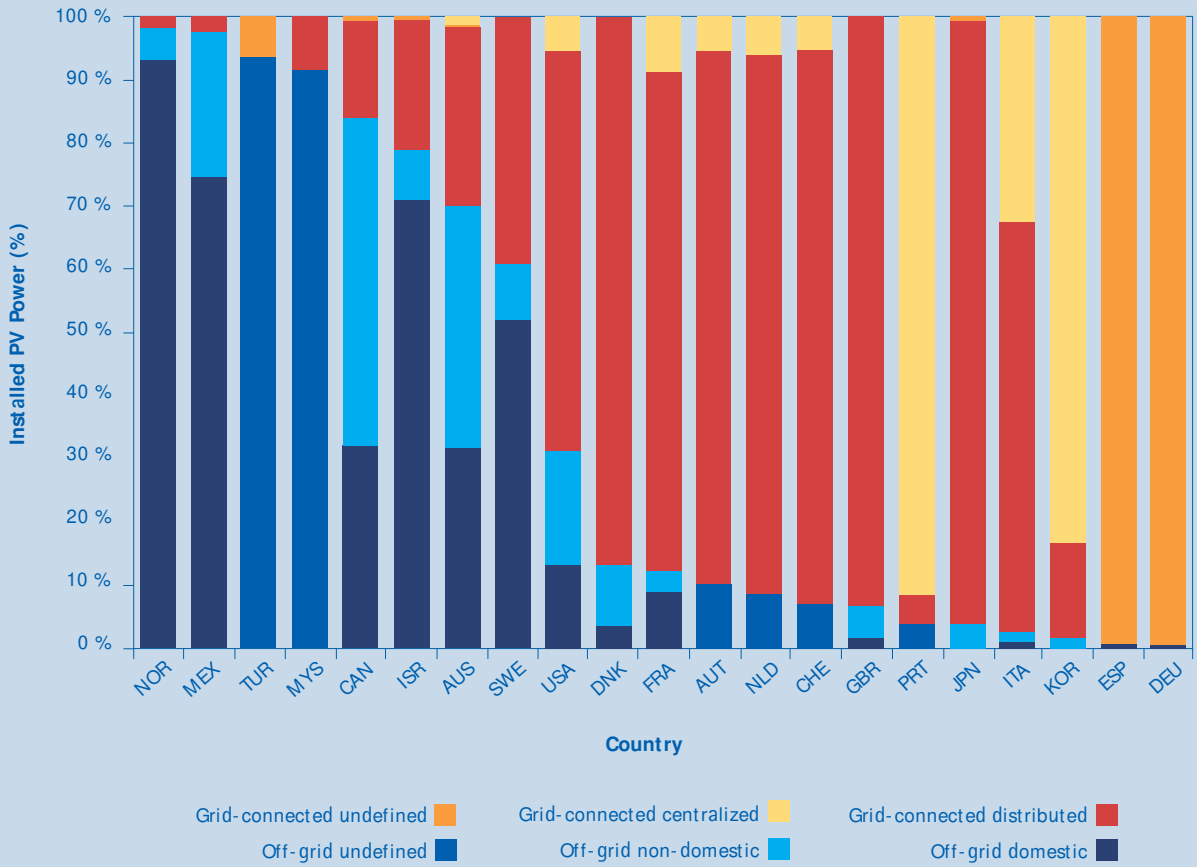

Fig. 4 - Over the years Task 1 has compiled a wealth of statistical information about the markets for PV worldwide.

EUPVSEC in Hamburg with 15 high quality speakers (from 10 countries) covering electricity utility topics and project development. The workshop was attended by 80 to 100 people.

Task 1 also organized a workshop in conjunction with PVSEC in Jeju, Korea, concerning IEA PVPS more generally and the national PV situation in Asia-Pacific and other countries.

All presentations were made available from the website.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2010

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 2010. These will all be made available via the public website.

The target date for publication of the 15th issue of the *Trends in Photovoltaic Applications* report is August 2010. Electronic versions of the information will be made available on the public website in July 2010 and conference papers will also be developed.

SUBTASK 1.2: Newsletter

Items for the newsletter are based on results and activities of the IEA PVPS Programme and key policy and programme information from the participating countries. It is planned that e-PVPower will be made available roughly quarterly (depending on availability of news and external requirements). At this stage, likely months for publication in 2010 are January, April, July and September.

SUBTASK 1.3: Special Information Activities

Task 1 (probably in conjunction with Task 14) will develop a workshop for EUPVSEC in Valencia, Spain early September 2010, dealing largely with electricity utility issues.

Other specific topics that may receive further attention from the Task 1 group include issues of interest from along the PV industry value chain and the evolution of the global PV 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 (2009 AND PLANNED)

The following were published and also made available on the public website during 2009:

Trends in photovoltaic applications in selected IEA countries between 1992 and 2008 Report IEA-PVPS T1-18: 2009 (plus papers and presentations at the EUPVSEC and PVSEC conferences).

e-PVPower issues 30 and 31.

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 2010 it is planned to produce the fifteenth issue of the Trends in Photovoltaic Applications report, up to four PVPower issues in e-newsletter format, and a range of country and workshop information. The website will be redeveloped in Content Management System (CMS) format during 2010.

MEETING SCHEDULE (2009 AND PLANNED 2010)

The 32nd Task 1 Meeting was held in Kota Kinabalu, Malaysia 4-6 March 2009, in conjunction with a workshop held in Kuala Lumpur.
The 33rd Task 1 Meeting was held in Leipzig, Germany 17-19 September 2009, in conjunction with EUPVSEC and an associated PVPS workshop held in Hamburg.
The 34th Task 1 Meeting will be held in Seville, Spain 3-4 June 2010.

TASK 1 PARTICIPANTS IN 2009 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 & Yvonnick Durand	ADEME
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer & Roxana Dann	Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	ERSE SpA
Japan	Osamu Ikki & Izumi Kaizuka	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
Malaysia	Wei-nee Chen & Gladys Mak	PTM
Mexico	Jaime Agredano Diaz	IIE
The Netherlands	Otto Bernsen	NL Agency, Directorate of Energy and Climate Change
Norway	Fritjof Salvesen & Lars Bugge	KanEnergi AS
Portugal	Pedro Paes	EDP
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Adam Hultqvist	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
Turkey	Mete Cubukçu	Ege University
United Kingdom	Samantha Cook	IT Power Ltd
USA	Carol Anna	NREL

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

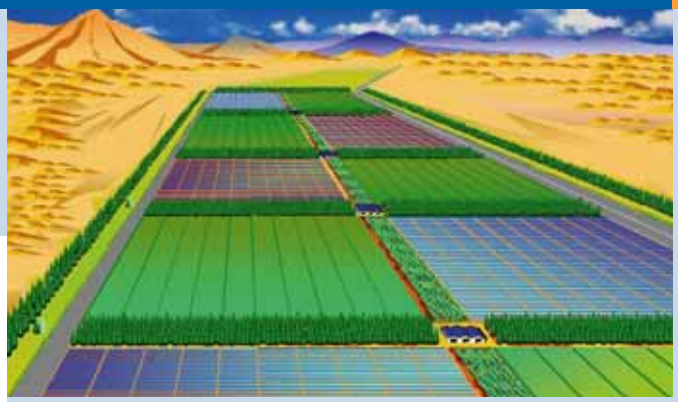

Fig.1 - Image of a VLS-PV System in a Desert Area.

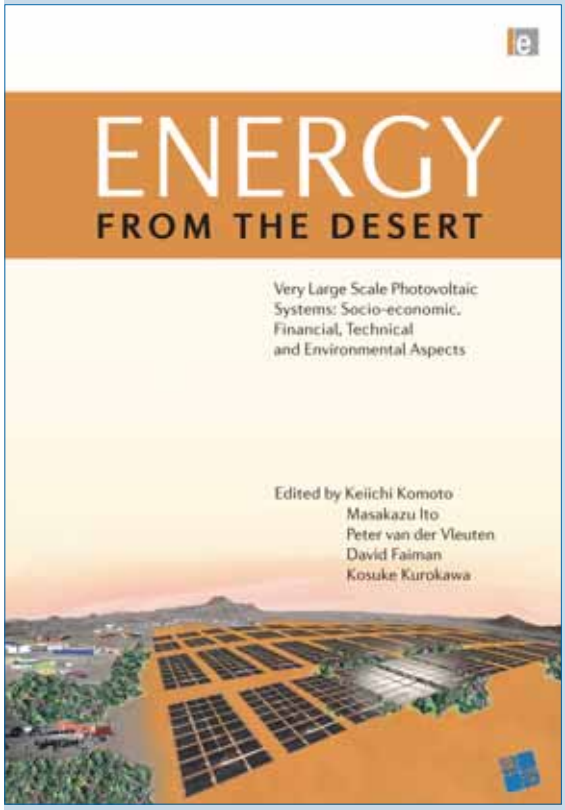

Fig.2 - Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects.

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).

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 would be 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, as new Task 8, officially established in 1999. Task8 started its 4th phase activity in 2009 under a three years Workplan.

In the 4th phase activity, three subtasks are organised:

- Subtask 2: Case Studies for Selected Regions for Installation of VLS-PV System on Deserts
- Subtask 5: General Instruction for Practical Project Proposals to Realize VLS-PV Systems in the Future
- Subtask 6: Future Technical Options for Realizing VLS-PV Systems

SUMMARY OF TASK 8 ACCOMPLISHMENTS FOR 2009

Task 8 published the latest technical report based on the 3rd phase activity entitled 'Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects' (See Fig. 2), and actively performed dissemination events.

Task 8 has started its 4th phase activity in 2009 based on a new three years Workplan. During 2009, through two meetings and e-mail communications, Task 8 discussed detailed working items to be discussed under the 4th phase for accomplishment of VLS-PV activity.

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 viewpoints of local, regional and global aspect. Japan leads the Subtask 2.

As for the LCA study on VLS-PV systems, Task 8 joined the Task 12 experts meeting in September 2009 in Hamburg, and both Tasks will start an information information exchange and collaborative work. Additionally, a new study on 'VLS-PV Drive Desalination Systems' was proposed. Furthermore, an updating on the remote sensing analysis and a collaborative study with Chinese members are under discussions.

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

Detailed practical instructions and training kit for the development of practical project proposals, to enable to sustainably implement VLS-PV systems in the future, will be discussed. Employing the results obtained in the previous phases, financial and institutional scenarios will be further discussed, and the guidelines for practical project proposals will be developed. The Netherlands leads Subtask 5.

The development of an 'Engineering and Financial Guideline for VLS-PV Systems' was proposed. The guideline will consist of 'Pre-engineering,' 'Technical engineering design' and 'Financial design.' Also, an idea on estimating 'Possible contributions of VLS-PV systems on global/regional sustainability issues' was proposed and discussed, as well as a VLS-PV strategy from viewpoints of socio-economic opportunities. The discussions are at a stage of a developing concept at this moment and all participants have confirmed the necessity of continual discussion.

Fig. 3 - 21st Task 8 meeting at OME office in Nanterre, France, in April 2009.

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 be also analyzed. Israel leads Subtask 6.

Not only future technical options such as hydrogen, global energy network, it was pointed out as an urgent issue for forecasting VLS-PV, that it would be necessary to understand the characteristics of VLS-PV and CSP.

OTHER ACTIVITIES

Publication of Technical Report

A technical report based on the 3rd phase, entitled "Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects," was published by Earthscan in 2009.
A summary of the book is available from the IEA-PVPS website.

Task 1 and Task 8 Joint Workshop in Hamburg, Germany

As a side event of the 24th EUPVSEC held in September 2009, the Task 1 and Task 8 joint workshop: "Towards a Future of Large-Scale Deployment of PV," was organised.
Seven members from Task 8 made presentations, mainly based on the 3rd phase report. At the workshop, the report was distributed to all participants.

Contribution to International Conferences

As dissemination activities, Task 8 made presentations at the following International Conferences:

- 24th EU-PVSEC in Hamburg, Germany (September 2009)
- 19th PVSEC in Jeju, Korea (November 2009)
- International Photovoltaic Solar Energy Conference and Exhibition, The Prospect of Large Scale PV (LSPV) Forum, in Beijing, China (November 2009)

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2010

Task 8 will continue to discuss and perform working items for accomplishment of the VLS-PV activity, along with the Workplan.

In order to disseminate Task 8 activities, e.g. results and on-going discussions, Task 8 will hold international workshops/symposiums on the occasions of related conferences:

- Task 8 workshop in conjunction with the Sede Boqer, in February 2010, in Israel
- International symposium as a side event of the Renewable Energy 2010 International, on 27 June 2010, in Yokohama, Japan.

KEY DELIVERABLES

Internal Publications

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

External Publications

Book: "Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems," James and James, 2003 (ISBN 1 902916 417)
Report: "Summary - Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems," 2003
Report: "Summary - Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems," 2006
Book: "Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems," Earthscan, 2007 (ISBN 978-1-84407-363-4)
Book: "Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects," Earthscan, 2009 (ISBN 978-1-84407-794-6)

MEETING SCHEDULE (2009 AND PLANNED 2010)

21st Task 8 Experts Meeting, 24-25 April 2009, Nanterre, France
22nd Task 8 Experts Meeting, 17-18 September 2009, Erfurt, Germany
23rd Task 8 Experts Meeting, 24-26 June 2010, Japan
24th Task 8 Experts Meeting, Autumn 2010

Fig. 4 - 22nd Task 8 meeting at Bosch Solar Thin Film GmbH, in Erfurt, Germany, in September 2009.

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	John S. MacDonald	Day4Energy Inc.
France	Fabrizio Donini Ferretti	Chora Finance
France	Karim Megherbi	Helios Energie
Germany	Claus Beneking	Aixcell Solar Technology GmbH
Germany	Edwin Cunow	LSPV Consulting
Germany	Joachim Koschikowski	Fraunhofer ISE
Germany	Christof Koerner	Siemens AG
Germany	Steven Pleging	Colexson Energy AG
Israel	David Faiman	Ben-Gurion University of the Negev
Italy	Fabrizio Paletta	ERSE
Italy	Angelo Sarno	ENEA
Italy	Gianluca Gigliucci	ENEL - Engineering and Innovation Division - Research
Italy	Michelle Appendino	Solar Ventures
Japan	Kosuke Kurokawa	Tokyo Institute of Technology (Tokyo Tech)
Japan	Keiichi Komoto	Mizuho Information & Research Institute (MHIR)
Japan	Tomoki Ehara	Mizuho Information & Research Institute (MHIR)
Japan	Masakazu Ito	Tokyo Institute of Technology (Tokyo Tech)
Japan	Masanori Ishimura	New Energy and Industrial Technology Development Organization (NEDO)
Korea	Jinsoo Song	Korea Institute of Energy Research (KIER)
The Netherlands	Peter van der Vleuten	Free Energy Consulting
The Netherlands	Jos van der Hyden	First Solar
USA	Thomas N. Hansen	Tucson Electric Power Company
USA	Herb Hayden	Southwest Solar Technologies, Inc
Mongolia (observer)	Namjil Enebish	National Renewable Energy Center

TASK 9 - PHOTOVOLTAIC SERVICES FOR DEVELOPING COUNTRIES

Fig. 1 - Woman weaving in the evening with son doing home work thanks to solar PV lighting in Bolikhomsay Province, Lao PDR (photo: IED).

Fig. 2 - IEA PVPS Task 9 Joint Workshop with Cap - REDEO project (EC funding) on potentials for Solar PV - diesel hybrids. From left to right: Mr Chareun, Advisor to the Minister of Energy, Lao PDR; Anjali Shanker - France / IED, PVPS; HE Mr Tun Lean, Director, Ministry of Energy, RG Cambodia - December 2008 (photo: IED).

RATIONALE AND OBJECTIVES

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 the electric network (an essential development infrastructure), to electric lighting, adequate clean water supplies, primary health care, education and other basic services. At the Milennium 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 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 Organization (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 available.

Unlike 10 years ago, today's framework conditions for the deployment of Renewable Energy is conducive as there is a broad consensus among global policy makers, that Renewable Energy and Energy Efficiency is a highway in the right direction. The Renewable energy conferences in Bonn 2004, Beijing 2005, Washington 2008 paved the way for international commitments and - together with the climate change debate and the oil prices - kept up the momentum for renewable energy on the international agenda. Hence today, more than 60 countries have a policy to promote Renewable Energy among them at least 23 are developing countries. Annual investments in renewable energy capacity have clearly crossed the 100 BUSD milestone and nearly all international financing institutions (WB, ADB, BID, KfW, AFD, etc.) promote their renewable energy products and funds.

The IEA is interacting more and more with the G8 (www.iea.org - G8 update) on issues related to Climate Change, Clean Energy and Sustainable Development. A number of publications have been made, focusing essentially on the OECD countries, but the spreading of recommendations and lessons learnt from studies such as *"Deploying Renewables, Principled for Effective Policies,"* and working out Developing Country specific dimensions is still needed.

At the country level, the situation is moving fast, though still very contrasted:

- A number of countries have formulated goals and targets in terms of *renewable energy deployment*: but policy frameworks still are in the making and business models under development. The situation is very contrasted between regions: India for example has a very sophisticated framework other developing countries could learn from, as much as from the different types of policies and measures implemented in OECD countries;
- A number of countries have formulated goals and targets in terms of access to modern energy and electricity, in the perspective of achieving the Millenium Development Goals, alleviating poverty: institutional structures are changing fast, with privatization of utilities and emerging of rural electrification agencies. Financing and implementation models need to be thought through, learning also from the various models of funds and agencies set up in OECD countries such as NRECA in the US or FACE in France; in Asia such as the Indian Renewable Energy Development Agency (IREDA) or the Rural Electrification Corporation (REC).

Though there definitely is an intersection between the above two issues of deployment of renewable energy and increased access to modern electricity services, there is no total overlap.

Fig. 3 - Cleaning PV Panels from a solar PV drinking water pumping system in the Sahel - PRS project from the European Commission (photo: IED).

Fig. 4 - Technical monitoring of a solar PV drinking water pumping system in the Sahel - PRS project from the European Commission (photo: IED).

2009 - THE END OF THE FIRST DECADE OF TASK 9

The year 2009 marked the end of the first decade of Task 9, and was a year of thinking back over past achievements and reconsidering the remit of Task 9. In order to capitalize on past work, a summary brochure was produced: *"Photovoltaic Services for Developing Countries*, **10 years of Task 9**."

The document covers the practical achievements of Task 9 as group, which can be summarized as *"Getting PV on the Agenda."* The group of experts crystallized key messages over time, through 10 publications, so called "Recommended Practice Guides - RPGs" and flyers, which have been distributed at conferences and workshops and used as supporting documents for courses and lectures. These publications can be downloaded free of charge from the IEA PVPS website: www.iea-pvps.org. The target groups of the RPGs are project planners and appraisers in development agencies, local institutions that wish to facilitate the introduction of new RE-technologies into rural markets and rural service utilities (water, electricity) that wish to extend their services.

Under its "International Relations" Subtask, the group worked towards getting PV on the agenda, initiating dialogue through partnerships, organizing relevant workshops and commenting policy papers and strategies of major donors and lending institutions including the G8. Over the last decade of dialogue, T9 initiated and participated in over 30 events, which can be classified in 3 categories - with details provided in the full report:

1. Discussion and exchange workshops;
2. Relevance of PV beyond SHS - brainstorming sessions;
3. Outreach in countries.

The key messages and perspectives, drawing on 10 years' of activity, can be summarized as follows:

1) *Do not Design and Run Technology Driven Projects*: focus on the final service to be provided and on all the players and activities in the value chain.
2) *Raise Awareness, Build a Community*: Provide opportunities to express different opinions and strategies for the promotion of renewable energies, getting professionals talking to each other and to define benchmarks, making nations understand the way forward to achieve the intended impact.
3) *Develop a Strategy and Operational Implementation Plans*: The political intention to provide access of modern energies to unserved people is on the agenda of many actors but sound strategies to achieve their goals, and formulation of operational financial mechanisms to effectively strengthen national capacity are still needed.

In parallel, the group continued its substantive production, for example the publication of scoping document on the potential for PV injection in diesel isolated systems.

DEPLOYING PV AND RENEWABLE ENERGY IN DEVELOPING AREAS

A Proposed Follow Up to Task 9

Building on the experience and lessons of 10 years' work, the Task 9 group formulated a new work program in 2009, for which a number of PVPS contributing countries have expressed interest. The first semester of 2010 will tell whether there is sufficient and real resource commitment to support the new work program, called *"Deploying PV and Renewable Energy in Developing Areas,"* with two major issues to be addressed:

1. **Access** to modern and sustainable electricity services in developing areas: What contribution from PV and renewable energy?
2. **Effective deployment of PV** and renewable energy technology services, which in the medium and long term reduces environmental impacts and costs.

Method of Work and Approach

The need for *"International Megaphones"* to reach the target audience. A prerequisite to be effective in reaching out is to establish Key Partnerships with carefully chosen relay(s) - or "international megaphones" and a strategy. The areas of work will be focused on in common looking at the past production of RPGs and on the areas of

Fig. 5 - Solar Panel array for a community PV service system on Wallis and Futuna, substitution for diesel consumption (photo IED 2009).

work of the current Workplan. The interactions must result in writing a clear Memorandum Of Understanding with the partner organizations, formalizing a common work program (3 years) and financial commitment. In order to maximize the spread of the message, it is suggested to contact regional organizations / large countries and to establish links with relevant agencies:

- To discuss synergies with Task 9 and common outputs: Workshops and events. Training. Publications. Working on specific issues and cases.
- A long list of such organizations could be: ADB, ACE, ASEAN Secretariat, ECOWASS, CEMAC, CILSS, OCT, SADCC, etc.
- Focus on those countries / regions where RE targets have been set, but no implementation plan formulated
- The "tools" at hand are the 10 existing publications already on the PVPS website and the substantive products described in the above section.

The Task 9 Workplan is divided into two categories of activities: those related to outreach and communication - above; those related to developing / adapting substantive content.

Proposed Thematic Areas of Work

Drinking Water Supply, Renewable Energy and the MDGs: The objective is to reach a substantive discussion on avenues for constructively and practically overcoming constraints of high upfront investment costs and offering a discussion of interest in terms of financing and implementation models applicable to drinking water supply and to off grid renewables by extension. An central issue to be addressed is that of covering the running costs which is the responsibility of the village / district level whilst the central level can cover investment costs.

Integrating PV in Mini-Grids for Rural Electrification: Building on the work of Task 9 and the production of the Flyer and Task 11 (hybrids), Task 14 (integrating PV in grids), the Alliance for Rural Electrification (hybrids) and PV Technology Platform (Feed in Tariff for Rural Areas) and given the specific context of developing areas where grids are often weak and unstable, where in remote areas, there is basically no better option than diesel based generation. PV now offers potential solutions, both technically reliable and economically viable. This area of work is of direct interest in terms of wide scale applications in South East Asian countries where there are numerous island archipelagoes; in semi-desert areas such as the Sahel, which have large numbers of diesel installations.

Pico PV Services: Recognizing that there are a large number of people living in remote rural areas away from the grid who basically have lighting and basic telecommunication needs, new very low consuming technologies such as LEDs offer new perspectives in terms of multiplying the number of people having access to services - including through efficient battery charging. Innovation is very speedy, and implementation models still need to be developed. A minimum amount of technical know-how is required to avoid proliferation of sub quality equipment.

PV in the Built and Urban Environment: PVPS Task 10 has produced recently a book on PV in the Built Environment. Given the fast growth of cities in a number of Asian and African countries, with substantial numbers of new buildings coming up yearly, the adequacy of air conditioning needs and the solar PV production load profiles and the fact that PV technology price is fast reducing, building integration of PV would certainly need to be better known. Though the average per capita income in a country may be low, there are often up market office and condominium buildings as well as shopping malls with glass façades being built. They are often energy inefficient and a heavy burden on peak load, implying huge investment burdens on the utility and often leading to brown outs. PV integration in facades today has a relatively modest incremental cost and would deserve to be promoted. Beyond BIPV, integration of PV in the urban environment presents tremendous structural benefits in that it changes the outlook of urban planners and generally orients towards a more sustainable development attitude within urban planning.

Large Scale PV: A similar approach with a PVPS publication and to be coordinated with the numerous ongoing initiatives of the international community, as well as Task 8.

TASK 9 MEETING SCHEDULE (2009 AND PLANNED 2010)

2009

21st Experts' Meeting, May, Munich, Germany.

2010

22nd Experts' Meeting, February, Lyon, France.
23rd Experts' Meeting, September, Stockholm, Sweden.

Fig. 6 - Inauguration of a solar PV drinking water pumping system in the Sahel - PRS project from the European Commission (photo: IED).

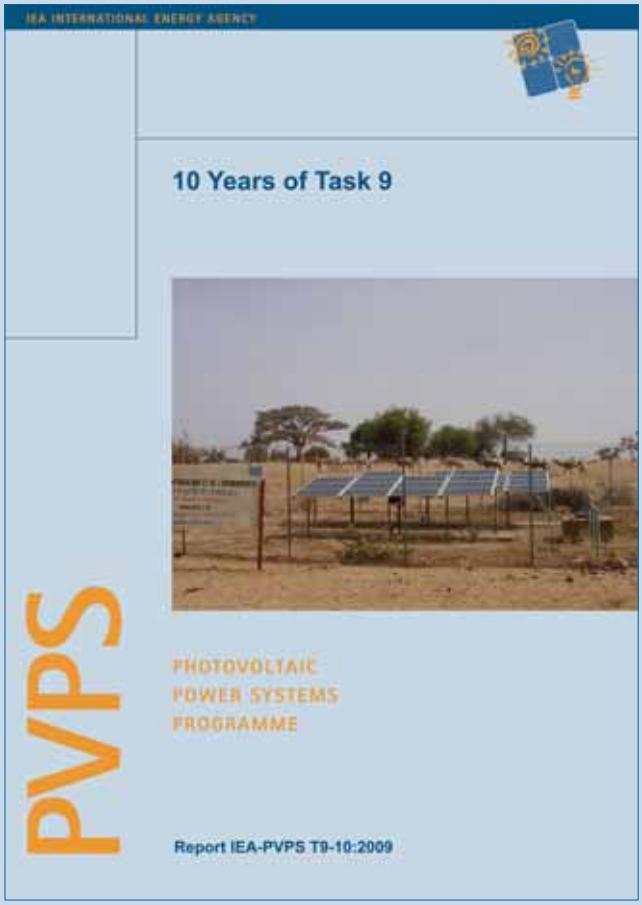

Fig. 7 – Latest Report from Task 9 Photovoltaic Services for Developing Countries, "10 Years of Task 9."

TASK 9 PARTICIPANTS

COUNTRY	NAME	AFFILIATION
Australia	*To be confirmed*	
Canada	*To be confirmed*	
Denmark	Peter Ahm	PA Energy
France	Anjali Shanker	IED
France	Lara Bertarelli	IED
Germany	Michael Blunk	GTZ
Germany	Rolf Posorski	GTZ
Japan	Takayuki Nakajima	JPEA
Japan	Masa Ishimura	NEDO
The Netherlands	Otto Bernsen	Senter Novem
Sweden	Linus Palmbald	Ministry of Energy
Switzerland	Alex Arter	ENTEC
Switzerland	Bettina Bühler	ENTEC
Switzerland	Thomas Meier	ENTEC
United Kingdom	Bernard McNelis	IT Power
ARE	Guido Glania	ARE
EPIA	Eleni Despotou	EPIA

TASK 10 - URBAN SCALE PV APPLICATIONS

INTRODUCTION

Task 10 had a 5 year planned period of work, but was extended for six months with its last meeting in Rome, Italy, May 2009. The Workplan for Task 10 was designed for flexibility towards the fast growing and emerging PV market. The PV Market grew at a compound annual growth rate of more than 40 % during the Task 10 work period (2004-2008), mainly due to aggressive incentive policies. Now in 2009, system prices are dropping, values related to climate change are a reality, grid parity to retail rates are emerging, and utilities are making substantial investments!

The Task's work was targeted at a wide array of stakeholders, realizing that the added values of PV technology markets required a transition from a bilateral business between utilities and customers to multilateral business(s) between utilities, customers, municipalities, builders/ developers, solar industry and financial institutions. In 2009, commercial businesses installed multi-megawatt distributed rooftop systems, utilities install panels on poles along the low-voltage distribution wires and municipal utilities partner with research laboratories for urban infill (see Figure 6 of Brookhaven 32 MW plan). The Task deliverables provide the foundation to assure the full value of PV, beyond the energy values, can be realized.

Task 10 work was a collaborative of technical experts from18 PVPS countries. Four of these countries brought in a significant parallel and coordinated body of work supported by the European Commission project titled PV-UP-SCALE or PV in Urban Policies: a Strategic and Comprehensive Approach for Long-term Expansion. PV-UP-SCALE also enhanced the contributions of Austria and France.

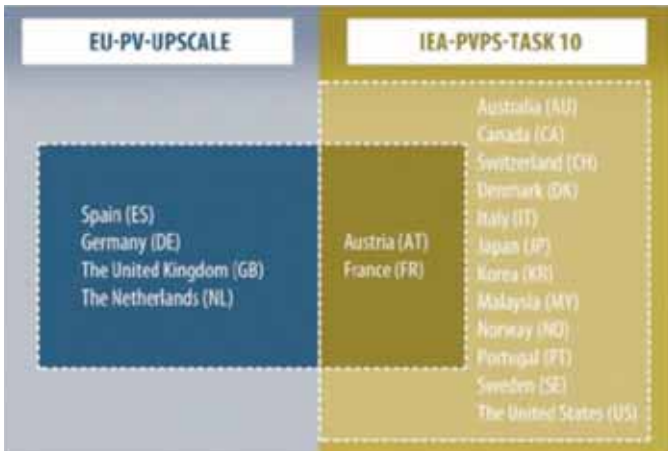

Fig. 1 - EU-PV-UPSCALE and Task 10 Country Participants

OVERALL OBJECTIVE

The objective for Task 10 was to develop the tools, analysis and research required to mainstream PV in the urban environment. The Task 10 products render the explosive market growth experiences from many countries into an array of relevant information for the multiple stakeholders required to continue PV growth in the world's energy portfolio.

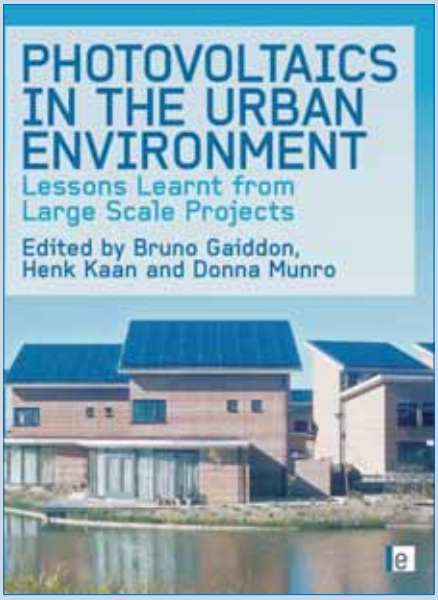

Fig. 2 - Joint Task 10 and PV-UP-Scale Urban Planning Book. 'In order to meet the challenges the world is facing we need nothing less than a global revolution in ways that energy is supplied and used... This book is the first kind of systematic collation of concrete urban scale PV projects and experience... I trust that [it] will find numerous readers among a broad range of professionals ranging from architects and engineers to urban planners and project developers.' From the Foreword by Stefan Nowak, Chairman, IEA PVPS.

The definition for urban scale PV applications:
Urban-scale applications include small, medium and large installations on both existing and new buildings, homes, sites, and developments as well as point-of-use, targeted load solutions on a distributed basis throughout the high density urban environment.

APPROACH

There are four subtasks in Task 10. The total range of deliverables was 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. Through developing and producing these deliverables, Task 10 will contribute to achieving the vision of mainstreaming urban-scale PV. The comprehensive list of targeted stakeholders is:

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

TASK 10 WORKPLAN

SUBTASK 1: Economics and Institutional Factors

This subtask seeks to provide opportunities for stakeholders to look beyond a single-ownership scenario to the larger multiple stakeholder values of the PV technology. 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.

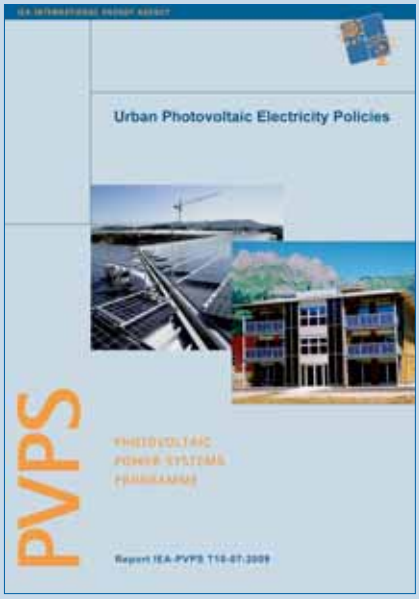

Fig. 3 - Task 10's "Urban Photovoltaic Electricity Policies," Report.

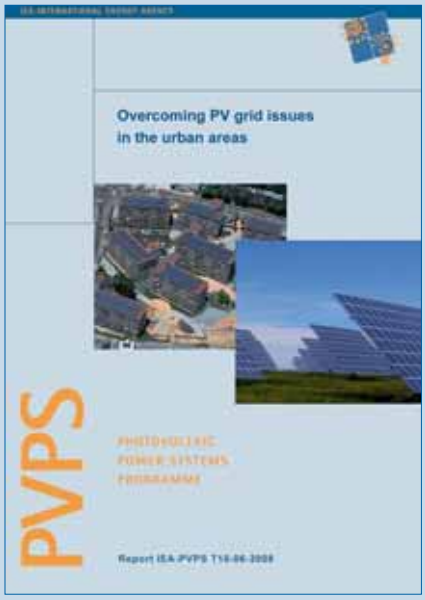

Fig. 4a - Task 10's "Overcoming PV Grid Issues in the Urban Area," Report.

	COUNTERMEASURES		
	GRID SIDE	**DEMAND SIDE**	**PV SIDE**
Overvoltage/ Undervoltage	LDC (Line voltage drop compensator) Shunt capacitor, Shunt reactor SVR (Step voltage regulator) Electric storage devices	Shunt capacitor, Shunt reactor Electric storage devices	Voltage control by PCS Electric storage devices
Instantaneous Voltage (Sags/Swells)	TVR SVC STATCOM Electric storage devices	DVR Electric storage devices Change	Electric storage devices
Voltage Imbalance Harmonics	STATCOM Shunt capacitor, Shunt reactor STATCOM Passive filter Active filter	DVR Shunt capacitor, Shunt reactor DVR Passive filter Active filter	Advanced PCS
Unintended islanding Protection	Electric storage devices Protective devices Transfer trip equipment	Electric storage devices Protective devices	Electric storage devices Advanced PCS
Short-Circuit Capacity			Advanced PCS
Disconnection Time for Intersystem Fault	Transfer trip equipment		
Increase in DC Offset from PC			Advanced PCS DC offset detector
Frequency Fluctuation	Electric storage devices	Electric storage devices	Electric storage devices
Supply Security	Electric storage devices	Electric storage devices	Electric storage devices
Peak Cut	Electric storage devices	Electric storage devices	Electric storage devices Advanced PCS

Fig. 4b - Source Overcoming Grid Issues in Urban Areas, T10-06-09, the table is a summary of grid issues countermeasures which may be applied to the grid side, demand side or PV side.

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, development and infrastructure planning practices.

In 2009 the book, Photovoltaics in the Urban Environment: Lessons learnt from Large Scale Projects, was published and launched at the 2009 EU - PV Solar Exposition and Conference in Hamburg, Germany. The book contains case studies of 15 existing and 7 planned urban PV communities, as well as information on regulatory framework and financing and design guidelines.

The report Urban Photovoltaic Electricity Policies was also published in 2009. The report provides information and analysis on both direct and indirect urban policies relating to PV.

SUBTASK 3: Technical Factors

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

An extensive body of work was finalised into a report on grid issues, Overcoming PV Grid Issues in Urban Areas. The report documents the issues and countermeasures relating to integrating PV on the grid. The report also provides three case studies of high penetration urban PV projects in Japan, France and Germany.

SUBTASK 4: Targeted Information Development and Dissemination

This subtask is focused on the information dissemination of all deliverables produced in Task 10. The range of activities in this task included workshops, educational tools, databases, and reports. An innovative deliverable involved holding two marketing competitions for urban-scale PV designs and application targeted at urban solutions. Both competitions were sponsored by industry.

TASK 10 KEY DELIVERABLES

Reports

- Analysis of PV System's Values Beyond Energy -by country, by stakeholder,
- Promotional Drivers for Grid Connected PV
- Urban PV Electricity Policies
- Municipal utility forward purchasing
- Residential Urban BIPV in the Mainstream Building Industry
- Community Scale Solar Photovoltaics: Housing and Public Development Examples Database
- Overcoming PV Grid Issues in Urban Areas
- Compared assessment of selected environmental indicators of photovoltaic electricity in OECD cities
- Lisbon Ideas Challenge I
- Lisbon Ideas Challenge II

Book

Photovoltaics in the Urban Environment: Lessons learnt from Large Scale Projects

Databases

Educational Tool of BIPV Applications from Idea to Operation
www.BIPVtool.com
Database of community and BIPV applications, www.pvdatabase.com

PowerPoint

Network Issues and Benefits Visual Tool

Workshops

2nd International Symposium - Electricity From the Sun, Feb. 11, 2004 Vienna, AUS
PV integration in urban areas, Oct.6, 2005, Florence, ITA
Photovoltaics in Buildings - Opportunities for Building Product Differentiation, Mar.16, 2005, Lisbon, POR
Photovoltaic Solar Cities - From global to local, June 1, 2005, Chambéry, FRA
International Workshop: Photovoltaic in Cities, Sept 13, 2006, Malmö, SWE
Lisbon Ideas Challenge (LIC I) Final Ceremony, Nov. 23, 2006, Lisbon, POR
PV in the Urban Planning Process, Oct 24, 2007, Madrid, ESP (PV-UP-Scale)
PV international experiences towards new developments, May 13, 2009 Rome Italy

COUNTRY	CITY	PV PENETRATION AND GROWTH				
		NATIONAL		LOCAL LEVEL		
		Installed grid-connected capacity in Wp/capita	Growth rate of PV capacity in 2005 in %	Installed grid-connected capacity in Wp/capacita	Share of BIPV in that capacity	Growth rate of PV capacity in 2005 in %
Canada	Toronto	0,52	20 %	0,10		10 %
Canada	Peel	0,52	20 %			
Canada	Kelowna	0,52	20 %			
Denmark	Horsens	0,49	16 %	2,85	<50 %	20 %
France	Lyon	0,54	27 %	1,00	<50 %	100 %
Holland	Heerhugowaard	3,10	3 %	73,47	100 %	
Holland	Langedijk	3,10	3 %	15,38	100 %	
Holland	Alkmaar	3,10	3 %	10,64	100 %	
Japan	Hachinohe	11,10	26 %	10,00		58 %
Japan	Ota	11,10	26 %	20,00		12 %
Japan	Tokyo	11,10	26 %	2,00		22 %
Sweden	Malmö	0,47	10 %	1,00	<50 %	100 %
Switzerland	Neuchâtel	3,70	14 %	4,50	100 %	0 %
Switzerland	Zurich	3,70	14 %	16,00	100 %	16 %
USA	Boston	2,8	27 %	20,00		30 %
USA	Orlando	2,8	27 %	0,5		0 %

Fig. 5 - PV Penetration and Growth.

Fig. 6 - 32 MW Urban in-fill at Brookhaven National Labs, Long Island , NY, USA.

Fig. 7 - Task 10 Meeting Rome, Italy, May 2009.

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
Austria	Mrs. Assun Lopez-Polo	Energy Economics Group
Austria	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	HESPUL
France	Mr. Bruno Gaiddon	ESPUL
Italy	Arch. Niccolo' Aste	Politecnico di Milano
Italy	Mr. Michele Pellegrino	CER ENEA
Italy	Mr. Carlo Zuccaro	CESI SpA
Italy	Mr. Antonio Berni	ETA Florence
Japan	Mr. Keiichi Komoto	Environment, Natural Ressources and Energy
Japan	Mr. Tomoki Ehara	Mizuho Information & Research Institute Inc.
Japan	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
Norway	Mrs. Anne Grete Hestnes	SINTEF Civil and Environmental Engineering
Portugal	Mrs. Maria Joâo Rodrigues	Center for Innovation Technology and Policy Research
Portugal	Mrs. Joana Fernandes	Instituto Superior Têcnico (Technical University of Lisbon)
Sweden	Mr. Mats Andersson	Energibanken AB
Sweden	Mrs. Anna Cornander	City of Malmo
Switzerland	Mr. Pierre Renaud	Planair SA
Switzerland	Mr. Lionel Perret	Planair SA
USA	Ms. Christy Herig	Segue Energy Consulting/Subcontractor to National Renewable Energy Laboratory

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

TABLE 2 - MEETING SCHEDULE (2004 -2009)

MEETING	DATE	PLACE
1st Task 10 Technical Experts	Feb. 4 - 5, 2004	Vienna, Austria
2nd Task 10 Technical Experts	Oct. 4 - 5, 2004	Florence, Italy
3rd Task 10 Technical Experts	March 17 - 18, 2005	Lisbon, Portugal
4th Task 10, combined with 26th Task 1	June 2 - 3, 2005	Lyon, France
5th Task 10 Technical Experts	October 4 - 5, 2005	Washington, DC, USA
6th Task 10, combined with Tasks 1, 2 & 9	March 27 - 28, 2006	Vancouver, BC, Canada
7th Task 10 Technical Experts and PV-UP-Scale	Sept 11 - 13, 2006	Malmö, Sweden
8th Task 10 Technical Experts and PV-UP-Scale	March 12 - 13	Freiburg, Germany
9th Task 10 Technical Experts with 1/2 day joint with Task 11	Nov. 30 - Dec.1, 2007	Fukuoka, Japan
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	May 14 -15th, 2009	Rome, Italy

TASK 11 - HYBRID SYSTEMS WITHIN MINI-GRIDS

Fig. 1 - The power generation system of the Isle of Eigg, Scotland, consists of 10 kWp PV, 3 hydro plants (100 kW, 2 x 6 kW), 4 Wind turbines (4 x 6 kW) and 2 Diesel gensets (2 x 80 kVA). Each of these sources has been sensitively sited to cause minimum visual and physical impact upon the island's landscape. Twelve Sunny Island 5 kW inverters are used connected in four three phase clusters to provide a total output rating of 60kW. A Multicluster Box enables the communication among the inverters and provides contactors for the connection to the island grid, to the PV and Wind inverters and the back-up gensets. Each cluster is connected to a 48V 2242 Ah (C10) battery bank consisting of 24 batteries. 87 inhabitants owning 37 residential and 5 commercial properties must be supplied by the system. The peak demand has been limited with the approval of the residents; domestic and small business supplies have been restricted at 5kW, and larger business supplies at 10kW.

INTRODUCTION

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

TASK 11 STRATEGY AND ORGANIZATION

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

Task 11's 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 subtask has the following three activities:

- Review, analysis and documentation of current hybrid mini-grid system architectures
- Evaluation and comparison of software based design tools for PV hybrid systems and mini-grids
- Documentation 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

Fig. 2 - Solar generator: 81 solar modules of 100 Wp, Schott GT-FT 100; Inverter: Sunny Boy 3 800 and Sunny Island 4 548, in total 6 units, SMA; Battery: 3 banks of 800 Ah, 48 Volt, OPzS Hoppecke, at the Community of the Vincentian Sisters in Mbinga, Tanzania.

following five activities:

- Investigation of existing methods for stabilizing voltage and frequency in mini-grids and recommendations for further development.
- Investigation of data communication architectures and protocols for mini-grids
- Evaluation of supervisory control parameters and strategies for mini-grids
- Evaluation of the role of energy storage technologies to stabilize mini-grid operation
- Investigation of 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:

- Development of performance assessment criteria for PV hybrid systems that allow objective comparison of different systems
- Development of recommendations to increase the solar fraction in hybrid systems through demand side management and optimization of the battery energy storage system.

SUBTASK 40: Sustainability Conditions

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

- Development of case studies that demonstrate the social and political framework for successful operation of PV hybrid systems within mini-grids
- Evaluation of the financial aspects of PV hybrid power systems, considering both first costs and operating costs, and determining the conditions for economic sustainability
- Evaluation of 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 2009

In 2009, Task 11 Activities moved forward on the preparation of the reports that are the principal deliverable items for this Task. Document plans and outlines were prepared, authors and reviewers were assigned, and several draft reports were circulated among the Task 11 Experts for review and comment. Work also continued on the collection of case study information. At the Experts Meeting in September 2009, the participants reviewed the Task 11 Workplan in detail and made changes to reflect the current status of Task 11 Activities, the available resources to complete the Workplan, and the time remaining. Task 11 is now in a good position to publish and disseminate its results in the remaining two years of its Workplan.

PLANS FOR 2010

Task 11 plans to publish several of its deliverable reports in 2010 and to advance the remaining deliverable reports to the final review stage so that they can be published in 2011. Task 11 will also plan and execute other dissemination activities to ensure that its results reach the target audiences. Several papers reporting on Task 11 activities and results will be presented at the 5th European PV-Hybrid and Mini-Grid Conference in Tarragona, Spain, 29 - 30 April 2010.

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. Many of these are available on the Task 11 website at http://www.iea-pvps-task11.org.

INDUSTRY INVOLVEMENT

Task 11 is fortunate to have significant active participation from equipment manufacturers and system integrators. In addition, personnel from electric utilities, system integrators, and engineering consultants often attend Task 11 Experts meetings as observers. A particular focus of Task 11's dissemination activities is to expand this industry engagement.

MEETING SCHEDULE (2009 AND 2010 PLANNED)

Task 11 had the following Experts Meetings in 2009:

- **7th Task 11 Experts Meeting**, 2-3 April, 2009, Vienna, Austria.
- **8th Task 11 Experts Meeting**, 9-11 September, 2009, Golden, Colorado, USA.

Task 11 plans to have two Experts Meetings in 2010. The first will be:

- **9th Task 11 Experts Meeting**, 26-27 April, 2010, Tarragona, Spain.

Fig. 3 - Task 11 Experts on technical tour to Blue Chip Energy GmbH, Güssing, Austria, during the 7th Task 11 Experts Meeting, April 2009.

TABLE 1 - TASK 11 PARTICIPANTS

As of the end of 2009, the following IEA PVPS countries are participating in Task 11 - PV Hybrids in Mini-Grids: Australia, Austria, Canada, France, Germany, Italy, Japan, Korea, Malaysia, 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
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USA	Benjamin Kroposki, NREL	benjamin_kroposki@nrel.gov

TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

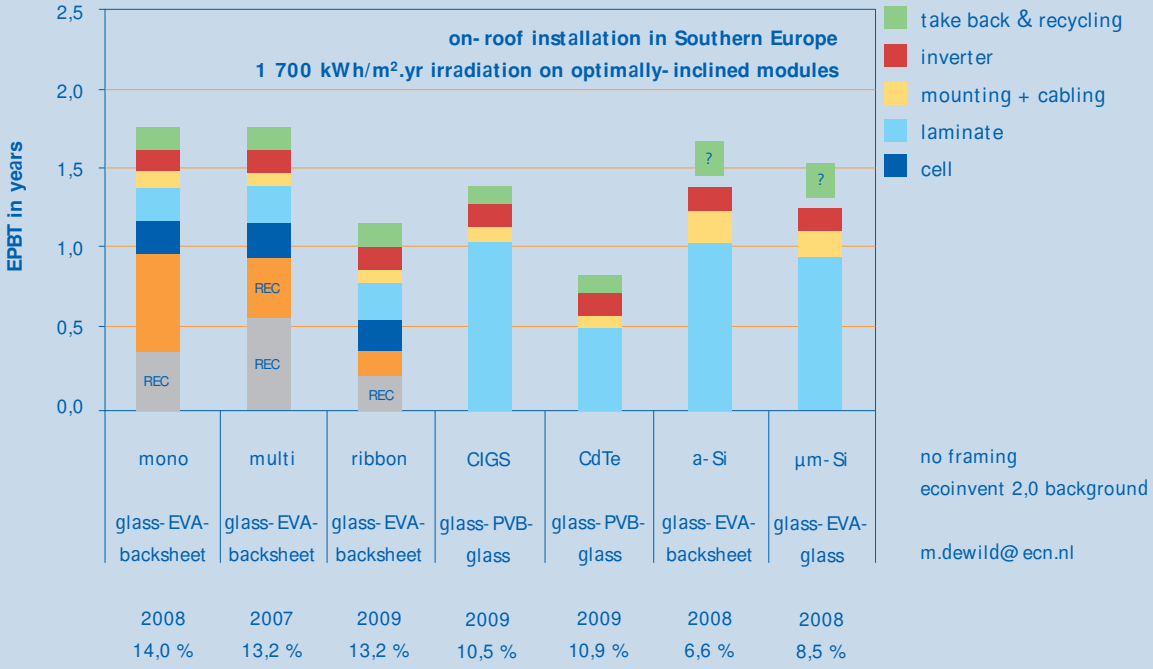

Fig. 1 - Energy Pay-Back Time of rooftop PV systems from different technologies in southern Europe (irradiation of 1 700 kWh/m²/yr). Source: M. de Wild-Scholten (ECN), Sustainability: Keeping the Thin Film Industry green, presented at the 2nd EPIA International Thin Film Conference in Munich on November 12, 2009.

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 cannot 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 on 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 cycle 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 activities performed within the four subtasks are the following:

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

The "Study on the Development of a Take-Back and Recovery System for Photovoltaic Products" was finalised during spring 2008 and served as a starting point for the work of PV CYCLE. It is available in both German and English at http://www.pvcycle.org/index.php?id=45.

In December 2008, the members of PV CYCLE (currently representing more than 85 % of what is sold onto the European market) signed a Declaration supported by the European Commission. It puts ahead a benchmark with the following targets: to collect a minimum of 65 % of photovoltaic modules installed in Europe since 1990 and to recycle 85 % of the collected waste and the promise to come up with an Environmental Agreement.

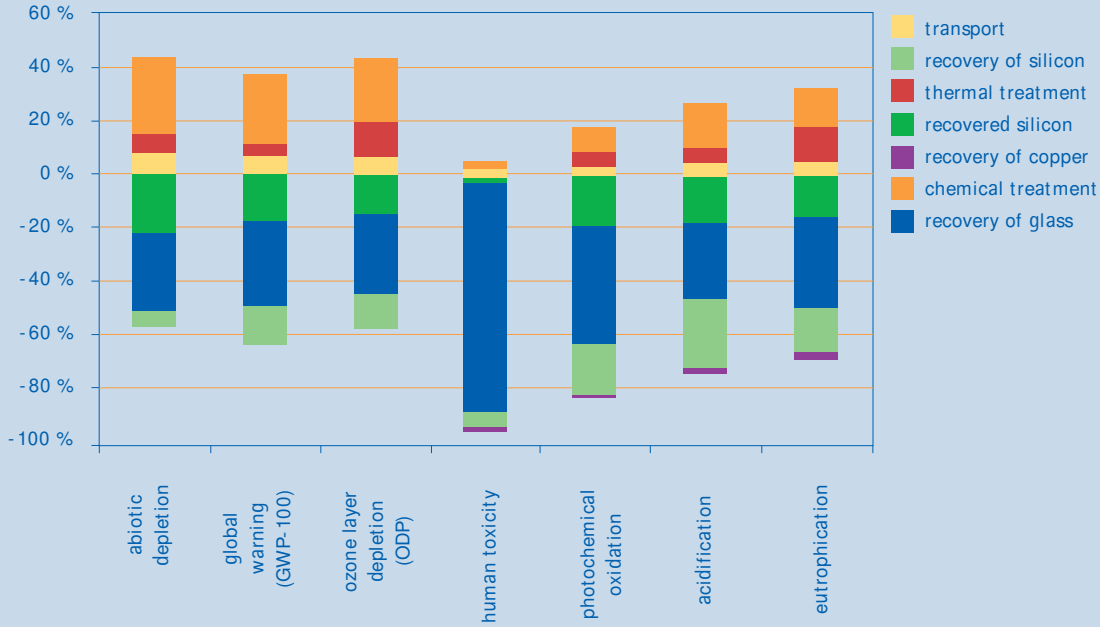

Fig. 2 - Life Cycle Analysis for recycling the Chevetogne modules in the Sunicon (SolarWorld) pilot plant.
Source: K. Wambach et al., PV CYCLE - The voluntary Take-Back System and Industrial Recycling of PV Modules, presented at the Photovoltaics Recycling Workshop held during the 34th PV Specialists Conference in Philadelphia on June 11, 2009.

A study performed by PricewaterhouseCoopers (PWC) will clear out the potential mechanisms by which the voluntary take-back and recycling scheme will be financed. For now, members have agreed to pay 0,24 EUR/kg on 2 % of the sales of 2008 in EU27 + EFTA countries to finance operations in 2010.

The first collection and recycling activity organized fully by PV CYCLE took place in Chevetogne, Belgium, in 2009; 2000 modules were collected from the oldest Belgian PV generator and recycled in Germany. The results of this project including a Life Cycle Analysis (see figure 2) were presented at the EU PV Solar Energy Conference in Hamburg in September 2009.

A Recycling Workshop was organized by Brookhaven National Laboratory (BNL) during the 34th IEEE Photovoltaic Specialists Conference (PVSC) in Philadelphia on June 11th 2009. The aim was to discuss future US activities in the field of PV module collection and recycling.
The collection infrastructure that PV CYCLE is setting in Europe was presented and proposed as the way to follow in the US. All the presentations held at the workshop are available at: www.iea-pvps-task12.org.

A Study is being developed by BNL, U.S., to define a "Cost Optimisation Model" for the collection and recycling of PV modules. For now, both SolarWorld's and First Solar's recycling schemes are included in the model.

SUBTASK 2: Life Cycle Assessment

Task 12 participants from Brookhaven National Laboratory (BNL), the Energy Research Centre of the Netherlands (ECN), Stuttgart University, ESU-services Ltd., CEP, MINES Paris Tech, and Elkem Solar are engaged in ongoing projects on LCA for all types of PV module technologies (see Figure 1).

Papers related to Life Cycle Assessment and other environmental aspects can be found at the respective websites of:

- Energy Research Centre of the Netherlands (ECN): http://www.ecn.nl/publicaties/default.aspx?au=44649
- University of Columbia: http://www.clca.columbia.edu/publications.html
- Brookhaven National Laboratory (BNL): http://www.pv.bnl.gov
- University of Utrecht: http://www.chem.uu.nl/nws/www/research/e&e/e&e_rena.htm
- ESU-services: http://www.esu-services.ch/cms/index.php?id=pv

The "Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity" have been completed by Task 12 members and were published in September 2009.

This document presents the first agreement at the international level on how to perform Life Cycle Analysis. It provides recommendations regarding technical characteristics related to photovoltaic systems, aspects regarding modelling approaches in Life Cycle Inventory, Life Cycle Analysis and Life Cycle Impact Assessment; furthermore, it provides procedures regarding reporting and communication.

The Ecoinvent Database has been updated. Data have been collected by Utrecht University, ECN, BNL, ESU-services Ltd. and other sources and were provided to this project. The latest version (V2.1) was published in May 2009 and is available at www.ecoinvent.org. It incorporates updated information on CdTe and BOS materials for mounting structures.

SUBTASK 3: Safety in Facilities

EPIA's has launched a Sustainability Working Group in 2009, which (chaired by Karsten Wambach, Sunicon and co-chaired by Marietta Grammenou, Heliosphera) works on environmental, health and safety

TABLE 1 – TASK 12 PARTICIPANTS

COUNTRY	ORGANISATION	PARTICIPANT
Austria	Umweltbundesamt	Mr. Werner Polz
Belgium	EPIA	Ms. Eleni Despotou
Belgium	EPIA	Mr. Daniel Fraile
Belgium	PV CYCLE	Mr. Jan Clyncke
Belgium	PV CYCLE	Ms. Virginia Gomez
France	CEP, MINES Paris Tech	Mr. Didier Beloin-Saint-Pierre
Germany	LBP Stuttgart University	Mr. Michael Held
Germany	Sunicon	Mr. Karsten Wambach
Germany	Sunicon	Ms. Sylke Schlenker
Germany	ZSW	Ms. Wiltraud Wischmann
Japan	Nedo (Technology Development Organisation)	Mr. Ichiro Nakaya
Japan	Kyocera Corporation	Mr. Mitsutoshi Hino
Japan	Tokyo Institute of Technology	Mr. Masakazu Ito
Norway	ELKEM Solar	Mr. Ronny Glockner
Norway	ELKEM Solar	Mr. Jan Ove Odden
Spain	ESCi (Escola Superior de Comerç Internacional)	Mr. Marco Raugei
Switzerland	ESU-Services	Mr. Rolf Frischknecht
Switzerland	ESU-Services	Mr. Matthias Stucki
The Netherlands	ECN	Ms. Mariska de Wild-Scholten
The Netherlands	Raboud University Nijmegen	Ms. Nellemieke Mohr
USA	Brookhaven National Laboratory	Mr. Vasilis Fthenakis
USA	Brookhaven National Laboratory	Mr. Jun-Ki Choi
USA	Columbia University	Mr. Hyung Chul Kim
USA	First Solar	Ms. Lisa Krueger

(EHS) issues by combining the expertise from the different industry participants. This working group is already cooperating with the participants of Task 12; by providing industry data and assuring that the Task 12 activities are in line with the industry needs.
One of the core activities of this expert group is to enforce EHS aspects of PV manufacturing. Industry surveys are taking place in order to obtain a clear understanding of safety and provide recommendation on the use and handling of hazardous substances and materials.

SUBTASK 4: EH&S Information Dissemination

The Task 12 website (www.iea-pvps-task12.org) was launched in 2009. It contains information on the progress that is being made within Task 12, offers links to relevant events and websites of the participants' institutions. The purpose of the website is to serve as a reference point, not only for scientific information on recycling and LCA, but also on the environmental benefits of PV in general. Hence, the website contains, besides links to the literature and scientific papers related to LCA and recycling, also some more general information on the environmental aspects of PV.

PLANS FOR 2010

In the framework of international collaboration, IEA-PVPS Task 12, EPIA and PV CYCLE will host the 1st International Conference on PV Module Recycling on the 26 January 2010 in Berlin, Germany with the support of the Joint Research Centre of the European Commission (JRC).

PV CYCLE's Environmental Agreement will be signed by its members during the first half of 2010 and submitted to the European Commission and Parliament. The exact implementation and future financing of the take-back and recycling scheme will be discussed upon based on a recently realized study by PWC.

Based on the feedback received on the recently published "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment", the possibility to update them during 2010 will be evaluated.

Fig. 3 - Task 12 Expert meeting in Berlin, 25th January 2010.

Research will be carried out on the use of water and GHG emissions of and by the PV industry.

The "Cost Optimisation Model" for the collection and recycling of PV modules that has been developed by BNL will be further expanded with more scenarios and processes.

PUBLICATIONS AND DELIVERABLES

In 2010, articles and papers will be presented in the press and during international conferences such as the 25th EUPVSEC. Some of which are the following:

- M. Stucki and R. Frischknecht, Vermindert Photovoltaik die Umweltintensität des Schweizer Stroms? Erkenntnisse aktueller Ökobilanzen zu Strom aus Solarzellen. (Do Photovoltaics Reduce the Environmental Intensity of Swiss Electricity? Results of LCA about Electricity from Solar Cells.), Bulletin SEV/VS.
- M. Held et al., Update of Environmental Indicators and Energy Payback Time of CdTe PV Systems in Europe, Progress in Photovoltaics: Research and Applications.
- Mohr et al., Environmental Life Cycle Assessment of Thin Film Amorphous $ilicon/Nanocrystalline Silicon Solar Cell Laminates.
- J.-K. Choi and V. Fthenakis, Economic Feasibility of Recycling Photovoltaic Modules: Survey and Model, Journal of Industrial Ecology.
- M.J. de Wild-Scholten, M. Sturm, P. Zurru, M. Noack, K. Heasman, G. Timò, Environmental Sustainability of two CPV Systems: Results from the Apollon Project, to be presented at the 6th International Conference on Concentrating Photovoltaic Systems (CPV-6) in Freiburg, Germany on 7-9 April 2010.

TASK 13 - PERFORMANCE AND RELIABILITY OF PV SYSTEMS

Fig.1 - PV system performance analysis - Search for yield and reliability data of various PV applications in different locations, regions and climates (photo: TÜV Rheinland).

Fig. 2 - PV system performance assessment - Monitoring and inspection of PV plant in Southern Germany (photo: TÜV Rheinland).

INTRODUCTION

Given the favourable political framework in many countries, the PV market has been growing to significant levels. With the market volume increasing, performance and reliability of PV systems have become key issues for minimising business risks and increasing market actors' trust in this innovative technology.

A most accurate yield prognosis as well as information on operational availability of PV systems are vital for investment decisions and, thus, for further market growth. In this context, performance and yield data, reliability statistics and empirical values concerning maintenance are far more relevant today than they used to be in the past. The availability of such information is, however, rather poor.

Task 13 is considered an extension of the work formerly carried out under PVPS Task 2 "Performance, Reliability and Analysis of Photovoltaic Systems." When Task 2 was concluded in 2008, the PVPS ExCo members and the participants felt a strong need for further working on the subject. Finally, the Task 13 Workplan was elaborated based on the outcome of two expert meetings in 2008 and 2009. It was then approved in October 2009. During the Workplan approval process, fourteen out of fifteen countries expressed their interest to participate in this Task. The project has a four year planned period of work and will start its activities in May 2010.

OVERALL OBJECTIVE

The overall objective of Task 13 is to help market actors to improve the operation, reliability and quality to PV components and systems. Operational data of PV systems in different climate zones compiled within the project will allow conclusions on the reliability and on yield estimations. Furthermore, the qualification and life time characteristics of PV components and systems shall be analysed, and technological trends identified.

Task 13 aims at:

- collecting information on the reliability of PV systems and components, which are available in the participating countries,
- compiling and disseminating technical reports, recommendations and best practice descriptions and
- providing an international platform for the information exchange among different stakeholders.

APPROACH

The PV industry is very interested in information on performance and reliability.

Companies which have the required data at their disposal tend, however, to be reluctant to share this information. The project partners will meet this challenge by involving these companies at an early stage of the project development. This will give the industry's representatives the opportunity to introduce cooperative and tailor-made activities into the Workplan. In order to guarantee anonymous processing of the data provided by the industry, standardized reporting forms will be developed and agreements will be established with the project partner in charge of the respective Subtasks.

Various branches of the PV industry will be addressed by the national participants in their respective countries using existing business contacts. Given the international nature of the project consortium, cooperation will include important markets such as Europe, Japan and the USA.

Two approaches to data collection and analysis of PV system performance will be applied:

- a broader approach that employs statistical means to evaluate larger samples at a global level, and
- a scientific approach that enables in-depth analysis of selected samples.

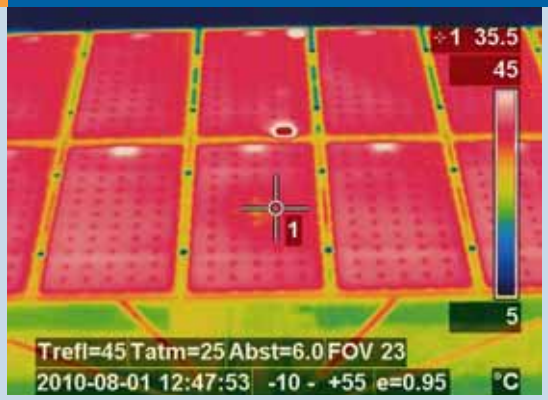

Fig. 3 - Characterization of PV system and components using IR imaging methods (photo: TÜV Rheinland).

Task 13 activities are organized into the following subtasks:

SUBTASK 1: Statistical PV System Performance Analysis

Subtask 1 addresses the statistical analysis of PV system performance. Participants will collect operational data of PV systems in their countries in a standardized format on a monthly basis. The information gathered will be accessible for interested market actors via an online Performance Database. In cooperation with the industry and national programmes, participants will collect facts on the long-term reliability of PV systems. The information gathered will be published in a report.

SUBTASK 2: Analytical PV System Assessment

Subtask 2 aims at an analytical assessment of PV systems. This activity will evaluate operational data of selected PV systems in detail. By simulation of the system's behaviour, loss mechanisms will be determined and evaluated. To this end, documented meteorological data will be fed into a computer model in order to calculate the yield in retrospect. Comparing the calculated to the real performance will allow detecting system parameters, which are incapable of direct measurement.

Innovative technologies and system concepts - such as thin-film, bifacial and cylindrical modules - will be addressed, too. A technical report will state on the PV system performance and assess how new PV technologies will compare to well known products.

SUBTASK 3: PV Module Characterisation and Life Time Assessment

Subtask 3 addresses PV module characterisation and life time assessment.

To this end, information on new characterization methods such as electroluminescence and thermography will be collected. The participants will develop common guidelines for the interpretation of the results of these imaging techniques. New methods that allow assessing quality and life time characteristics of PV modules will be reviewed and presented systematically. In addition, relevant approaches for the performance measurement of different thin-film technologies will be compiled.

On the basis of existing reports on PV systems by the participants as well as by insurance companies and consultants, failures of PV systems will be identified and studied in a statistical way and in case studies. This information will be published in a technical report. Research results on degradation of PV modules, on the comparison of degradation in the laboratory and in the field as well as on the climatic factors influencing the life time of the modules will be compiled.

SUBTASK 4: Dissemination

Subtask 4 focuses on the dissemination and discussion of the results of the Subtasks 1, 2 and 3. Different target groups and market actors will be addressed through a variety of communication channels.

TASK 13 PARTICIPANTS (TO BE CONFIRMED)

The following countries and organisations have indicated their interest to participate in Task 13:

COUNTRY	ORGANISATION
Australia	CAT Projects
Austria	Austrian Institute of Technology (AIT)
Canada	Natural Resources Canada (CANMET)
EPIA	European PV Industry Association
France	ADEME
France	Institut National de l'Energie Solaire (INES)
France	EDF R&D
Germany	TÜV Rheinland
Germany	Fraunhofer ISE
Germany	Institute for Solar Energy Research (ISFH)
Israel	Ministry of National Infrastructures (tbd)
Italy	GSE, Gestore dei Servizi Elettrici
Italy	EURAC Research
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Japan	Development Organization NEDO (tbd)
Malaysia	Universiti Teknologi Malaysia (UTM)
Norway	University of Agder
Spain	University of Madrid
Sweden	Swedish Energy Agency (tbd)
Switzerland	TNC Consulting AG (tbc)
Turkey	ANELES
United Kingdom	Building Research Establishment (BRE)
United Kingdom	Northumbria PV Application Centre
USA	NREL
USA	Sandia National Laboratories

Up-dated contact details for Task 13 participants can be found on the IEA-PVPS website www.iea-pvps.org.

MEETING SCHEDULE

The Task 13 Kick-off Meeting will be held in Cologne, Germany, 17-18 May 2010.

TASK 14 - HIGH PENETRATION PV IN ELECTRICITY GRIDS

INTRODUCTION

Task 14, which started in late 2009, will focus on the role of PV in electricity grid configurations with a high penetration of RES, where PV constitutes the main RES. Although up to now, no common definition of "high-penetration PV scenarios" exists, there is common consensus within the Task Definition group that a high penetration situation exists if additional efforts will be necessary to integrate the dispersed generators in an optimum manner.

While penetration levels of PV discussed in the literature are based on general experience from DG (not only from RES), Task 14 will analyse the particular issues related to the penetration of PV in electricity grids and establish penetration scenarios in order to show the full potential of grid integrated photovoltaics.

Easy access to the main findings of the reports is expected to mitigate concerns of high penetration PV to the benefit of a large number of countries.

OVERALL OBJECTIVES

The main goal of Task 14 is to promote the use of grid connected PV as an important source in electric power systems on a high penetration level where additional efforts may be necessary to integrate the dispersed generators in an optimum manner. The aim of these efforts is to reduce the technical barriers to achieve high penetration levels of distributed renewable systems on the electric power system. Due to the fact that a number of distribution system integration-related issues are emerging first for PV systems, Task 14 will focus on working with utilities, industry, and other stakeholders to develop the technologies and methods enabling the widespread deployment of distributed PV technologies into the electricity grids.

The objectives of this new task are:

- to develop and verify mainly technical requirements for PV systems and electric power systems to allow for high penetrations of PV systems interconnected with the grid
- to discuss the active role of PV systems related to energy management and system control of electricity grids

Of all power generating sources PV systems have special features, which have to be considered when integrating a large number of such distributed generators into the electric power system.

SUBTASKS AND ACTIVITIES

Task 14 will address mainly technical issues to high penetration of PV in electricity networks. Technical issues include energy management aspects, grid interaction and penetration related aspects linked to local distribution grids and central PV generation scenarios.

A strong focus will be on inverters with multifunctional characteristics aiming the smart interface between the generator and the electricity network. In order to evaluate the aforementioned technical issues, modeling and simulation techniques will be applied.

Fig. 1 - Experts from the IEA PVPS Task 14 Definition Workshop in Montreal, Canada, August 2009.

Work in pursuit of the foregoing objectives will be performed by photovoltaic system specialists and engineers working in the fields of planning, installation and research in the Participants' countries.

Participants will carry out the following Subtasks:

The work programme is organized into four main subtasks and one cross-cutting subtask, which will be a hub to all subtasks.

CROSS-CUTTING SUBTASK: Information Gathering, Analysis and Outreach

The scope of this subtask is to collect and share state of the art information amongst the various tasks as well and collating information for the general public. The objective is to review and document worldwide implementations of high penetration PV scenarios into electric power systems and based on subtasks work, generalize and refine them to generate a set of convincing cases of safe and reliable implementation.

This Subtask has the following activities:

- Setup a repository for information and models exchange
- Collect and analyze state of the art information about existing high penetration PV installations
- Gather a collection of existing modeling information
- Select and refine a set of pertinent cases for publication

SUBTASK 1: PV Generation in Correlation to Energy Demand

This Subtask deals with local solutions to improve PV penetration in grids without large infrastructure investment. The objective of the Subtask is to show and determine how with better prediction tools and optimized local energy management, PV penetration level can be improved in grid. Case study will be oriented to demonstrate the feasibility of local high PV penetration in grid (different penetration scenarios in case studies).

This Subtask has the following activities:

- Review monitoring tool and adapt prediction tools to anticipate the shift in local grid
- Review and analyze local storage and energy management system to improve the penetration of PV in local grid (Network driven demand side management).

SUBTASK 2: High PV Penetration in Local Distribution Grids

Subtask 2 addresses the Identification and Interpretation of the Role of PV in Distribution Grids and includes an Impact Analyses of High PV Penetration in Distribution Grids and concludes with recommendations on Grid Codes, Incentives and Regulation.

It has the following four activities:

- Review of State-of-the-Art of actual and future Distribution Grids with High PV Penetration.
- Optimized Reactive Power Balancing in distribution grids: Review of optimization approaches and comparison of impacts on country-specific grids
- Optimized Active Power Control Strategies in distribution grids: Review of optimization approaches and comparison of impacts on country-specific grids
- Change from Distribution to Supply Grids and Dynamic Studies

SUBTASK 3: High Penetration Solutions for Central PV Generation Scenarios

Subtask 3 addresses the PV integration into power systems from the total power system view point, based on the PV generation forecasting, power system operation and power system augmentation. It has the following four activities:

- System-wide PV generation analysis and forecast
- Power system operation planning with PV integration
- Power system augmentation planning with PV integration
- Completion of the final report

SUBTASK 4: Smart Inverter Technology for High Penetration of PV

Subtask 4 addresses the inverter technology, technical requirements and standards, and system integration aspects for successful smart integration of a high penetration of PV. It has the following three activities:

- Outline of opportunities for smart PV inverters in high-penetration scenarios
- Analysis of technical capabilities and Inverter Topologies including simulation modelling of devices
- Review and Analysis of remote control and communication for Smart Inverters

PROGRESS IN 2009

The activities in 2009 focused on the Task Definition process, which initially began in November 2008 with the first Task definition meeting held in Sydney, Australia.

Following this meeting, a Task Preparation Team consisting of 6 institutes/experts from 6 countries (AUT, CAN, DEU, CHE, JPN, USA) jointly prepared the first draft work plan. In summer 2009, the second Task Definition Meeting was held in Montreal, Canada, on initiation of Natural Resources Canada. During the meeting, the work programme was discussed in detail. The outcomes, summarized in the final Task Concept Paper, were officially presented at the ExCo Meeting in Anaheim, California, USA, in October 2009. During this meeting the ExCo officially endorsed the new Task 14.

SUBTASKS AND ACTIVITIES

The initial work programme was developed after the first Task definition meeting in Sydney (November 2008). A task preparation team consisting of 6 institutes/experts from 6 countries was identified based on volunteering work to jointly prepare this Workplan. These experts also chaired the relevant sessions at the second task definition meeting in August 2009 in Montreal where the work items were discussed in detail.

Currently, experts from the following countries have confirmed their interest in participating in the new Task: Australia, Austria, Canada, Switzerland, Germany, Denmark, Israel, Italy, Japan, Norway, Portugal, Spain, Sweden and the U.S.A.

PLANS FOR 2010

The duration of Task 14 will be four years (April 2010 - March 2014). With the kick-off meeting planned for April 2010, the Workplan will be finalized and the activities will effectively start.

PUBLICATIONS AND DELIVERABLES

The products of work performed in Task 14 will be designed for use by electricity network planners, specialists for photovoltaic systems and inverters, power system simulation engineers, utility engineers concerned with interconnection of distributed energy resources, and equipment manufacturers.

Results of the joint activity will include:
A first data collection will include a review of the current literature as well as information on existing systems in the various countries, leading to a report about state-of-the-art high PV penetration systems.
A report describing Forecast Tools with links between weather forecasts, prediction and monitoring tools developed in Subtask 1, and an additional report that will provide a summary of case studies and conclusions about network driven DSM.

Reports and Case Studies describing the current Experiences of High PV Penetration in Distribution Grids on Active and Reactive Power Balancing in Distribution Grids, will outline the results of the Subtask 2, and provide recommendations for managing the transition from Distribution to Supply Grids.

The results of the work performed in Subtask 3 will be summarized in a Report on System-wide PV Generation Analysis and Forecast and a report describing high penetration solutions for central PV generation scenarios including aspects of Power system operation and augmentation planning with PV integration.

Reports produced by Subtask 4 will discuss the opportunities for Smart PV inverters in High-Penetration scenarios, the technical capabilities, as well as Inverter Topologies and the remote control and communication for Smart Inverters. These reports will be completed by a joint workshop with communication standards working groups.

AUSTRALIA

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

Fig. 1 - Flexible Dyesol PV panel (photo Dyesol).

GENERAL FRAMEWORK

The photovoltaics sector in Australia has been through large changes over the past year, with many changes in support mechanisms, in the local industry base and in the market. Important grant schemes for small-scale and off-grid PV applications have ended, while new mechanisms including State and Territory based feed-in tariffs, large-scale solar generation programs and R&D support have been introduced.

At the industry level, local PV cell and module manufacture ceased in early 2009, while a record number of overseas manufactured modules have now entered the local market. The grid-connect market has continued to grow strongly, with associated growth in installer accreditation. Over 3 000 people now work in the PV sector, not including government agencies and researchers.

The public perception of PV remains positive and, as prices have fallen and support programs and climate change issues better understood, uptake has increased strongly. Rooftop PV systems are increasingly being offered as a standard option by many builders, while local governments are beginning to address solar access and development approval processes.

NATIONAL PROGRAMME

Australian Government support programs impacted significantly on the 2008 and 2009 PV markets. Key programmes are described below. The majority of support was focussed on small systems (i.e. less than 10 kWp, and mostly less than 2 kWp), with the exception of the newly announced Solar Flagship program (50-250 MWp) and the ACT feed-in tariff (up to 30 kWp).

Solar Homes and Communities Program (SHCP)

The SHCP aimed to accelerate the uptake of PV for residential and community buildings and to develop the local industry. It had the most impact on the PV market in Australia during 2008 and 2009, providing rebates up to AUD 8 000 for 1 kWp of PV installed on residential buildings and up to 50 % of the cost of PV systems up to 2 kWp installed on community buildings. Uptake rates increased significantly when rebates were increased from AUD 4 000 to AUD 8 000 per kWp in 2007, despite the imposition of a means test. 84 MWp were installed between March 2000 and December 2009. The majority of this (79 MWp) was for grid-connected installations. The program ended in June 2009, although there is a year's backlog of installations, and was replaced by the Solar Credit mechanism.

Solar Credits

The Australian Government has expanded the Renewable Energy Target (RET) to 45 000 GWh by 2020. This is expected to increase the amount of renewable generation from current levels of around 8 % of total generation to 20 % by 2020. The RET will continue to use the Renewable Energy Certificate (REC) mechanism, with each MWh of renewable energy generation eligible for one REC. REC multipliers, or Solar Credits, are available to PV systems, wind turbines and micro-hydro systems for the first 1,5 kWp of capacity, as shown below. Output from capacity above 1,5 kWp is eligible for 1 REC per MWh. As well as homeowners, other organisations such as schools, community groups, businesses and developers, who were previously ineligible under the Solar Homes and Communities plan, are eligible for Solar Credits, with no means test applied.

YEAR	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	From 2015-16 onwards
SOLAR CREDITS MULTIPLIER	5	5	5	4	3	2	No multiplier

Renewable Remote Power Generation Program (RRPGP)

The RRPGP provided rebates of up to 50 % of the capital cost of renewable energy and related components used for diesel displacement in stand-alone power systems. It operated from 2000 to 2009 with a budget of 300 MAUD. Typical applications included off-grid households, indigenous communities, community organisations, retail/roadhouses, tourism sites, pastoral stations and other off-grid business and government facilities.

The program operated under a number of sub-programs, including water pumping, industry support, Bushlight and major projects, some of which are administered via State Government agencies. In 2008, AUD 980 000 was provided from the Industry Support component of the RRPGP for 64,9 kWp of PV in the new Alice Springs Desert Knowledge Australia Solar Centre where a range of different PV systems and configurations are being monitored and tested.

In 2008 a total of 2 472 kWp of PV was installed in remote residences and 1 080 kWp in non-residential systems. A total of 36,7 MAUD was provided in rebates. In total 11,92 MW of PV had been installed under RRPGP to end 2008.

The National Solar Schools Program (NSSP)

The 480 MAUD NSSP commenced on 1 July 2008 and finishes on 30 June 2015. It offers grants of up to AUD 50 000 per school to install PV and other renewable power systems, solar hot water systems, rainwater tanks and a range of energy efficiency measures including insulation, energy efficient lighting and ceiling fans. Some State Governments offer additional funding focussed on PV and some have arranged central purchasing as a means of minimising cost. The 2009-10 budget allocation was oversubscribed and applications closed early. Applications will reopen in 2010. Most schools are installing PV systems of 2 to 4 kWp, with the program expected to result in the installation of 20-40 MWp of PV by 2015. This program will increase awareness and understanding of PV as students move through the school system, and will also increase community knowledge and acceptance levels.

Solar Flagships

In 2009 the Australian Government announced a call for 1 GW of solar generation via 4 solar thermal and PV power stations. 1,3 BAUD has been allocated, with funding available to cover up to one third of the capital cost. Proposals are expected to include PV companies, electricity retailers, State and local governments, financial institutions and research partners. Initial bids for one PV and one solar thermal power station, with a total capacity of 400 MWp are due mid February and will be shortlisted prior to the development of detailed proposals. A second call for another two power stations will be made in 2013-14. Favourable consideration will be given to proposals which include local industry development, so interest is high in potential local component manufacture. All projects must include research programs, with funding up to 400 MAUD available for research infrastructure.

R & D, D

Government expenditure on PV research, development, demonstration and market incentives totalled 117,91 MAUD in 2008. Australian Government market incentive programs accounted for 88 % of expenditure.

Demonstration

The Desert Knowledge Australia Solar Centre *(www.dkasolarcentre.com.au)* is an 3,1 MAUD initiative of Desert Knowledge Australia that showcases and demonstrates a range of solar power technologies from different manufacturers and suppliers in commercial-scale installations. These installations provide meaningful and accurate comparisons of the performance of the technologies' in the arid environment of Central Australia, improving the knowledge base for solar initiatives globally. Funding has been provided via the RRPGP.

The Australian Solar Institute

In 2009, the Australian Solar Institute was established with funding of 100 MAUD over 4 years to foster concentrating solar thermal and PV R&D and to accelerate commercial deployment. A first round call for R&D projects was made in 2009, with successful projects commencing in 2010. 40 % of funding has been committed to core

projects undertaken at the Commonwealth Scientific and Industrial Research Organisation, the University of NSW and the Australian National University. Contestable funding is available for other basic and applied R&D projects. The first 5 projects to be funded are:

- University of New South Wales: *Development and Commercialisation of High Efficiency Silicon Solar Cell Technology.* 3,972 MAUD.
- University of Newcastle: *Fabrication of Thermionic Devices Using Directional Solidification / Sintering Processes for High Temperature Concentrating Solar Thermal Applications.* AUD 515 000.
- Australian National University: *Plasmonics for high efficiency Photovoltaic Solar Cells using nanotechnology to capture more light.* 1,67 MAUD.
- University of Queensland: *New Materials and Architectures for Organic Solar Cells - Beyond the Shockley-Queisser Limit.* AUD 945 000.
- CSIRO and the Australian National University: *Advanced steam generating receivers for high concentration solar collectors.* 4,084 MAUD.

The NSW Energy Challenge

A new 5 MAUD international research prize has been announced by the NSW Government to encourage innovative solutions in the provision of clean energy. To be eligible for the prize, research teams must have two essential partners - a NSW university and a company with its headquarters in NSW.

IMPLEMENTATION

Feed-in Tariffs (FiTs)

A number of States and Territories have now introduced FiTs, although only the Australian Capital Territory and the Alice Springs Solar City offered gross FiTs. A gross FiT will commence in New South Wales from 2010. Net export FiTs operate in Victoria, South Australia and Queensland.

Solar Cities

In 2008, the Solar Cities program saw two new Cities announced, Moreland and Perth, expanding the Program to 7 Solar Cities. Four Solar Cities were operational in 2008: Adelaide, Blacktown, Alice Springs and Townsville, with 716 kW of PV installed. Central Victoria and Moreland Solar Cities began to roll out projects to their communities in 2009.

Alice Solar City provides a capital subsidy of up to 50 % for eligible householders to install a PV system. Householders are also able to sell all electricity generated to the Power and Water Corporation and benefit from a gross feed-in tariff of AUD 45,76 c/kWh, capped at AUD 5 per day.

Ergon Energy is installing up to 1 MWp of PV on premises around Magnetic Island, as part of the Townsville Solar City project. Residents can volunteer their roof space and Ergon will fully manage installation and maintenance of the PV systems, as well as using the electricity generated to reduce daytime peak load on the inland. The Solar Cities program is one of the few providing support for PV systems in the commercial / industrial sector. A 100 kWp system has been installed at the Cadbury-Schweppes factory in Blacktown, a 305 kWp system on the Crowne Plaza in Alice Springs and several 50 kWp systems for the Adelaide Solar City.

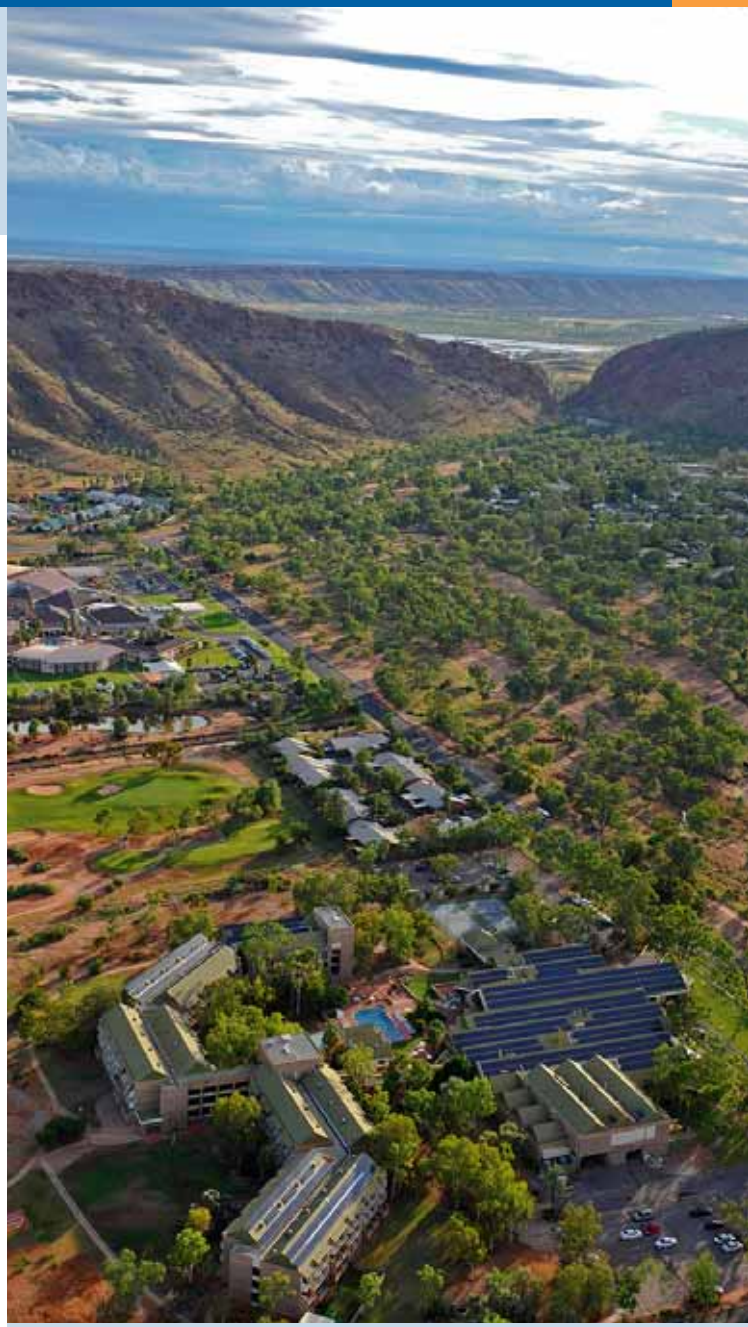

Fig. 2 - 305 kWp PV system on the Crowne Plaza at Alice Springs (photo SunPower Corporation).

Diesel Grids

The installation of PV in diesel grids is cost effective in many areas of Australia. Western Australian electricity company Horizon Power has commissioned SunPower to install 500 kWp of tracking PV on its diesel grids at Marble Bar and Nullagine, 1 500 km from Perth. Flywheel storage systems will also be installed by Powercorp to optimise use of the PV output. The systems are expected to generate over 1 GWh of electricity each year and save 35-40 % of the diesel fuel used in the power stations.

INDUSTRY STATUS

42 MWp of cells were produced in Australia in 2008, from imported wafers, and 8 MWp of modules. Unfortunately, BP Solar, the only

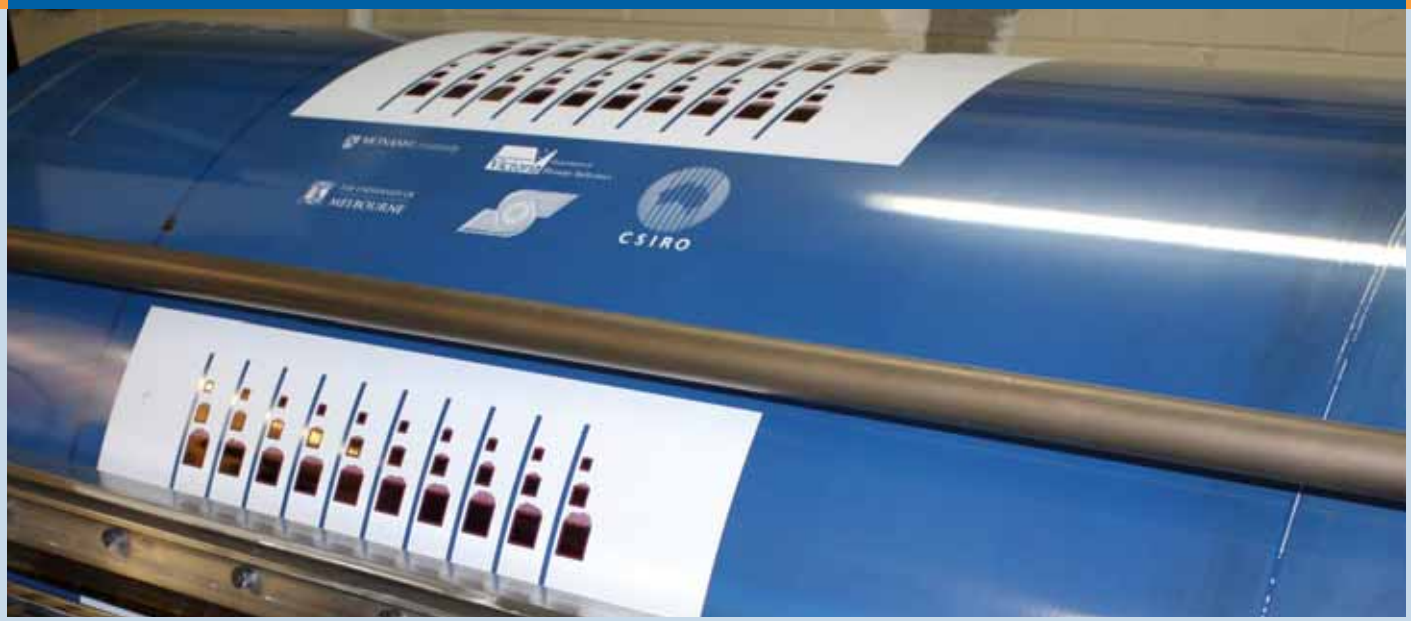

Fig. 3 - Printing Press for Organic Solar Cell production (photo CSIRO).

commercial PV manufacturer in Australia, ceased production in early 2009. However, a number of other companies are interested in manufacture, with Silex having purchased the BP Solar plant and planning production from 2010.

Selectronics Australia manufactures a range of inverters and released its SP PRO grid inverter in 2009, which can also be used in back-up mode or as an inverter charger for stand-alone applications. The Latronics' PV Edge inverter is also designed and built in Australia. It offers a PV only, a PV- wind or micro-hydro option, or an uninterruptible power supply option, which can be used with multiple energy sources and a battery bank.

MARKET DEVELOPMENT

A total of 22 MWp of PV were installed in Australia in 2008, an 80 % increase on 2007 levels. Of this, nearly 69 % was grid connected, taking the cumulative grid connected portion to nearly 30 %, up from 19 % in 2007. Total installed capacity in Australia at the end of 2008 was 104 MW. Over 60 MW is estimated to have been installed in 2009 with even higher levels expected in 2010 in response to the attractive PV prices, increasing electricity tariffs and new State and Territory gross feed-in tariffs.

The high capital rebates, and the subsequent high PV uptake levels, have seen a number of market innovations. One was the emergence of bulk purchase and install schemes organised by both private companies and local governments, whereby households signed up for a low cost system, on the basis of sufficient local interest (typically 50 homes) being shown. Bulk purchase of lower-cost Chinese modules, combined with streamlined installations in a local area allowed prices to fall considerably, (around AUD 9/Wp in 2008 compared with standard purchase costs of around AUD 12/Wp). Prices continued to fall in 2009, in line with international market trends and strong competition in the Australian market.

FUTURE OUTLOOK

With PV prices now reflecting the significant production cost reductions which have occurred over the past decade, and with grid electricity prices rising rapidly, PV grid parity is expected to be reached in many areas of Australia within this decade. In the short term, the residential market will be driven by the Solar Credit mechanism and gross feed-in tariffs, where available. In the longer term, there will be a need to incorporate PV into building codes and zero energy building targets. Interest is growing in the commercial market, where daytime electricity use is growing fast and contributing to peak load problems. The market for central solar power plants will be stimulated by the Solar Flagships program. The important off-grid market, where up-front capital costs of PV are a major barrier, is currently not well supported.

As PV penetration levels rise, maintaining high quality products and installation standards will become more challenging, while grid impacts will begin to signal the need for different grid management strategies.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - PV Production at Solon Hilber, Tyrol (©photo: das fotoatelier Steinach).

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

In general, the Austrian situation in photovoltaics has slightly improved in 2009. The internationally acting production companies could perform quite well, in spite of the global economic crisis. The home market improved a bit, improved a bit. The continuity in public support schemes is still lacking. Traditional export rates of the individual production companies are 90 % or even more.

A wide public support for PV installations (in order to match leading photovoltaic markets) 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 revised green-electricity act (GEA) is in operation.

Even though the "new *RES*" are supported by this act, mainly via up to 13 years guaranteed feed-in tariffs, the financial cap is much too low to significantly increase the share of renewables in the Austrian electricity system. 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 will receive about 10 % of the support volume
- The duration of the program is 10 years constant + 2 years declining support

Through these feed-in-tariffs only systems > 5kW will be supported. Systems up to 5kW can apply for investment cost funding through the Austrian Climate and Energy Fund. This support initiative, launched once a year, 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 (< 5 kW) which lead to another about 900 PV Systems with a total of about 4 MW. In 2009, the budget was doubled leading to about 7-8 MW of PV installations. This support scheme provided additional financial benefits to building integrated systems (BIPV).

The announced Austrian Climate and Energy Fund' increased budget for 2010 for PV support in the range of 35 MEUR could lead to another 20 MW of installations, since the support per kW installation will be reduced according to the lower PV prices. Besides this, some regional states have announced increases in PV support budgets, as well.

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 internationally noticeable Austrian PV home market. Differently to other countries the feed-in-tariff system will only be responsible for the minor part of the supported PV in Austria.

RESEARCH AND DEVELOPMENT

The European 20-20-20 targets led to a governmental energy strategy process on how to achieve the given national targets for renewables, which should increase from the current 23 % to 34 % in 2020.

The Austrian Ministry of Transport, Technology and Innovation ordered a revision of the existing national PV technology roadmap in order to explicitly address the 2020 targets.

The revised roadmap was introduced into this process in early December 2009. In this new roadmap, two realistic but ambitious targets were worked out, reaching 5 % respectively 8 % of the total Austrian electricity by photovoltaics in 2020, provided the frame conditions will be changed immediately. Beside the energy output, in these scenarios up to 36 000 employees could find a job in the Austrian PV industry; these numbers mainly due to the design and installation of PV systems. National Industry producing PV components for the world market could further increase these numbers.

The National PV Technology Platform, founded in September 2008 along with the 6th Austrian PV conference, was further developed. The PV Technology Platform brings together about 15 leading Austrian PV industries in order to discuss their needs for a long term strategy towards an international competitive positioning on the growing world market. Currently, about 2 200 employees are working in the PV industry in Austria. This initiative is coordinated by the University of Applied Science Technikum Vienna.

For many years, 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 research 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 already in 2008 and cover quite broad research items on energy technologies, including PV with a focus on PV building integration. In 2009, PV research was addressed explicitly for the first time in a separate subpart of the programme. 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. Austria actively participates in the PV-ERA-NET and is funding Austrian participation in transnational ERA-NET calls on PV.

Electricity companies are more and more investing in research on renewable energy. Departments were founded to establish a business, mainly by investments in new and existing renewable energy plants. 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, with many PV activities as well as the Upper Austrian Energie AG, which just designed Austria's first 1 MW PV systems near Eberstalzell; to be operational in 2010.

Research Highlights of Photovoltaic in Austria are:

- The Christian Doppler Laboratory at the University of Salzburg "**Applications of Sulfosalts in Energy Conversion**" installed a new method to grow single sulfosalt crystals using melt solution growth and a new photoacoustic spectroscopy system for semiconductor band gap determination. The improvement of solar cell efficiencies by use of buffer layers was investigated and sulfosalt candidates with high Seebeck coefficients combined with high electrical conductivity for applications in thermoelectrical energy conversion were identified.
- The research topics of another Christian Doppler Pilot Laboratory at the Technical University in Graz "for **Nanocomposite Solar Cells**" are focused on the preparation of nanocomposite materials with controlled morphology for photovoltaic applications. The basic research program will focus on the formation processes and the investigation of the morphology of nanocomposite layers, consisting of inorganic and organic semiconductor phases.
- **Crystalsol** is aiming at developing a new type of flexible photovoltaic module with a significant cost and versatility advantage, compared to currently known photovoltaic technologies. The core innovation is the light absorbing layer made of a patented new crystalline semiconductor powder and the low-cost roll-to-roll production process. For this innovative technology development, Crystalsol received the Austrian State Award Environmental and Energy Technology 2010.
- **Austrian Institute of Technology**, Energy Department (formerly arsenal research) investigates methods for characterization and analysis of different PV module technologies (Crystalline, thin-film, concentrators) and their performance according to power, energy yield, lifetime and spectral influence. The research field includes integrating existing and emerging systems to design an intelligent multifunctional façade. The existing laboratory infrastructure will be extended with the opening of a thin film laboratory in the second half of the year 2010. The integration of PV into Smart Electricity Networks is the focus of national and EU financed projects which started in 2009. As the main highlight, the new IEA-PVPS Task 14, which was initiated by international collaboration, will be coordinated by Austria.
- Due to the intensive investigation of thin-film Organic Solar Cells at the Johannes Kepler University, **Konarka Technologies**, a US-based PV-company is operating a Research and Development centre in Linz.
- **HEI** develops and manufactures novel, self-sufficient solar LED-lighting systems with tube-shaped PV panels which are fully integrated to the light pole. The lights are dedicated for professional lighting of roads, squares and pathways. The company started production in 2007 and is now expanding fabrication facilities.
- **Vienna University of Technology**, Energy Economics Group (EEG), major topics of teaching and research on Photovoltaics:
  - diffusion of technology and market penetration on national and international level
  - non technical obstacles and supporting factors for diffusion of technology (e.g. socio-economic impact parameters)
  - energy policy design and political economy effects of PV
  - PV integration in buildings
  - medium and long term diffusion scenarios of PV

- At the Energybase, the largest passive solar office building in Austria, and home of the new Programmes "Renewable Urban Energy" of the **University of Applied Sciences Technikum Vienna**, the Master course commenced in September 2009 with a strong focus on PV and other solar technologies.
- The **Austria Solar Innovation Center (ASIC)** covers consultation for PV, as well as teaching and training in collaboration with the Upper Austria University of Applied Sciences, degree programme Eco-Energy Engineering (BSc, MSc). Students have lectures and laboratory classes. Students practice with a 17 kWp PV system - 5 different module types, 5 different inverter types, 2 monitoring/ data logging systems, and a meteorological station.

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 32 MW of PV power had been installed in Austria, by the end of 2008. No figures are yet available for 2009, but it is expected that currently, not more than about 40-45 MW are totally installed in Austria. The annual growth rate in 2008 was, with a total 4,7 MW, still modest.

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. Building integration is an important issue and a few remarkable installations were realised in 2009.

Besides 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.

INDUSTRY STATUS

Austrian market framework conditions the Austrian PV industry could still expand their activities during 2009; focussing on the export of their products predominately to the booming German market and other International markets. In Austria, about 2 200 employees in the PV business seems to be a success, but this is very much dependent on the development outside the country's borders.

In 2009, AT&S has industrialized a new PV module technology aiming at higher efficiency, based on back-contacted cells. They are targeting a commercial launch in 2010.

Blue Chip Energy started production of silicon solar cells in the energy autarkic municipality of Güssing (Burgenland) in 2008.

Energetica is a module manufacturer and system supplier located in Carinthia and offers complete solutions in the field of photovoltaics. Production of photovoltaic modules, production of inverters and the planning and mounting of photovoltaic- and solarthermal systems are within the scope of Energetica.

The **Ertex Solartechnik GmbH** is a company of the ERTL Glas Group. One of their main product is the VSG, a laminated safety glass which can be also assembled easy to insulating glass. In recent years, Ertex-solar realized a few projects all over the world. The focus in 2009 was Italy, France, Germany and Portugal.

Falconcell Produktions GmbH is a manufacturer of mono- and multicrystalline silicon solar cells. Founded in 2006, Falconcell began operations in 2007 with a production capacity of 30 MW.

Kioto-Photovoltaic, since 2004 produces mono- and multi-crystalline solar modules based on 6" wafers in St.Veit/Carinthia.

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

SED manufactures PV-roof tiles for BIPV applications. The custom laminates produced are directly stuck into standard format tiles made of recycled plastic and can easily replace conventional roofing materials. SED also manufactures PV elements for noise barrier walls. The glassless flexible laminates are mounted on aluminium carriers and fit all custom noise barrier types.

SOLON HILBER Technology: The company produces modules with a yearly capacity of 50 MW and all kind of installation systems/trackers (Tixed Tilt, Single Axis, Dual Axis, Bus Ports and Alpine Solutions). SOLON HILBER also installs turn key projects all over the world. The references are in Europe, USA and Australia with a total capacity of more than 150 MW. The company belongs to the German SOLON SE. Currently, more than 200 employees are working in this company.

Sunplugged, based in Tyrol, is developing a new type of flexible CIGS Cells. Energy supply for efficient cooling systems on commercial vehicles will be one specific application of this new development.

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 developed and produced inverters for grid-connected PV systems since 1994. With a current production capacity of approx. 2 000 MW of inverter power Fronius is the second-largest manufacturer in the world and is selling its products in more than 30 countries worldwide.

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-METALL GmbH in Tyrol is manufacturing refractory metals for diverse applications; more particularly metallic targets for thin film solar cells.

Fig. 2 - Development of composite films for encapsulating photovoltaic modules (photo: Isovolta).

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

PTS in Klagenfurt offers complete turnkey module production systems with their "string@once" technology.

The Energy Department of the Austrian Institute of Technology, (formerly arsenal research) is known as the internationally accredited PV module test institute for crystalline modules (since 2003) according to the IEC/EN 61215, and for thin film modules, according to the IEC/EN 61646 and module safety qualification according to the EN 61730. Another industry related activity at the AIT are PV inverters, in particular their performance (MPP, efficiency aspects) and their grid compatibility (Control, Fault-Ride-Through). The AIT PV inverter laboratory attracts worldwide inverter manufacturers for collaboration.

ACCOMPANYING MEASURES FOR ACCOMPANYING MEASURES FORMARKET DEVELOPMENT

The National Photovoltaic Association is very active in public relations and has built a national network for dissemination of information on PV and initiates various workshops, press conferences and other awareness raising activities. By fostering 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. At the end of 2009, well over 100 companies and individuals involved in the PV business were Association members.

The Annual National Photovoltaic Conference (a three days event) organised by the University of Applied Sciences Technikum Vienna and supported by the Ministry of Transport, Innovation and Technology is established as THE annual gathering of Austrian PV stakeholders. In 2009, this event was combined with the General Assembly of the European Photovoltaic Technology Platform, bringing together about 450 experts in Vienna in June 2009.

The "Certified PV Training," offered by the Austrian Institute of Technology has increased their PV program significantly by performing 8 day-trainings courses all over the country, with a total of more than 120 participants in 2009.

FUTURE OUTLOOK

The situation of the steadily growing export oriented Austrian PV industry is expected to be further improved, due to the international booming PV market, and the small home market.

The Austrian PV market will remain limited, relying on various incentives which will only partly support the market.

Some strategic initiatives to show the potential of PV for Austria are PV Technology-Roadmap, PV-Technology Platform, PV Lobbying by the Association, PV Conferences, etc.

PV research and development will be further concentrated on international projects and networks, following the dynamic know-how and learning process of the world-wide PV development progress. Mainly within IEA PVPS, the new Task 14 on "High Penetration Photovoltaics in Electricity Networks," lead by Austria, might become a focal point of the research activities.

The direct links to the new members of the European Union in Central and Eastern Europe (Czech Republic, Slovakia, Slovenia, Bulgaria, etc.) in energy related items are to be mentioned, where PV increasingly plays an important role.

The level of the public know-how and interest about the potential and perspectives of PV is continuously growing. Several renewable energy education courses are already implemented and some new ones are currently under development. All of them include PV as an essential part of the future energy strategy. The importance of proper education for installers and planners of PV systems will increase depending on the market situation. The training is already available and can be extended easily. Meanwhile, at the University of Applied Science Vienna (Technikum-Wien), about 200 students are studying at the Bachelor and Master courses in "Urban Renewable Energy Technologies" with solar, and specifically, PV systems as one core element of the education.

CANADA

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

Fig. 1 - SunEdison's and SkyPower Corporation's 9,1- megawatt (MW) First Light Solar Energy Park in Stone Mills, Ontario, and the largest solar energy park built to date in Canada (photo: Dave Turcotte, CanmetENERGY).

GENERAL FRAMEWORK

Canada's Department of Natural Resources (NRCan) supports priorities to promote the sustainable and economic development of the country's natural resources, while improving the quality of life of Canadians. CanmetENERGY[1], reporting to the Innovation and Energy Technology Sector of NRCan, is the largest federal energy science and technology organization working on clean energy research, development, demonstration and deployment. Its goal is to ensure that Canada is at the leading edge of clean energy technologies to reduce air and greenhouse gas emissions and improve the health of Canadians. The federal photovoltaic activities is led by the CanmetENERGY research centre located in Varennes, Quebec and funded through federal RD&D programs that include the Program of Energy Research and Development[2] and the ecoENERGY Technology Initiative[3].

In 2009, the Province of Ontario, Canada's second largest province, through the passage into law of the *Green Energy Act*, adopted an aggressive green energy policy that includes a powerful Feed-In Tariff (FIT)[4] program as its centerpiece. The provincial government launched the program in September 2009, and delegated the responsibility for its implementation to the Ontario Power Authority (OPA). The FIT program replaced the province's highly popular Renewable Energy Standard Offer Program (RESOP)[5], which underwent review in 2008. As part of the FIT launch process, all renewable energy supply projects that have been approved under RESOP and are in commercial operation will continue according to their RESOP contracts. As of the third quarter of 2009, the OPA had 1 422 MW of renewable energy supply capacity of which 525,4 MW are from PV power generation projects under the RESOP Program (Table 1). Of these, Canada's first three large-scale PV parks of 23,4 MW by enXco/ EdF-EN Canada[6], 20 MW by Enbridge[7] and First Solar and 9,1 MW (Figure 1) by Skypower Corporation[8] have achieved commercial operation in 2009 and became eligible for RESOP contract payments of 0,42 CAD/kWh for a 20-year power purchase agreements.

As of the fourth quarter of 2009, the RESOP Program was replaced by the FIT Program and RESOP contract holders whose projects were not in commercial operation were given an opportunity to rescind their RESOP contracts and apply for a FIT contract.

TABLE 1 - ONTARIO POWER AUTHORITY RESOP CONTRACTS CAPACITY IN 2009[9] (MW)

RE SOURCE	IN COMMERCIAL OPERATION	UNDER DEVELOPMENT	TOTAL
Solar PV	**54,3**	**471,1**	**525,4**
Wind	67,6	671,3	738,9
Water	17,7	53,2	70,9
Bio-Energy	26,1	60,9	87,0
TOTAL	**142,3**	**1279,9**	**1422,2**

The Canadian Solar Buildings Research Network (SBRN)[10] 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. The goal of the SBRN research is development of the solar-optimized buildings an integrated advanced technological system that approached net-zero annual total energy consumption. The 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 2009, the Government of Canada invited Canadian residential developers, planners, designers and municipalities to develop and showcase neighborhoods that are more sustainable and energy-efficient than most existing communities under the new EQuilibrium ™ Communities Initiative. The initiative, which is funded and led by NRCan and the Canada Mortgage and Housing Corporation (CMHC), builds on the success of the EQuilibrium™Sustainable Housing Demonstration Initiative[11] launched by CMHC in 2006, and is supported by NRCan's CanmetENERGY expertise. It provides leading-edge teams with an opportunity to be at the forefront of bringing to market energy-efficient, sustainable and profitable clean energy technologies integrated into buildings and neighborhoods that benefit consumers, the environment, and the economy. Also in 2009, a number of the EQuilibrium™houses moved beyond the demonstration stage when they were purchased and occupied, and are now starting a one year monitoring phase to verify their actual performance. Performance data from the PV systems installed on these homes will be available online for a minimum of one year with a live feed from Fat Spaniel Technologies[12].

NATIONAL PROGRAM RESEARCH AND DEVELOPMENT

NRCan's CanmetENERGY is responsible for conducting photovoltaic RD&D activities in Canada that facilitate the development and deployment of PV energy technologies throughout the country. Efforts undertaken by CanmetENERGY, such as the coordination of various research projects, participation in international committees on the establishment of standards, and producing information that will support domestic capacity-building, provide stakeholders with the necessary information to make informed decisions. Most research projects are carried out, on a cost-sharing basis, with industry, universities, research groups, quasi-public agencies, and other departments and governments. CanmetENERGY 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.

As of September 2009, a new research network on solar cells has been formed and funded by the Government of Canada. This research network, supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) at 1 MCAD per year over the next 5 years, will bring together a core group of 25 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners to develop and transfer to the Canadian industry innovative PV technologies. The network will focus its efforts on organic, nanostructure and other innovative PV device approaches that have the potential to leapfrog existing and established technologies. In addition a new cross-agency collaboration with the Business development Bank of Canada to support research partnerships with industry in the field nanomaterial that includes 2,9 MCAD over three years[13].

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)[14] - a Program that supports national science and technology 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.

CanmetENERGY is also conducting research into the optimal integration of solar Photovoltaic/Thermal (PV/T) technologies and systems into net zero energy homes, with the aim of developing simple models to predict the electrical and thermal yield of PV/T systems. This work is s aligned with the Canada's mandate to conduct innovative R&D in the building whereby the optimized integration of technologies and systems is essential for achieving marketable near- and net- zero houses of the future. This work is undertaken in collaboration with other federal delivery organizations such as CMHC and the Solar Buildings Research Network.

DEMONSTRATION

Alstonvale Net Zero Energy Solar Smart Home, Hudson, Quebec

The Alstonvale Net Zero Energy Solar Smart House[15] (ANZEH) under construction in the city of Hudson, Province of Quebec, is one of 15 winners chosen in 2007 by the Canadian Housing Mortgage Corporation's (CMHC) nationwide EQuilbrium Initiative[16], a sustainable housing program launched in 2006 and geared towards mitigating

Fig. 2- The Alstonvale Net Zero Energy House, Hudson, Quebec, Canada (photos: Sevag Pogharian Design).

emissions of carbon dioxide from the housing sector. The ANZEH strives towards net-zero energy consumption by minimizing the energy requirement of the house through a high performance building envelope, reduced energy demand loads, and aggressive use of passive heating and passive cooling techniques, as well as generating on-site sufficient energy, through renewable resources through a roof-integrated 8,4 kW photovoltaic array and solar thermal panels (Figure 2). The scope of the ANZEH, however, has evolved to broader and more ambitious objectives than its EQuilibrium cohorts. It will attempt to generate all the energy required for the household's domestic as well as local transportation energy needs, by storing excess PV generated power into an electric-drive vehicle, in an effort to demonstrate the attainability of a more encompassing net-zero energy lifestyle. NRCan's CanmetENERGY is leading this R&D work with the home builder.

Team North and Team Alberta 2009 Solar Decathlon Competition

Canada was represented by two university teams in U.S. Department of Energy 2009 Solar Decathlon competition: Team North (the "North House", Figure 3a) bringing together students from University of Waterloo, Ryerson University and Simon Fraser University and Team Alberta (the "ENMAX SolAbode" Figure 3b) consisting of University of Calgary, SAIT Polytechnic, Alberta College of Art and Design and Mount Royal College students. Team North greatly impressed by finishing in fourth position of the general ranking. The team performed consistently throughout the whole competition by finishing in the top 5 of 7 of the 10 tests they had to compete in and by obtaining the second position in the communications test. Team Alberta also distinguished itself by achieving the 6th rank in the global competition and getting the 5th position in the home entertainment and comfort zone challenges. The U.S. Solar Decathlon is an excellent opportunity that provides architecture and engineering students with hands-on experience in innovative design that target net-zero energy solar optimized homes.

Fig. 3 - Canada's two entries in the 2009 US DOE Solar Decathlon Competition, the North House (a), and ENMAX SolAbode (b) - marketable solar powered home that makes use of the latest in high-performance architecture energy management technology while building Canada's next generation of leaders in sustainable engineering, business and design (photos: Team North and Team Alberta).

Fig. 4 - The T'Sou-ke First Nation Solar PV Project, BC's largest solar system (photo: Sia Vojdani).

The T'Sou-ke First Nation Solar Power Project, Sooke, British Columbia

In 2009, the T'Sou-ke First Nation, a native community in Sooke on the southern end of Vancouver Island became the largest solar energy producing community in the Province of British Columbia. The T'Sou-ke solar project is a suite of solar options for producing hot water and electricity. The PV component consists of three models: 62 kW grid-connected array atop the band's canoe shed providing the electricity needs of the community or for sale to BC Hydro, the provincial utility; a 7 kW grid-connected system on the band hall for emergency battery back-up in case of a power outage; and a 6 kW system on the bands' fisheries office that will require some form of backup such as diesel, propane or another renewable technology. The T'Sou-ke First Nation solar project is being held up as an energy autonomy model for other aboriginal communities across the province, particularly those that are off grid and reliant upon diesel generators for electricity.

IMPLEMENTATION

Ontario's Feed-In Tariff (FIT) Program

Ontario's FIT program launched the third quarter of 2009 and managed by the Ontario Power Authority is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar PV, bioenergy waterpower and wind. The FIT program is divided into two streams, one targets the small, medium and large renewable energy projects generating more that 10 kW of electricity (referred as the "*FIT Program*")[17], and the other targets very small renewable projects generating 10 kW of electricity or less, such as a home or small business installations (referred to as the "microFIT Program"). Prices paid for renewable energy generation under FIT and microFIT programs vary by energy source and take into account the capital investment required to implement the project. Under the program, solar PV applicants are paid a fixed price of up to 0,802 CAD per kWh for the electricity they generate for a 20 years contract.

As of December 2009, under the FIT program, the OPA received about 1000 applications with approximately 8 000 MW of potential generating capacity[18]. Of this, approximately 2 500 MW will be awarded contracts under the first round of contracts. Under the microFIT program, the OPA received about 1 200 applications representing 8,6 MW of generating capacity of which about 1 166 are solar PV projects totaling 8,382 MW.

TABLE 2 - ONTARIO POWER AUTHORITY FEED-IN TARIFF PRICE SCHEDULE FOR SOLAR PV (CAD)[19]

APPLICATION TYPE	SIZE TRANCHES	CONTRACT PRICE (¢/KWH)	
Any type	< 10 kW	80,2	microFIT
Rooftop	> 10 d 250 kW	71,3	FIT
Rooftop	> 250 d 500 kW	63,5	
Rooftop	> 500 kW	53,9	
Ground-mounted	> 10 kW d 10 MW	44,3	

Net-Metering in Canada

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).

Interconnection Standards and Codes

NRCan's CanmetENERGY in partnership with key industry players and associations has championed a national effort to address the delays and 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[20]. 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 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.

This national effort has been expanded to address future 'Smart Grid' applications. The Standard Council of Canada and NRCan's CanmetENERGY have established a Canadian Smart Grid Technology and Standards Task Force in support of a global effort to harmonize requirements. As an example of its commitment to the International Electrotechnical Commission, Canada provided support for the development of an international standard for electricity network communication and distributed energy resources. This is a key issue to ensure that systems are inter-operable with utility networks. This effort was completed in 2009 with the final approval and publication of the IEC 61850-7-420 Ed.1 standard for basic communication structure, including photovoltaic device and system logical nodes.

Federal Programs in Support of Technology Demonstration to Market Commercialization

Sustainable Development Technology Canada (SDTC)[21] - 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 2009 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.

INDUSTRY STATUS

There is nearly 350 solar photovoltaic companies (sales companies, wholesalers, product manufacturers, project developers, private consultants, systems installers and industry associations) operating in Canada many of which are members of the Canadian Solar Industries Association[22] and Énergie Solaire Québec[23]. The majority of these companies are also participating in the Province of Ontario's new Feed-In Tariff Program (and its precursor the Renewable Energy Standard Offer Program). The FIT Program continued to attract to renewable energy project developers and product manufactures to the Province in 2009. Under 'new content rules', any developer wishing to participate in the FIT Program must show that the equipment and labor used to install the system consist of 40 percent 'Ontario' content for projects less than 10 kW in size. Above that threshold the required local content is 50 %.

In 2009, Canadian Solar Inc.[24] (a vertically integrated provider of ingots, wafers solar cell and modules and specialized solar products) announced its intentions to establish a manufacturing facility in Ontario that will create 500 jobs to take advantage of the province's FIT Program that mandates local content. Also, ATS Automation Tooling Systems Inc.[25], the parent company of Photowatt International[26] announced in 2009 that it has established Photowatt Ontario Inc. at its site in Cambridge, Ontario as part of its plan to lead the Ontario solar energy market. Phottowatt Ontario offers turnkey solar project development, installation and solar products. Another development in 2009 is the Government of Ontario[27] and Korea-based Samsung C&T Corporation[28] - led consortium announcement of a 7 BCAD green energy investment for 2,500 MW of solar (500 MW) and wind (2 000 MW) energy generation in the Province. This investment is expected to triple Ontario's renewable solar and wind energy generation and lead to manufacturing facilities being constructed in Ontario. The Province's Green Energy Act is creating the appropriate business conditions to attract investments to grow the solar industry in Ontario.

MARKET

Growth in the Canadian sector has been consistent over the past 17 years, with capacity growing by more than 22 % percent annually between 1993 and 2009 The Ontario FIT (and RESOP) program offering 0,443 - 0,802 CAD per kilowatt-hour for PV electricity production is paving the way for a steep uptake for grid-connected PV. 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 17 years in Canada and continues to accounts for about 75 % of total PV installed without the FIT component. This is an unsubsidized market that is meeting the remote power needs of Canadian customers particularly for transport route signalling, navigational aids, remote homes, telecommunication, and remote sensing and monitoring. The Canadian total PV installed capacity increased by 211 % to about 102 MW in 2009 with nearly 52,5 MW attributed to the three large-scale PV parks installed in Ontario. In 2009, the PV module market in Canada was 67,3 MW compared to 6,94 MW in 2008. In 2009, total domestic and export modules sales by Canadian-based industry reached 41,82 MW, an increase of 48 % over the previous year of which 81 % were for on-grid applications (distributed), and 19 % for off-grid applications (residential and non-residential). Module prices (weighted average) have gradually declined from 11,09 CAD in 1999 to 3,31 CAD in 2009. This represents an average annual price reduction of slightly over 11 % over the ten-year period.

FUTURE OUTLOOK

The Feed-In Tariff Program (and RESOP) is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. By the end of 2009, the RESOP had exceeded its 5-year target with 525 MW of solar PV contracts signed of which 54,3 MW being in commercial operation to date. The FIT program addressed many of the concerns regarding the delays and interconnection obstacles identified by CanSIA and other renewable energy industry associations during the review process of the RESOP, and have made it less complicated for applicants. The tremendous initial response to the microFIT program signals a strong support for residential solar rooftop applications in Ontario. Based on its popularity, this market niche is expected to grow substantially in 2010 beyond the announcement of a 700 solar rooftop projects by the Province.

The federal government is investing in research activities to develop and test photovoltaic electricity generation forecasts, with emphasis on physical parameters and timescales relevant to electric utilities, PV system developers, owners and operators. Such forecasts are important to reliable and cost-effective large scale integration of PV systems into electricity grids, to solar electricity trading and to the development of load control strategies for PV integrated into buildings and building clusters. As solar electricity in Ontario continues to grow its share of the province's electricity mix, the federal government is also leading the R&D investments into activities to better understand the technical challenges of high penetration levels of PV into the electricity grid[29]. This work will be undertaken in collaboration with an international group of stakeholders to better address the emerging field of PV integration in smart grids in Canada.

Endnotes:

1 http://canmetenergie.rncan.gc.ca/eng/index.html
2 http://www.nrcan-rncan.gc.ca/eneene/science/perdprde-eng.php
3 http://www.nrcan-rncan.gc.ca/eneene/science/etiiet-eng.php
4 http://www.fit.powerauthority.on.ca
5 http://www.powerauthority.on.ca/sop/Page.asp?PageID=861&SiteNodeID=209
6 The firm behind the project is enXco and EdF-Energie Novelles group. The Canadian operation is known as EdF-EN Canada. http://www.enxco.com/
7 http://www.enbridge.com
8 http://www.skypower.com
9 Information extracted from OPA, "A Progress Report on Electricity Supply, Third Quarter 2009". 10,9 MW of solar PV capacity reached commercial operation in Q3 of 2009 and reported in the OPA report, and 20 MW achieved commercial operation in Q4 of 2009.
10 http://www.solarbuildings.ca
11 http://www.ecoaction.gc.ca/equilibrium-eng.cfm
12 http://www.fatspaniel.com/fat-spaniel-in-action/live-sites/
13 http://www.nserc-crsng.gc.ca/NSERC-CRSNG/FundingDecisions-DecisionsFinancement/Nanotechnology-Nanotechnologie_eng.asp
14 http://canmetenergy.nrcan.gc.ca/eng/renewables/integration_der.html
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16 http://www.ecoaction.gc.ca/equilibrium-eng.cfm
17 http://www.microfit.powerauthority.on.ca
18 No breakdown of the solar PV generating capacity given.
19 http://www.fit.powerauthority.on.ca
20 http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2007-172/2007-172e.pdf
21 http://www.sdtc.ca/en/index.htm
22 http://www.cansia.ca
23 http://www.esq.gc.ca
24 http://www.canadian-solar.com
25 http://www.atsautomation.com/
26 http://www.photowatt.com/en/
27 http://www.news.ontario.ca/opo/en/2010/01/korean-companies-anchor-ontarios-green-economy.html (announced on Jan. 21, 2010)
28 http://www.samsungcnt.com/pr/board_view.asp?fnum=131&fidx=1805&fpart=eng
29 http://www.iea-pvps.org

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS
FLEMMING KRISTENSEN, ENERGIMIDT LTD., DENMARK
PETER AHM, PA ENERGY LTD., DENMARK

Fig. 1 - School in the Skive municipality, 300 kWp single crystalline modules integrated in the roofs.

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 focus 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 developmenof 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 sets 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 to 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 2009, more than 27 % of the national electricity consumption was generated by renewable energy sources, including incineration of waste. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the present energy plan; the two main objectives being the development of a future environmental benign energy system and a high degree of security in the energy supply many years ahead, both at favourable cost to the consumers.

Photovoltaic technology (PV) is not specifically mentioned in the government's energy plan, but early 2004, the Danish Energy Authority (EA) in collaboration with the electricity sector, the industry and other key stakeholders finalized a national strategy on PV after a public hearing. This PV strategy includes the fields of research, development and demonstration. Deployment activities in support of the PV strategy are envisaged to be developed in the coming years and an overall framework for the coordination of PV development and deployment in Denmark is thus envisaged to be in place inside a few years. The PV strategy was updated mid 2006 by the way of an annex outlining the need of long term operational targets and support mechanisms for demonstration. A full update

Fig. 2 - School in the Horsens municipality, 2,55 kWp poly crystalline modules integrated in the facades.

has been completed in 2009, including the need for large scale demonstration or deployment instruments; but so far, no political decision on supporting instruments is in place.
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 less than 20 years.

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, a fully government owned body. In late 2006, a new support mechanism, the Energy Development and Demonstration Programme (EUDP), to be administered by an independent board and with the Energy Authority as secretariat was announced. A first call for proposals was closed in September 2007 and has been followed by several calls. 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 administered by Energinet.dk 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, and the regional municipality of Bornholm is now considering a major PV initiative.

By the end of 2009, about 4,6 MW has 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. Net-metering for privately owned PV systems was established mid 1998 for a pilot-period of four years. Late 2002, the net-metering scheme was extended another four years up to end of 2006.
Net-metering has proved to be a cheap, easy to administrate and effective way of stimulating the deployment of PV in Denmark; however the relative short time window of the arrangement has so far prevented it from reaching its full potential. During the political negotiations in the fall of 2005, the net-metering for privately owned PV systems was made permanent, however net-metering alone - event at a present typical level of EUR 0,27/kWh - appears on its own not to be able significantly to stimulate PV installations.

RESEARCH & DEVELOPMENT, DEMONSTRATION

During 2003, the government has announced additional financial support to the new R&D programme started in 2002. Over a 5 year period more than 150 MDKK was allocated to renewables; however, as the focus of the programme is on university research activities, it is so far only to a limited extend PVs have 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 per year.
This R&D facility named ForskEl is administered by Energinet.dk, the Danish transmission system operator (TSO). Since then, the government has pledged itself to increase the funding for R&D in new energy technologies up to 1 000 MDKK in 2010 and a few R&D PV projects have indeed benefitted from support during 2009; with most of the funding going to basic R&D in organic and polymer cells. As previously mentioned, a new support instrument named ForskVE under administration of Energinet.dk 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."

Fig. 3 - Flexhouse at the Danish Technical University, 18 kWp single crystalline modules integrated in the roofs.

In 2004, the EA became partner in 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 2009, this role was transferred to Energinet.dk. Denmark has participated in the first Joint Call (Polymol) on PV R&D in the framework of the PV-ERA-NET, and has recently entered the second Joint Call (PV+Grid).

R&D activities into organic PEC cells are ongoing at the Danish Institute of Technology and since 2002, have been supported by Energinet.dk. This R&D activity has now attracted commercial finance and a new company has been formed. At the DTU-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; again supported by Energinet.dk and the EUDP programme.

Mid 1995, the Photovoltaic System Laboratory (PVSyslab) was established in collaboration between DTU-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.

The SOL 1000 programme ran by the utility EnergiMidt, which as mentioned above intended to demonstrate low cost and architectural acceptable integration of PV technology primarily on existing single family houses, has by end of project ultimo 2006 implemented a bit more than 700 kW in total. There was a focus on the gradual increase of end-user payment, this way paving the way to a commercial market with no investment subsidy. The highest acceptable end-user payment appeared to correspond to a simple pay-back time for the owner of about 20 years. A third objective was to disseminate information and experience on PV roof-top deployment to the Danish distribution utilities. Several projects for building integrated PV systems including commercial buildings, apartment buildings and schools have been implemented, typically in the range of 2-15 kWp. The “small,” “do-it-yourself” PV plants were also introduced with a size of 250Wp, 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.

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 transferred to the PVSyslab.

INDUSTRY STATUS

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

Inverter technologies have been R&D'd for some years for both fuel cell and PV applications. For the latter, a commercial breakthrough was also announced in 2003 by the Danfoss related company Powerlynx,

which reported 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 named 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 1 MW per shift has existed since 1996. A few other companies producing tailor-made modules such as window-integrated PV cells can be found.
In late 2009, the RACell Company announced its intention to set up a pilot production line in 2010 for Si mono-X cells and modules; the pilot production line is expected to ramp up to 100 MW annual capacity in 2011.

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

Total PV business volume in 2009 is very difficult to estimate with any degree of accuracy primo 2010, due to the commercial secrecy surrounding the above mentioned new business developments in the fields of Si cell/modules, feed stock and inverters. However, an increase from 60 MEUR in 2008 to 80 MEUR in 2009 is a “best guess,” mostly due to exports.

The cumulative installed PV capacity in Denmark (including Greenland) was estimated to about 3,8 MW by end of 2009.

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/deployment, as the eventual R&D results need support to be demonstrated and reach the market. However, it is the hope, that the earlier mentioned effort to establish and up-date a national PV strategy and consequent deployment schemes may succeed in creating a more coordinated and unified approach to PV in Denmark. However, funding for large scale demonstrations has proven to be difficult to find in the existing support structure of the Danish Energy Authority and the PSO system, with the exception of the small ForskVE program.

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. The regional municipality of Bornholm may host a 5 MW programme with a first phase starting in 2010.

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 to 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 2009 indicate, 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/deployment effort has still 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
ANDREAS PIONTEK, EUROPEAN COMMISSION, DG RESEARCH

POLICY

The challenges of climate change, security of energy supply and competitiveness remain there and the current financial and economic environment only stress the need to rethink and redesign our long term vision about our energy production and consumption patterns and their sustainability. This is why the European 2020 targets are confirmed and, with the adoption of the new renewable energy directive, the European legal framework has been established [1]. These developments give a new impetus to the PV sector, which is expected to be a significant contributor to reach our RES target because the new renewable energy directive provides a favourable legal framework and demonstrates strong political commitment. This is expected to attract more PV activities in EU markets, also in those Member States which have not yet started to use this technology. European legislation has proven to be an important driver of renewable energy development (including PV), particularly in certain Member States. The new renewable energy directive sets for the first time legally binding European and national targets for the share of renewable energy sources in final energy consumption. It is ambitious in its objectives and, even if it is technology neutral, it will require the use of a wide range of technologies, with a growing role of technologies that are technically available but are not yet in or are at the beginning of the mass market deployment phase, such as photovoltaics.

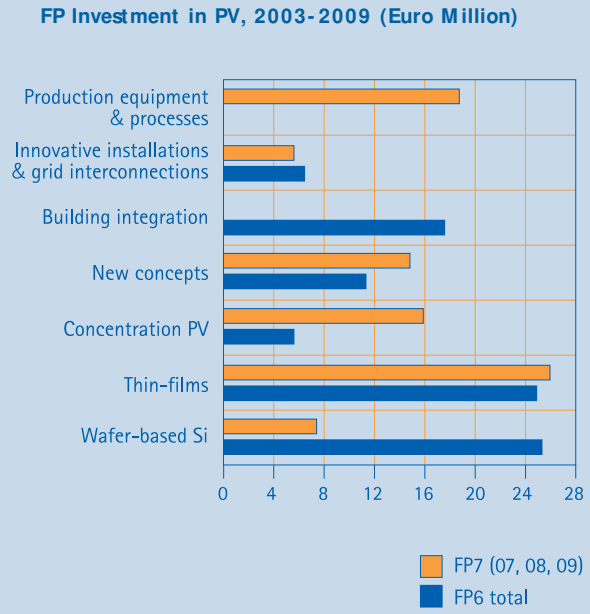

Fig. 1 - Investments in Photovoltaics under FP6 and the first three calls of FP7

Although the Directive sets a well defined EU framework, it leaves the details of implementation up to each Member State. More specifically, sectoral targets, as well as enhancing measures, such as streamlining administrative procedures, minimum requirements in buildings, improvement of the information to the public, training of equipment installers, electricity grid connection and operation conditions will be defined in each country´s National Renewable Energy Action Plan, which are due by June 2010. The directive, together with these National Action Plans, will ensure a stable framework for investment decisions. Member States may also continue to decide on their support scheme. In this respect, technology specific schemes, such as differentiated feed in tariffs, have proven to be particularly important for PV development so far. The Commission also monitors continuously the success of the different support schemes in relation to the achievement of national RES-E targets and has recently stated that harmonization of support schemes remains a long term goal. However, in the short term, it has recommended a co-ordinated approach to RES support schemes based on cooperation between countries and optimisation of national schemes.

DEPLOYMENT

Some of the signals coming from the PV sector, and which are complex to decipher, appear peculiar to each specific industrial segment. From one side, the weakened demand, determined by the tight access to project financing in an environment where supply has continued to grow has resulted in a reduction of the average selling prices. In some PV market segments, sales may have also risen in volumes but their margins have been down. It has been reported that some photovoltaic manufacturers are directly investing their own resources to circumvent the credit difficulties and get large projects off the ground. At the same time, other companies, in the highest efficiency segment, maintain an optimistic feeling, on the assumption that customers are continuing to pay a premium for higher quality products.

In these critical times government programmes can be extremely relevant to the sector, provided that they are soundly devised and sustainable in the medium term, to ensure continuous PV deployment.

According to the estimates reported in a recent publication, the cumulated installed photovoltaic capacity in Europe, by the end of the year 2008, is more than 9 500 MW (it was about 4 900 MW at the end of 2007) [2]. In the year 2008, 80 % of the world's new photovoltaic power was installed in the European Union, mostly in Spain and Germany. However, EU growth prospects are now facing the challenges of both the global financial crisis and the expected slow down in the Spanish market. The European market remains very heterogeneous. Germany is by far the leading European manufacturer along the whole photovoltaic value chain, from feedstock production, to cells, modules inverters and components. In 2008, the German PV industry had a turnover of about 7 BEUR and employed 48 000 people (46 % in the industry and components supply, 47 % in the installation and 7 % in sales) [2]. Overall, however, Europe remains a net importer of PV-cells and the trend will likely continue as the recent rapid growth of PV production capacity in Asia brings new challenges to EU players. Quality and longevity of PV-cells and modules, and profitable life-cycle features of whole PV-systems may become ever more important in such a highly competitive world market situation.

Fig. 2 - Sun Cities Project: Community of Heerhugovaard (NL) (Source: Project Sun Cities funded under the EU Framework Programme).

EUROPEAN SOLAR INDUSTRIAL INITIATIVE OF THE SET PLAN

The EU has endorsed the European Strategic Energy Technology Plan (SET-Plan) to accelerate the development and large scale deployment of low carbon technologies. The SET-Plan proposes a collective approach to research, development and demonstration planning and joint implementation of focused large scale programmes [3]. The SET-Plan has started being implemented and is currently working towards the establishment of large scale programmes such as the European Industrial Initiatives (EIIs) that bring together the industry, the research community, the Member States and the Commission in risk-sharing public-private partnerships aiming at the rapid development of key energy technologies at the European level. Six technology priorities have already been identified as the focal points of the first EIIs: wind, solar, electricity grids, bio-energy, carbon capture and storage and nuclear fission. The Solar European Industrial Initiative (SEII) addresses photovoltaics and concentrating solar power. The objective of the PV part of the Initiative is to improve the competitiveness of the technology and to facilitate its large scale penetration, as well as its integration into the electricity grid, in order to establish PV as a competitive and sustainable technology contributing up to 12 % of European electricity demand by 2020. Achieving this objective for photovoltaic energy requires the substantial reduction of PV costs, the improvement of device efficiencies, and at the same time, the demonstration of innovative technological solutions for the integration of large-scale PV-generated electricity into the European grid. The SEII proposes a R&D programme focused on increasing performance and extending life time of PV systems and components, and on key technologies for the connection to the power grid, such as inverter and storage devices; pilot plants of advanced automated high throughput manufacturing processes for mass production; and a portfolio of demonstration projects of PV power production in decentralized applications in urban communities, e.g. for building integrated concepts and as centralised power plants of 50-100 MW. This will be underpinned by a long term R&D programme on advanced PV concepts and systems. The total cost of the SEII programme over the next ten years has been estimated at about 16,1 BEUR, of which 9 BEUR for the PV part.

RTD & DEMONSTRATION

Through a series of RTD framework programmes, the Commission has maintained long-term support for research, development and demonstration in the PV sector, providing a framework within which researchers and industrialists can work together to develop PV technology and applications. During the **6th Framework Programme**, FP6 (2003-2006), the European Commission committed 105,6 MEUR for supporting research and demonstration on PV, thus continuing a 30-year tradition of co-financing the development of solar electricity in Europe. All the PV projects funded under FP6 are collected in a synopsis recently published by the European Commission [4]. The **7th Framework Programme**, FP7 (2007-2013) has a significantly increased budget compared to the previous programme, and will run for seven years. Calls for proposals based on topics identified in the work programme are being launched on an annual basis. Concerning photovoltaics, FP7 has begun with less emphasis on the development of traditional wafer-based silicon, which is the focus of increasing R&D investment by companies and national programmes. Material development for longer-term applications, concentration PV and manufacturing process development have attracted most European funding. Furthermore, significant funding is expected to be made available for thin-film technology. Four calls for proposals have been already launched for the years 2007, 2008, 2009 and 2010.

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S ACTIVITIES AND ROADMAP

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

Fig. 1 - European Parliament, Brussels.

With over 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 supports the development of the PV industry and markets, driven from the strength of unique and strong voice at European and international levels.

SHAPING THE PV INDUSTRY VISION

In March 2007, the European Union adopted an integrated climate and energy policy, putting forth ambitious quantitative policy goals for implementation by 2020. The so-called "20/20/20" goals are underpinned by a broader EU policy rationale to promote environmental sustainability and combat Climate Change, increase the security of energy supply as well as to support the EU economic competitiveness and the availability of affordable energy.
Following the unanimous agreement of the PV Industry to revise its objectives in September 2008, EPIA commissioned a study to the strategic management consultancy A.T. Kearney. The so-called **"SET For 2020"** study (www.setfor2020.eu) shows that PV could supply as much as 12 % of the European electricity market by 2020. The study was published in March 2009, demonstrating the benefits and implications that the 12 % PV target represents for European society, including the PV industry (in terms of growth and consolidating worldwide leadership), the European utilities and regulators (integrating and managing a high-level of distributed PV generation, as well as other sources like wind power and CSP) and other related stakeholders (such as the construction sector, architects, glass manufacturers, automobile industry, equipment suppliers) and, of key importance, for the final consumers who will play a crucial active role in the electricity system of the future.

Fig. 2 - EPIA Team at the end of 2009.

Realising the Vision will require that the right policy framework conditions are set by the Member States, and that continuous public support is provided to the industry in order to carry out the research and development, demonstration and deployment (RDD&D) measures needed. The **Solar Europe Industry Initiative (SEII)**; initiated in 2009 in the frame of the SET-Plan, describes the strategic RDD&D components of "SET For 2020". The official launch of the SEII is foreseen to take place in June 2010 during the Spanish presidency of the European Council.

A DEDICATED INFORMATION AND NETWORKING PLATFORM

A source of knowledge and expertise for the entire PV sector, EPIA published in 2009 a number of reference documents:

- "Global Market Outlook for Photovoltaics until 2013": Annual report presenting the most recent and upgraded data regarding PV market performance and short-term forecast.
- "SET For 2020 - Solar Photovoltaic Electricity: A mainstream power source in Europe by 2020": a unique, wide-ranging combination of facts, figures, analysis and findings based on an intensive and broad analysis of existing data as well as interviews with around 100 key people in industry, research institutes, utilities, regulatory agencies and government across Europe and other parts of the world over.
- IP Performance: An overview of the main outcomes of the European Integrated Project (IP) Performance.
- Electricity from the Sun: A general publication about solar photovoltaic electricity dedicated to the widest audience; available in English, French and German (further translations are being undertaken).

Presenting exclusive and regularly updated contents on all topics of interest for the PV sector, the EPIA website (www.epia.org) and the Solaris Newsletter were a great source of information for all PV stakeholders and in particular for EPIA Members, in 2009. In 2009, the association organised top-level events in order to accelerate PV deployment and create privileged networking opportunities. These included:

- 3rd International Conference on Solar Photovoltaic Investments;
- 6th European PV Industry Forum, within the frame of the 24th EU PVSEC organised by WIP;
- 2nd EPIA International Thin Film Conference;
- Executive Briefings about the SET For 2020 study in Brussels, Spain and Italy;
- Workshop on Market Potential and Production Capacity;
- Technical conferences and workshops (network integration, building integrated photovoltaics, standards, power measurements...);
- PV information tours.

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

EPIA is a member of:

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

Fig. 3 - IEA PVPS island stand in Hamburg; hosted by EPIA at the EPIA booth.

Fig. 4 - 6th EPIA Industry Forum, 23rd September 2009, Hamburg.

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

IEA PVPS ExCo meetings

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

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

EPIA together with the Brookhaven National Laboratories chair this task which took-off during 2008, after its beginning in 2007. A Task 12 meeting during the 24rd EU PVSEC in Hamburg was hosted by EPIA.

The "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" were finalized and published in September 2009.

A recycling workshop was organized by Brookhaven National Laboratory (BNL) with the support of EPIA during the 34th IEEE Photovoltaic Specialists Conference (PVSC) in Philadelphia on June 2009.

General Support to IEA-PVPS

The association hosted an IEA-PVPS island booth at the EPIA Industry Area during the 24th EU PVSEC in Hamburg, in September 2009.

FRANCE

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
YVONNICK DURAND AND ERIC PEIRANO
FRENCH AGENCY FOR ENVIRONMENT AND ENERGY MANAGEMENT (ADEME)

GENERAL FRAMEWORK

About 220 MW were installed in France during 2009; the cumulative installed photovoltaic power was about 390 MW at the end of the year (national statistics-SOeS estimation). ERDF and EDF SEI estimated that 269 MW were connected to the grid at the end of 2009 (200 MW were connected during 2009). In terms of energy production, the 2009 production of photovoltaic energy is estimated at 190 GWh according to SER (Syndicat des Energies Renouvelables - professional association).

The year was mainly marked by the development of projects in medium and high power capacity, as well as the development of the BIPV market and the emergence of new industrial actors. The market is influenced by the priorities given to the integration of photovoltaics in buildings. The feed-in tariff policy introduced in 2006 was a strong incentive, reinforced by the tax credit to stimulate private individual investments.

In the industrial sector, new operators are emerging, all along the value chain. In terms of employment, one estimates that there are 8 500 jobs in the sector (end 2009) in activities such as component manufacturing and installation of systems, with significant growth compared to data collected in 2008 (~ 4 500 jobs).
The manufacturing industry is developing in France with the completion of the sector at each stage of the value chain of silicon: purification, ingots production, cells and modules manufacturing, distribution of products and systems, installation and operation of electric power generation systems.

The procedures for grid connection have been simplified and the processing time of applications has been reduced. However, in late September 2009, 30 500 systems were queuing up for connection to the continental grid for a total of 1 659 MW to which one should add 957 MW in Corsica and overseas territories (source: SER).

PHOTOVOLTAIC PROGRAMME

The Agency for Environment and Energy Management (ADEME) is the pubic body that has historically supported France's development and promotion of photovoltaics. Since 2005, new initiatives, from national and regional authorities, have complemented the support of ADEME. The creation of the French National Research Agency (ANR) and the funding agency OSEO has allowed leveraging the R&D funding.

Since 2005, the ANR grants roughly 8,5 MEUR per year to photovoltaic R&D projects (10 to 12 projects per year on average with public/private partnership), to develop new concepts and improve the efficiency and the manufacturing costs of current technologies.

In the HABISOL program launched in 2008, the ANR chose to merge the building and photovoltaics research programs in order to enhance the initiatives for BIPV.

Apart from the ANR projects, a major industrial project has been considered for funding by public bodies in 2008: Solar Nano Crystal program (2008-2012) aims at establishing a pilot manufacturing (Lab-Fab) of crystalline silicon photovoltaic cells. This pilot will test the technical innovations from public research laboratories. The overall objective is the reduction of production costs, the increase in photovoltaic conversion efficiency and the reduction of environmental impacts of production processes. In February 2009, the EU approved the 46,5 MEUR funding to the French consortium (one part in the form of grants and the other part in the form of repayable advances).

Fig. 1 - PV System on a sport center in Challes les Eaux (Savoie Department) - 203 kW (photo: Edisun Power).

ADEME is also continuing its support to R&D, dedicated to new materials and new process development allowing manufacturing costs reduction and performance increase of PV components, dedicated to integration of photovoltaic modules in the built environment (RESSOURCES program) and supports demonstrators programs. ADEME also supports the training of project developers and project implementers (PHOTON training sessions). At the international level, ADEME continues with its partners the shared-cost projects within the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS), particularly in the Task working groups 1, 2, 9, 10 and 11. The International Electrotechnical Commission (IEC) receives contributions from French teams supported by ADEME particularly in the field of technical specifications for rural electrification by renewable energy sources (IEC 62257 series).

In the framework of the plan for renewable energies presented in November 2008 by the Ministry in charge of energy (MEEDDM), the Regulatory Commission of Energy (CRE) has published a call for tender for construction by 2011 of a solar power plant in each region for a total capacity of 300 MW which will be divided into 4 geographical areas. The first projects are being defined.
Three national clusters set up in 2005 (in the regions Languedoc Roussillon - Provence Alpes Côte d'Azur - Rhône Alpes) animate the action of 40 research centers/laboratories, 30 training centers and nearly 150 companies with activities related to solar and energy efficiency in buildings.

Fig. 2 - Photovoltaic power plant in Vinon sur Verdon (Var department) - 4,2 MW (photo: Solaire Direct).

Four research themes are coordinated: innovative concepts, manufacturing of components, systems, performance characterization.

In its information report submitted in July 2009, the Economics Committee of the National Assembly reported 9 guidelines for a national program for development of photovoltaics:

- Prepare the parity system (tariff rates adjustments)
- Prevent conflicts of use and uptake of arable land by solar power
- Integrate development for PV and planning (regionalization of rates and geographical balancing infrastructure)
- Support the building integration as a development path of the French sector (qualifying conditions for integration)
- Adapt the administrative framework (simplification of procedures for management of projects)
- Support major research efforts (storage, PV technologies, the transition from R&D to industrial application)
- Strengthen the industrial sector (encourage the emergence of actors, mobilize funds, establish quality standards)
- Make PV energy available to the general public (training, links with home automation)
- Introduce a large part of PV in the Mediterranean Solar Plan

As in previous years, regional councils are active in providing support to projects of photovoltaic plants through call for tenders in which targeted energy efficiency and solar energy must be involved.

RESEARCH AND TECHNOLOGICAL DEVELOPMENT

Three complementary approaches have been developed in the R&D HABISOL program funded by ANR in the period 2008-2010:

- method of energy management in homes;
- energy efficiency and development of renewable energy use in buildings;
- development of photovoltaics for widespread use in buildings.

14 new R&D projects have been identified on these themes. They added to the ten R&D projects already supported by this programme in 2008.

The areas of work of the R&D project Solar Nano Crystal, funded by OSEO and ADEME, launched for the period 2008-2012 are:

- the direct production of solar grade silicon;
- a significant increase of the performance of cells and modules;
- the direct experimentation of research findings in a pilot production of cells (Lab-Fab).

The coordinator of the project is the PV-ALLIANCE associated companies (Photowatt, EDF-EN and CEA-Innovation) in partnership with silicon specialists such as EMIX, PHOTOSIL, APOLLON SOLAR and the National Institute for Solar Energy (INES). Results of the development will be tested on a local PV power plant implemented near the Photowatt site.

Another major R&D project called POLYSIL, funded by ADEME, the region Rhône-Alpes and the local authorities started in December 2009. This project, which represents a R&D budget of 15 MEUR, aims to develop amorphous silicon thin film modules based on an innovative technology coming from research laboratories. The start-up SOLSIA is the coordinator of the programme in partnership with other companies and laboratories.

Institut National de l'Energie Solaire (INES) brings together researchers from CEA, CNRS, Université de Savoie and CSTB (workforce of 190 people which should grow). Its activity is divided in three departments: INES - Education (information and awareness), INES - RDI (public / private research) and INES - Demonstration (pilot technology). The research in photovoltaics concerns the development of new industrial processes for manufacturing cells, improved yields of organic cells, the implementation of nanotechnologies, methods of modules characterization, electrochemical storage systems, energy management, systems performance evaluation.

The activities of the Institute for Research and Development of Photovoltaic Energy (IRDEP) are mainly devoted to thin film technologies and concepts of high efficiency cells, with a special

TABLE 1 - FEED-IN TARIFFS FOR PHOTOVOLTAIC ELECTRICITY IN FRANCE 2009

TARIFFS EUR/kWh	CONTINENTAL FRANCE	OVERSEAS DEPARTMENT AND CORSICA
Basic tariff	0,32823	0,43764
Building integrated PV systems	0,60176	

interest in CIGS. The team consists of 40 researchers from CNRS, EDF and the University of Paris.

Other initiatives of R&D in the field are developing in institutes such as INESS (Strasbourg), INL (Lyon) and IM2NP (Marseille).

Note also the research carried by APOLLON SOLAR in developing a new concept of modules with an automated process of encapsulation of cells, which allows a simplified realization of contacts (NICE project).

IMPLEMENTATION

National guidelines have been set to implement the recommendations of the "Grenelle of Environment."

Public action structures and accompanies market expansion: it takes the form of a feed-in tariff, with a special focus given to "Building Integrated Photovoltaics" (BIPV) systems, and various tax measures of support for individuals and companies.

In this framework a contract for electricity supply from PV is established for a period of 20 years between each producer and a distribution company (usually ERDF). The financial act passed in December 2008 provides that the proceeds from the sale of electrical power from photovoltaic systems will be exempt from income tax when the nominal power of the photovoltaic systems does not exceed 3 kW.

Tariffs will be applicable till 2012 and might be revised afterwards.

TABLE 1 shows PV electricity feed-in tariffs in use in 2009. The government confirmed in September 2009 its intention to promote an intermediate tariff around 0,45 EUR/kWh which should concern simplified BIPV for professional buildings.

The function of the special rate for BIPV is to build a national economic sector by promoting integration of solar installations in the French landscape with the lowest impact (landscape, architecture, etc.). The major difficulty induced by a BIPV tariff is in the delicate delineation of equipment that might fall into this category.

Note that to take advantage of incentive BIPV tariffs, many investors began to build empty buildings, for no other purpose than to produce solar electricity. Examples: buildings known for agriculture, shade structure installed on supermarket car parks, etc.

Therefore, measures were announced in late 2009 to reduce a speculative approach in the production of solar electricity that could ultimately lead to higher electricity prices. At the request of regulators, new pricing rules will be implemented from January 2010, and the rules for grading projects to benefit from these rates.

- Several important events were held during the year to promote the production of electricity from photovoltaics:
- The second edition of the Solar Event (June 26-28 2009) organized in Savoie near the INES facilities, open to the general public and professionals, hosted nearly 15 000 visitors. Several themes have been presented for the promotion of photovoltaics: housing, jobs, vehicles, boats, innovations, North / South projects and programs.
- SIREME, International Exhibition of Renewable Energies and Energy Management (30 000 visitors) event, was also held June 25-26, 2009.
- The international exhibition for renewables, ENERGAIA, for trade visitors and general public (30 000 people) was held December 9-12, 2009 in Montpellier. This international event offered an exhibition (400 exhibitors), a large program of conferences, a business forum, a job forum and an investor international conference to meet the needs and requirements of professionals in the fields of renewable energies, green building and energy control.
- Events were also organized on the initiative or to the attention of policymakers.

A conference was organized by ENERPLAN (trade association of solar energy) with the support of ADEME to the attention of mayors in France in order to increase awareness and understanding of local

issues and opportunities related to solar energy, as part of a local political energy and sustainable development (May 14, 2009).

The "Energy" study group of the Senate, whose mission is to study issues related to energy policy of France, hosted a symposium in June 2009, on the theme: "23 % Renewables by 2020: Utopia or Achievable Goal?" Testimonies from various stakeholders (large groups involved in renewable energy, trade unions, politicians, consumers) have concluded positively on this issue by confirming the necessity of sustainable choices in the accompanying measures in place, both for consumers and technical actors (R&D institutions, designers, manufacturers and installers).

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 photovoltaics professionals. Quality initiatives such as "QualiPV" have been widely developed. According to the organisation Qualit'EnR, 4 500 firms were certified by the end of September 2009. Each installation company has the opportunity to be certified if they have complied with the ten points of a charter established by the profession. In this field, TRANSENERGIE developed its educational and demonstrative solar photovoltaic QUALIPHOTON® platform. This tool has been used for training project developers, specifiers, architects, electrical and roofing professionals. Technical workshops have also been organised specifically on inverters technology and operation. Quality audits will be organised to assess the conformity of the systems to the QualiPV requirements.

In addition, discussions are under way to qualify the eligibility of land identified for the implementation of ground photovoltaic power plants.

INDUSTRY STATUS

The industrial production of materials, cells and modules continues to grow 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 activity of the company is also focussed on the design and implementation of turnkey photovoltaic systems.

EMIX produces multicrystalline silicon ingots from the electromagnetic cast technology in cold crucible (installed capacity of 360 tons). Projects are under development to produce wafers.

The start-up NEXCIS aims to produce PV modules based on CIGS thin film technology, resulting from research studies carried out by IRDEP. Free Energy produces amorphous silicon modules and PV systems (1 MW capacity).

Tenesol Technologies, a subsidiary of TENESOL, produces modules from cells supplied from the outside (annual capacity of about 55 MW).

SOLAR FORCE is develops a process of high quality silicon wafers for photovoltaics, based on ribbon technology.

SOLEMS, and independent SME, is manufacturing thin film silicon cells and sensors.

APEX BP SOLAR a subsidiary of BP SOLAR, produces and installs systems and launched this year, as a new product, a 3 kW roof integrated kit for residential applications.

INVENSIL, APOLLON SOLAR and FERROPEM have set up a pilot production of silicon metal in the project PHOTOSIL conducted in collaboration with CEA and CNRS, in Le Bourget-du-Lac, near the facilities of the National Institute of Solar Energy.

Cumulative solar capacity installed and operated in France by EDF EN at mid June 2009 was 7,4 MW (27,6 worldwide); POWEO is operating 2 MW. SOLAIRE DIRECT launched a programme of 4 PV power plants (total 38 MW), with a first step of 4,4 MW by the end of 2008 and is preparing investments in modules manufacturing facilities.

The initial construction by SILPRO of the plant for the production of photovoltaic solar grade silicon has been cancelled.

Many other industry players contribute to the development of equipment for the photovoltaic industry or the marketing of new products: Air Liquide, Saint-Gobain, ECM, Vesuvius, Semco, Imerys-Roofing, Lafarge Roofing, Sunland21, Kawneer Europe, Arcelor, etc.

In addition to these historical actors already well established in the market, new companies are now operating significantly: AUVERSUN, SILLIA Energie, FONROCHE, VOLTEC SOLAR as new module manufacturers, EXOSUN for trackers.

New companies such as ECOLIS are coming as new PV electricity producers.

New innovative products appear on the market to meet "BIPV" demand.

MARKET DEVELOPMENT

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

According to the classification given by EPIA and SOLER, the 2009 installed PV power is quoted as follows: 120 MW for small-medium size (< 36 kW) and 100 MW for medium-large size > 36 kW).

The market for individual systems for homes increased significantly in 2009 because of feed-in tariff and tax incentives. According to Qualt'EnR data, approximately 3 000 to 3 500 projects were registered each month.

According to a survey provided by an independent association, the average price (including taxes) for an individual system (typically 3 kW) is around 6 to 7 EUR/W for an « added roof system » and 6,5 to 7,5 EUR/W for an “integrated” one (including installation).

The number of applications for connection of PV systems to the grid is still increasing. The figures (primarily individuals) were 1 600 in 2006, 7 000 in 2007, 25 000 in 2008, ~ 23 000 during the first six months of 2009.

An illustration of the impact of the BIPV incentives for the design of "small systems."

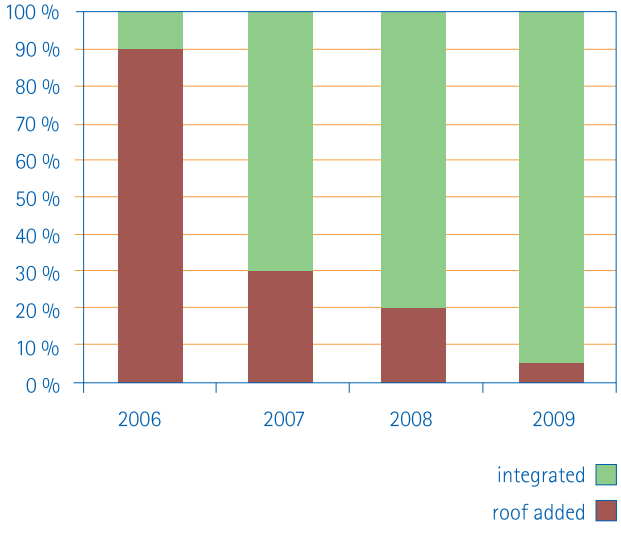

Fig. 3 - Evolution of the “Small” Installed Systems Design.

On the same time basis, one can see with TABLE 2 the emergence of large scale PV power plants on the ground in Continental France.

TABLE 2 - ANNUAL INSTALLED POWER PROFILE EVOLUTION 2006-2009 (MW)

	<36 KW	>36 KW	TOTAL
2006	12	2	14
2007	30	7	37
2008	55	50	105
2009	120	100	220

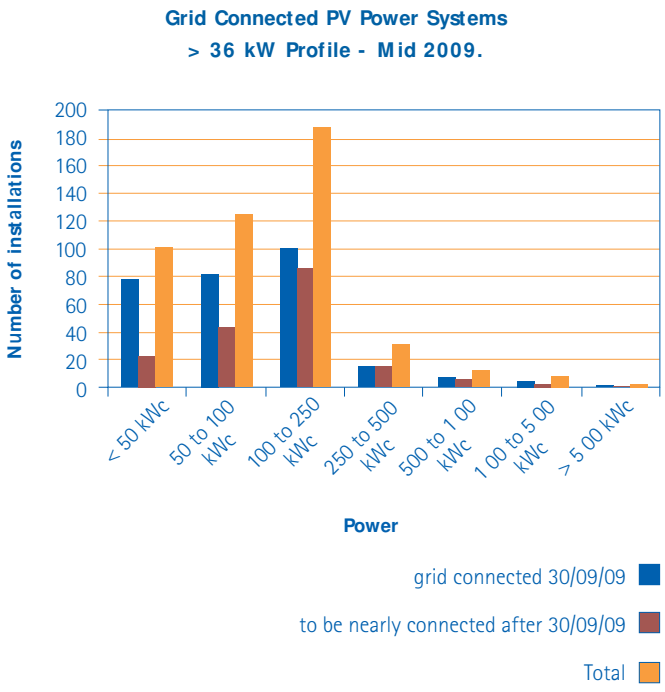

Fig. 4 - Power profile of the cumulative power of systems >36 kW connected to the French grid.

Power systems less than or equal to 3 kW represent 90 % of the installations in operation and 42 % of the installed capacity.
The average power connected to the network is around 4,5 kilowatts in the mainland and approximately 19 kW in Corsica and overseas (late September).

The regional councils have continued to provide financial support to the implementation of photovoltaic systems and training of professional bodies. They are also involved as owners to carry out installations on their own office or teaching buildings which they are responsible.

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

To facilitate the development of BIPV products, a new procedure was developed by CSTB whose mission is to certify compliance of innovations in buildings with existing regulations. “Pass' Innovation” is a voluntary scheme that allows businesses, technical inspectors and insurers to have an initial technical evaluation of products or processes in a short timeframe (3 months). It provides the necessary safeguards to control the placing on the market before committing to the Technical Assessment, which is an optional step. 10 Pass on innovative photovoltaic devices are currently issued (mid-December 2009).

At the request of the producers of modules, CSTB, the National test lab (LNE) and CEA, supported by ADEME, decided to establish on the site of INES a platform for certification of energy performance of photovoltaic modules, according to criteria of quality standards NF EN 61215, EN 61646 and NF EN 61730.

CONCLUSION AND OUTLOOK

The “Grenelle of Environment” sets the goal of a photovoltaic installed capacity of 5 400 MW by 2020, capable of supplying 1 % of the national electricity consumption. If on an energy perspective the contribution of photovoltaics seems marginal at this horizon, on an industrial perspective the sector is destined to develop numerous jobs throughout the value chain, from production of solar grade silicon to the installation of PV systems.

The year 2009 was mainly marked by the development of building integrated systems and the implementation of ground MW scale PV power plants.

Major industry players, coming from the energy or building sectors, are positioning themselves already in the production of components as well as in the PV electricity production business.

The feed-in tariffs structure for photovoltaic electricity has so far created the conditions to develop one of the largest markets in the world for BIPV which should allow the emergence of numerous players, small and medium-scale, and should boost innovation.

Note:
This article is prepared by ADEME for the 2009 annual report of the photovoltaic cooperation programme of the International Energy Agency (IEA PVPS).

Acknowledgements
ADEME thanks M. Philippe Jacquin from PHK Consultants for his contribution in data collection and writing of this paper dedicated to the annual report of the cooperative programme of the International Energy Agency (IEA PVPS).

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY – STATUS AND PROSPECTS

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Fig. 1 - The new 4 GW inverter factory of SMA Solar Technology AG was officially opened in July 2009; the plant is designed to work CO_2-free and is therefore equipped with a 1.1 MW PV system and a biogas CHP unit (photo: SMA Solar Technology AG).

GENERAL FRAMEWORK

Renewable energies are one of the most prominent topics on the political agenda in Germany. The new Federal Government which was elected in September 2009 laid down in its coalition agreement that the way into a renewable era will be followed consequently. And the efforts of recent years already bear fruits. For 2009, renewable energies are expected to have a share of 16 % of the domestic electricity production [1]. When compared with the initial targets of 12,5 % for 2010 and 20 % for 2020 (meanwhile extended to 25 to 30 %) one observes that the first steps into this new era are already made.

Photovoltaics (PV) are part of this development. At present, a PV capacity of roughly 9 GW is installed meaning an increase of around 3 GW in 2009 alone. The installation of PV systems in Germany was boosted in the second half of 2009 driven by the Renewable Energy Sources Act (EEG) on the one hand, and on the other hand there was a decrease of system prices of roughly 30 % compared to 2008. As this may lead to a situation where the EEG support exceeds the needs measures to balance the EEG scheme are currently under way.

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) [2]. In terms of achieving expansion targets for renewable energies in the electricity sector, the EEG is the most effective funding instrument at the German government's disposal. It determines the procedure of grid access for renewable energies and guarantees favourable feed-in tariffs for them.

Research and Development (R&D) is conducted under the 5th Programme on Energy Research and Energy Technology "Innovation and New Energy Technologies" [3]. Within this framework, the BMU as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. Main parts of the programme are administrated by the Project Management Organisation PtJ in Jülich.

RESEARCH AND DEVELOPMENT

Funding Activities of the BMU

In November 2008, the BMU released a call for tender which is open until end of 2010. Concerning PV, the call addresses five focal points which are all connected to applied research:

- Silicon wafer technology,
- Thin-film technologies,
- System technology for both, decentralised grid-connection and island systems,
- Concentrated Solar Power and other alternative concepts and finally,
- Cross-cutting issues like lifetime enhancement or recycling.

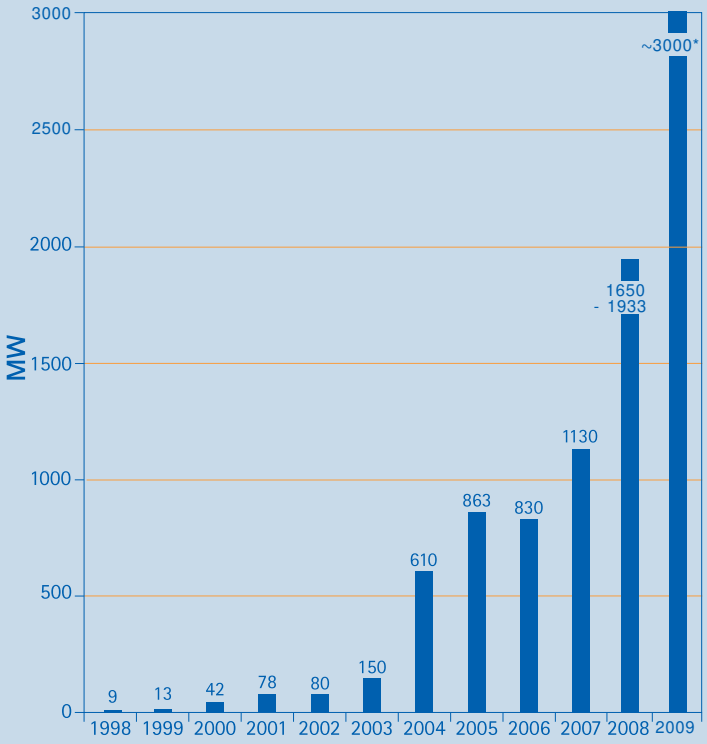

*Fig. 2 - Development of grid connected PV capacity in Germany (for details see text), *first estimate as of January 2010.*

Fig. 3 - Repeater station in the German Black Forrest powered by a PV hybrid system (photo: Steca/Fraunhofer ISE - UESP).

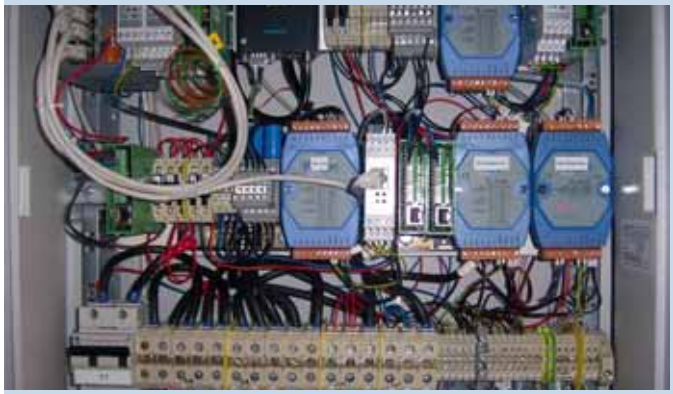

Fig. 4 - Installations for an autonomous PV Hybrid system using the flexible Universal Energy Supply Protocol – USEP developed by Steca and Fraunhofer ISE (photo: Steca/Fraunhofer ISE – UESP).

In 2009, the BMU support for R&D projects on PV amounted to about 32,9 MEUR shared by 141 projects in total. The distribution of the budget shows that the focal point is still on silicon wafer technology (50 % of the budget). The second centre of attention lies on thin-film technologies (32 % - almost evenly shared between silicon and CIS thin-film technologies). Following the call for tender, the development of system technology (8 %), alternative technologies especially concentrating PV (2 %) and crosscutting issues (8 %) are funded as well. The German contributions to the PVPS Tasks 11 and 12 are part of the programme. During 2009, 35 new grants were contracted. The funding for these projects amounts to 31,4 MEUR in total. Details on running R&D projects can be found in the BMU brochure, "Annual Report on Research Funding in the Renewable Energies Sector," [4] or via a web-based database owned by PtJ [5].

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 which is complementary to the BMU funding. Concerning PV, currently there are three focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells. Currently there are 13 projects running with a total amount of public funding of 55 MEUR.
- Networks aiming for the development of thin-film solar cells were initiated in 2008. They put emphasis on topics like material sciences including nanotechnology, new experimental or analytical methods and the usage of synergies with other fields of research like microelectronics or bionics. In 2009, 8 co-ordinated research projects were started receiving a total amount of 20 MEUR in funding.
- Additionally, the BMBF funds the development of the cluster "Solarvalley Mitteldeutschland" as part of the Federal High-Tech Strategy. This cluster comprises most of Germany's PV industry and received grants of 40 MEUR for the next four years.

IMPLEMENTATION

Since 2004, Germany is among the countries with the highest annual PV installation world-wide. This remarkable development is based on the "Renewable Energy Sources Act (EEG)" [2]. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. For PV, the feed-in tariff depends on the system size and whether the system is ground mounted or attached to a building. Since 2009, there is also a tariff for self consumed power. The rates are guaranteed for an operation period of 20 years. [6]

In late 2008, it was decided to raise the yearly degression rate of the tariff in order to stimulate a stronger price reduction. For rooftop-systems smaller than 100 kW the rate changed from 5 % to 8 % [2]. Moreover, a mechanism was introduced to adapt the degression rate to the market growth. If the marked deviates from a predefined

TABLE 1 - PV PRODUCTION CAPACITIES FOR 2009 AFTER [7], [9].
(numbers have been rounded, for clarity's sake)

	NUMBER OF ACTIVE COMPANIES	PRODUCTION CAPACITY 2009
Silicon Wafer Technologies		
Silicon feedstock	5	17 000 t
Wafer production	8	2 000 MW
Solar cell production	11	2 000 MW
Module production	> 21	~ 2 000 MW
Thin-film technologies		
Silicon thin film	10	330 MW
CIS technologies	11	230 MW
CdTe	3	225 MW
Concentrated PV (CPV)		
CPV cells	1	100 MW
Systems	2	25 MW
System technology		
Inverter for grid-connection	> 15	> 4 000 MW

corridor, the degression rate is increased or decreased accordingly by 1 % for the following year. For 2009 the corridor was set between 1 000 MW and 1 500 MW. As the upper boundary of 1 500 MW was exceeded significantly, for 2010 the preliminary degression rate is 9 % instead of 8 %.

On the background of significantly lowered system prices, an additional reduction of the feed-in-rates in 2010 is currently under way. It is foreseen that is foreseen that for example for systems attached to buildings a supplementary decrease of the tariff of 16% from July 2010 on will apply. The effect of the market size on the degression rate will be also adapted.

INDUSTRY STATUS

While the German PV industry showed a strong and steady growth over the last years, burdens resulting from the current world economic crisis and from increased competition result currently in a far more complex situation. Nevertheless, the foreign trade and inward investment agency of the Federal Republic of Germany, “Germany Trade & Invest,” lists in total 70 companies involved in PV production [7] creating a turnover of 9,5 BEUR in 2008 [8]. In addition 62 PV equipment manufacturers supply tools for every step of the PV value chain [7]; they generated an additional turnover of 2,39 billion EUR in 2008 [8]. Beside this, the development of inverter industry is another success story. SMA Solar Technology AG for example opened in 2009 the worldwide first Gigawatt production line related to PV; see Figure 1.

On the background of the comparably high number of companies, it becomes increasingly difficult to obtain up-to-date numbers on the yearly production. Table 1 shows a summary of the current production capacities for the different stages of the production chain after [7], [9]. The list shows that the German PV industry is offering products along the whole value chain. During the last years, equipment and production companies became the most experienced ones world-wide. At the end of 2008, around 53 300 workers were employed in the PV industry, in handcraft and trade companies [8].

MARKET DEVELOPMENT

The EEG accelerated the installation of grid-connected PV-systems in Germany significantly. In addition, a decrease in system prices of roughly 30 % in the last twelve months made PV systems economically more and more attractive. An analysis published by BSW-Solar, the German Solar Industry Association, shows that the average price for PV rooftop systems of less than 100 kW arrived at 3 135 EUR/kW in the last quarter of 2009 [8].

The PV 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 2.

For 2008, an additional capacity of grid connected systems of 1 650 MW and thus a cumulated capacity of 5.4 GW at the end of that year was published by BSW-Solar [8]. At the same time, Photon published an additional capacity of 1 933 MW for 2008 [10].

For 2009, current estimates assume an additional PV capacity between 2 500 MW [8] and 4 000 MW [10]. Since the beginning of 2009, owners of new PV systems are legally obliged to register their systems at the German Federal Network Agency. The published statistics of the Federal Network Agency currently last until October 2009 and show a capacity of 2 245,4 MW for the first eleven months of 2009 [11] being in fair agreement with an estimate of around 3 000 MW for the entire year. Thus, at the end of 2009, around 9 GW in total may be connected to the German grid.

Fig. 5 - Flatcon (c) CPV System of Concentrix Solar (photo: Fraunhofer-ISE, Freiburg).

Fig. 6 - Laboratory deposition system for the preparation of amorphous and mikromorphous Silicon Thin Film devices (photo: Forschungszentrum Jülich GmbH).

In addition to the market of grid connected systems, there is a steady request for stand alone systems. First estimates indicate that in 2009 around 4,5 MW were installed mainly for industrial applications, such as the automotive sector, traffic signals, etc.

FUTURE OUTLOOK

In 2009 again, the German PV market showed an impressive growth. Around 3 GW were added to the grid. The driving force for this development is the EEG. In addition, a decrease of system prices of roughly 30 % in the last twelve month made PV systems economically attractive. On this background, an additional reduction of the feed-in-rates in 2010 is currently under way. The EEG will continue being the basis for a robust growth in the German PV market and PV industry.

In parallel, the German PV industry is confronted with an environment of competition. It is therefore important for them to offer high quality state-of-the-art products. The current technical and economical status does not allow standstill. Enhancement of production efficiency and at the same time lowered costs are even more important than a few years ago. For that reason, high-level R&D together with sustainable market supporting mechanisms like the EEG are still needed.

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

[3] *An English version of the 5th Energy Research Programme of the Federal Government is available at http://www.bmu.de/english/renewable_energy/downloads/doc/36411.php*

[4] *BMU brochure "Annual Report on Research Funding in the Renewable Energies Sector", see http://www.erneuerbare-energien.de/inhalt/45313/45315/*

[5] *PtJ database, see http://www.forschungsjahrbuch.de/*

[6] *For 2010 the tariffs are currently (January 2010) defined as 28,43 Ct/kWh for ground mounted systems. For systems attached to buildings the tariffs are 39,14 Ct/kWh for systems smaller than 30 kW, 37,23 Ct/kWh for systems smaller than 100 kW, 35,23 Ct/kWh for systems smaller than 1 MW and 29,37 Ct/kWh for systems bigger than 1MW. For self consumption 22,76 Ct/kWh are foreseen, see www.bundesnetzagentur.de.*

[7] *Germany Trade and Invest - for PV see http://www.gtai.com/homepage/industries/renewable-energies/pv-industry/*

[8] *BSW-Solar Fact sheet "Statistische Zahlen der deutschen Solarstrombranche", November 2009, see http://www.solarwirtschaft.de*

[9] *Photon, August 2009, p. 54 and December 2009, p.16*

[10] *Photon, November 2009, p. 60, and December 2009, p.16, see also http://www.photon.de/presse/mitteilungen/hintergrund_gigawatt.pdf*

[11] *see http://www.bundesnetzagentur.de, data of March 2010; a complete and final dataset for 2009 will be available later in 2010.*

ISRAEL

PV TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE

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GENERAL

2009 has been a momentous year for PV in Israel. Cumulative installed capacity reached about 14 MWp, nearly 85 % grid-connected. Many more installations are planned for this year.

Until 2007, the cumulative installed capacity amounted to about 2 MWp, the vast majority of systems being off-grid electrification applications (remote homes, agriculture, security and alarm systems, communications and exterior lighting). However considerable progress has been made recently as a result of intensive Government activity during the last years:

- The Ministry of National Infrastructures has 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.
- Feed-in tariffs for distributed PV systems entered into effect in 2008 (presently 1,97 NIS/kWh ~ 0,53 USD/kWh ~ 0,37 EUR/kWh), with an installation cap of 50 MWp over seven years (35 MWp allocated to commercial installations and 15 MWp reserved for private households). 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. By the end of 2009, there was over-subscription by entrepreneurs interested in installing larger commercial installations. In an extraordinary step, the Public Utility Authority-Electricity authorized all projects which were submitted before December 14, 2009.
- The National Council for Planning and Construction has approved rules to accelerate approval by local authorities and to exempt roof-mounted systems from the need for building licenses and local taxes.
- Additional tariffs were introduced recently by the Public Utility Authority-Electricity for powerplants between 51 kWp and 5 MWp (1,49 NIS/kWh ~ 0,40 USD/kWh ~ 0,28 EUR/kWh), with an installation cap of 300 MWp .
- The banking sector has started to express interest in financing PV systems. In addition to special interest rates offered by some banks, a significant step in making it easier to obtain financing was a new procedure (September 1, 2009) whereby income from a private PV system can be paid directly to a bank as collateral on the loan.

It is expected that these actions will continue to 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 addition, the international tender for a 15 MWp PV powerplant issued by the Government in April 2008 will be decided early in 2010. A site for this powerplant has been allocated at the Ashalim Junction, in the Negev desert. Ten international consortia have answered the PQ tender.

INDUSTRY INVOLVEMENT

The number of firms active in the PV field has risen sharply during the past year. Most companies are small and deal mainly with system integration.

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 installations in central Europe.

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:

- At the Weizmann Institute of Science, a project is underway to develop high-voltage semiconductor-sensitized nanoporous cells. Recent advances made in very high-efficiency tandem cells, where three cells, sensitive to different parts of the solar spectrum are built in series, have resulted in greater than 40 % efficiency. However these cells are extremely expensive. Nanoporous photovoltaic cells are based on a highly-porous substrate (invariably a metal oxide) on which a sensitizing layer (a dye or a semiconductor) is deposited. A specific subset of these cells is the Extremely Thin Absorber (ETA) cell, using a semiconductor sensitizer on the oxide and also a hole conductor to complete the circuit. The purpose of this project is to investigate ETA cells (which are intrinsically cheap) with the intention of finding one which is selectively sensitive to the high energy part of the solar spectrum and can provide the high voltage part of a tandem cell. This will be done by identifying a materials combination that is capable of giving a high voltage and engineering the different interfaces in the system to minimize the energy losses in the conversion process.
- Ben-Gurion University's Blaustein Institutes for Desert Research (BGU-Blaustein) has initiated work on constructing solar radiation contour maps (both direct normal irradiance and global horizontal irradiance) of the Negev desert at a scale of 1:100 000. Currently, insolation data are available for nine specific sites at which monitoring equipment is located. However there is great demand for solar radiation data in other parts of the Negev (e.g. the Ashalim site, where the country's first solar power plants will be built). Furthermore, since land availability is severely restricted, it is important to locate solar plants as optimally as possible. A set of contour maps, prepared using appropriate interpolation between the measurement sites, would be of great functional use.

- 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 waste of cell active area.

DEMONSTRATION AND APPLICATION

- MST is a leading new energy company that has developed a highly-efficient technology to generate solar electricity, and is presently planning to move into production phase of a system having a lower cost per kWp installed than any other existing one. After two years of development, MST has unveiled recently its first commercial 50 KWp concentrating PV tracker in the city of Arad, in the south of Israel (Fig. 1). The system tracks the sun accurately on two axes, generating 100 000 kWh per year. It is based on concentrating photovoltaic (CPV) technology employing high-efficiency solar cells designed and used in the space industry and adapted to terrestrial use. Present CPV cells efficiencies are very high (about 37 %), and are expected to reach industrially 45 % within three years. The sunlight is concentrated 500 times by lenses and projected on the cell through an optical medium. The MST tracker is composed of 3 200 solar cells. The electricity produced is collected by a specially designed system and fed to the grid. Overall power plant efficiency exceeds 25 %, making it among the most efficient solar systems in the world.

Fig. 1 - MST 50 KW_p solar tracker in southern Israel.

The MST solar system appears to have significant advantages over other existing ones: low cost, high efficiency/higher energy output per panel, better performance in hot climates compared to silicon-based systems, possibility of installation on unleveled and rocky terrain (Fig. 2), higher power per land area (1 MWp per 10 000 m^2) . During the coming year the company is planning to start building a production line with an annual capacity of 75 MWp.

Fig. 2 - Simulation of MST solar power plant on rocky and unleveled terrain.

- Recognizing the worldwide scarcity of land resources on the one hand, and the abundance of underutilized water resources on the other, Solaris Synergy has developed a floating concentrated PV system (Fig. 3). Featuring patented cooling technology, the system leverages the low temperature of the water on which it floats to keep the PV elements at a low, steady temperature, thereby significantly increasing efficiency. With a 1 kWp working prototype already up and running, Solaris Synergy is set to begin work on a 50 kWp pilot project in 2010, with the option of expanding the system to 2 MWp by 2011. Creating new synergies between two highly valuable resources, water and sun, the system delivers a rapid return on investment for water resource owners and operators.

Fig. 3 - Simulation of Solaris Synergy system.

- ZenithSolar is set to develop and mass produce a reliable cogeneration solar power system, with a full vertically integrated strategy, that can be deployed as a distributed energy network. Its concentrated solar energy generation system is based on a new paradigm in optical design and high-efficiency solar cells. This start-up company 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 m² aperture Zenith Solar CPV unit generates approximately 2 kWp of electrical power and 5 kWp of thermal power (in the form of hot water). A multi-dish pilot system was inaugurated in early 2009 at kibbutz Yavneh, just east of Ashdod (Figure 4).

Fig. 4 - ZenithSolar multi-dish system.

EDUCATIONAL ACTIVITIES

In the Nitzana village in the Negev desert, an educational project, called “Science following the sun”, brings the message of solar energy, including photovoltaics, to hundreds of school children.

GOVERNMENT ACTIONS

It is expected that the Government activity described above (solar power plant tenders and tariffs for distributed PV) will continue to 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, including start-ups. The R&D expenditures in photovoltaics of the Ministry of National Infrastructures (MNI) were about 280 000 USD in 2009; however, additional funding is available in this area from other research foundations.
- Partial funding (up to 30 %) of innovative deployment-support projects.

ITALY

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

Fig. 1 - 48 kW array mounted on shading elements, Sarcedo (VI).

GENERAL FRAMEWORK

The "Conto energia" promoting Programme is eventually ensuring a stable situation, providing the basis for the expansion of PV market in Italy. Bureaucratic problems related to the incentive mechanism have been overcome while the ones concerning plant construction and grid connection seem to have been smoothed out. In this context, during the last year photovoltaic is becoming more and more important and the PV market seems to be followed by an adequate growth of the national PV industry.

A preliminary evaluation of PV power, installed in Italy during 2009, sums up to about 500 MWp. Then the total installed and operating power in Italy at the end of 2009 should result in about 900-960 MWp with a growth rate of around 50 %, in respect to the previous year. At this growth rate, the overall cumulative power which is supported by the "Conto energia" Programme (1200 MW), is expected to be reached by mid 2010.

In this growing context, the public budget for research and demonstration initiatives remain still flat with respect to the previous years and not adequate to market stimulation resources.

NATIONAL PROGRAMME

The first phase of the "Conto energia" Programme (issued in September 2005) has been completed during 2009. In this context, about 5 500 plants have been installed, corresponding to a total power around 160 MW, out of 380 MW admitted to incentive tariffs. Reasons for that were due to administrative barriers, bureaucratic problems for authorizations and grid connection and a bubble effect related to "license trade" effect.

This situation has been overcome with a new phase of the "Conto energia" Programme (issued in February 2007) that has established simplified procedures and overcome most barriers, revamping again the Italian photovoltaic sector. This new phase resulted in setting in operation about 60 000 plants, corresponding to about 770 MW.

More specifically, the "Conto energia" initiative has confirmed a remarkable success among citizens which represents, especially in the framework of the new decree, the greater part of feed in tariff beneficiary (over 80 % in numerical terms and about 30 % as installed power) as well as the private company with a share in power of about 64 %.

The geographical distribution of PV installations at the end of 2009 confirmed that about 50 % of the total power is installed in the northern part of Italy while only the 33 % of PV installations has been counted in southern Italy (islands included), in spite of higher solar radiation availability in these areas.

The analysis of PV installations demonstrates a positive exploitation of areas not differently utilisable. 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 usually installed on the ground by fixed or sun tracking module supporting structures. As consequence of these plant locations, a low environmental impact ha been obtained.

As far as module manufacturers, the amount of installed modules fabricated in Italy (15 %) still remains low while the share of modules supplied by German (25 %) and Chinese (15 %) companies is increasing. Different is instead the position of Italian firms operating in the power conversion system field. In fact, about 47 % of the power conversion units installed have been constructed in Italy, while the share of Germany and Austria sum up to about 30 % and 13 % respectively.

Concerning component and system costs, the Programme highlighted a consistent decrease with respect to the previous year. Turnkey prices of plants ranged from 4 EUR/W to 5 EUR/W. In the case of large size plants, prices can decrease up to 3,5 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.

On the whole, taking into account the volume and the value of import and export components, as well as the capacity and the value of the installed power, in Italy the overall net value of PV manufacture and sale has been around 1 500 MEUR in 2009.

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 ERSE (previously CESI RICERCA, a research company owned by ENEA and GSE - Gestore dei Servizi Elettrici, the Italian publicly-owned company promoting and supporting renewable energy sources). Additional contributions have been supplied by some Universities, CNR (the National Council for Scientific Research) and a few private laboratories.

Fig. 2 - 1 MW tracking plant at Osimo (AN).

Fig. 3 - 49 kW PV system installed on the façade, Laces (BZ).

ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest are: crystalline silicon, Cu_2O solar cells, microcrystalline Si devices, micromorph tandem solar cell as well as concentrators' technologies. In this last context, ENEA is carrying out experimental activities on standard units of 5 kW, in order to assess the technical and economical feasibility of this application.

ERSE 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, ERSE 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 2009. In particular, expenditure on PV research and demonstration has been about 5 MEUR, remaining essentially flat with respect to the previous years.

IMPLEMENTATION OF SYSTEMS

As previously mentioned, a total capacity of about 950 MWp was installed and operating in Italy at the end of 2009, according to a preliminary evaluation. Taking into account that during this year about 500 MWp have been installed, the annual growth recorded has been around 50 %.

This increase has been driven by the support mechanism of on-grid distributed systems market, which now accounts for over 98 % of the total photovoltaic installed. The installations in Italy in the three significant sectors of PV power system applications are as follows:

Off-grid Systems:	amounting to 14 MW;
On-grid Centralized (>200 kW):	reaching about 330 MW Systems corresponding to 1/3 of the total capacity installed;
On-grid Distributed Systems:	amounting to about 600 MW (dominating Italy's cumulative installed photovoltaic power).

INDUSTRY STATUS AND MARKET DEVELOPMENT

In the year 2009, about 15 main producers of crystalline silicon cells and finished PV products have been 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) 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 Italy, Solarday, Xgroup, Solsonica).

On the whole, a total production around 300 MW has been estimated for the year 2009, while for the next year the production capacity could reach more than 500 MW, according declarations of the operators.

During last year, neither ingots nor wafers have been produced in Italy, although some companies (Estelux, Silfab, Italsilicon, Depasol Silicon and Xgroup) have announced an annual total capacity of about 10 000 t by the end of 2010.

As far as BOS components, in Italy 5 main companies manufacture inverters for on-grid and off-grid applications (Elettronica Santerno, Poweone, Aros, Siel-Siac, and Italcoel). Some of these have experience in inverters for large PV power plants, while others have produced small apparatus under Electric Utilities specifications for the connection to the grid. About 45 % of the inverters installed in 2009 have been produced in Italy while a larger figure has been exported. Taking into account also exported volume, about 900 MW of inverters have been produced in Italy during 2009.

FUTURE OUTLOOK

With its very attractive incentive scheme, Italy is today the world's second largest PV market. Nevertheless, the Italian market is not booming because of technical and non technical barriers still existing and the uncertainty on the next phase of the “Conto energia” Programme (under preparation) that will redefine the maximum power supported and tariffs of the PV plants commissioned after 2010. In this context, the Italian PV industry proposes a new decree with the same incentive scheme (no changing law) including a maximum power supported of 8 GW for the period 2011-2015 with an annual degression rate in the range 5-20 %/year. The target of the Ministry of Economic Development seems to be rather lower, but both agreed that to ensure a sustainable development of the market the future incentive scheme should be based on simplified procedures, guarantee an acceptable pay back time, avoid huge windows of opportunity, drive price down and create job opportunities.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS
MASAMICHI YAMAMOTO, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)
OSAMU IKKI, RTS CORPORATION

Fig. 1 - Kirin Hiroshima Brewery PV system, 10 kW (Fuchu-cho, Hiroshima Prefecture).

GENERAL FRAMEWORK

The general framework for Japan's energy policies and measures regarding 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, "Basic Energy Plan" was formulated in order to materialize 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: Special Measures Law Concerning the Use of New Energy 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. 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: "PV2030+(Plus)" roadmap for technology development of PV systems (formulated in 2004 as PV Roadmap Toward 2030 (PV2030), reviewed and revised in 2009 as PV 2030+(Plus)). Goals for technology development of PV cells and systems were set, five years ahead of the original schedule, from a mid-term perspective for the period up to 2030, with a longer-term perspective towards 2050.
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 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) and the J-Recovery Plan (formulated in 2009)
   Targets to increase the amount of installations of PV systems were set to 28 GW by 2020 and 53 GW by 2030.
8) Obligation to purchase surplus power generated by PV systems: "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers" (formulated in 2009)
   Basic purchase price of surplus power generated by PV systems is set at 48 JPY/kWh in the first fiscal year.
9) Policies and measures for dissemination: Various subsidy programs by the Ministry of Economy, Trade and Industry (METI), the Ministry of the Environment (MoE) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), etc.; Project to support introduction of residential PV systems, Project to support field test projects and technology development on PV power generation, Project for accelerating introduction of renewable energy, Eco School maintenance project, etc.

NATIONAL PROGRAM

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).

METI restarted the subsidy program for residential PV systems from January 2009 with the supplementary budget of FY 2008 (9 BJPY). METI continued the program for FY 2009 with total budget of 42,05 BJPY including FY 2009 supplementary budget. METI also supports the introduction of PV systems by local governments and private entities through the programs promoting renewable energy. In the area of R&D, METI continuously promotes technology development of PV systems for cost reduction and dissemination of PV systems and demonstrative researches.

As a prioritized policy to fully work on creating a low-carbon society, the Ministry of the Environment (MoE) promotes countermeasures for global warming and continues to promote dissemination of PV systems through support programs for introduction of new and renewable energy to individual houses, businesses and communities and programs developing low-carbon technologies.

The budgets for major national PV programs implemented in FY 2009 are as follows;

1) Subsidy for measures to support introduction of residential PV systems (FY 2008 supplementary budget): 9 BJPY
2) Subsidy for measures to support introduction of residential PV systems: 42,05 BJPY (FY 2009 budget: 20,05 BJPY + FY 2009 supplementary budget: 22 BJPY)
3) Technology Development of Photovoltaic Power Generation: 3,59 BJPY
   - Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation System: 310 MJPY
   - Research and Development of Next-generation PV Generation System Technologies: 1,1 BJPY
   - Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program): 1,5 BJPY
   - Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems: 350 MJPY
4) Field Test Project on New Photovoltaic Power Generation Technology: 330 MJPY
5) Verification of Grid Stabilization with Large-Scale PV Power Generation Systems: 2,02 BJPY
6) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources: 1,7 BJPY (new)
7) Project for Supporting New Energy Operators: 3,007 BJPY
8) Project for Promoting the Local Introduction of New Energy: 6,26 BJPY
9) Promotion of regional energy development and utilization: 110 MJPY
10) Project for Establishing New Energy and Energy Conservation Visions at the Local Level: 540 MJPY
11) Project for developing technology to prevent global warming: 3,805 BJPY
12) Project to promote comprehensive measures to create low-car bon local communities: 990 MJPY
13) Project to promote the use of PV and other types of renewable energy: 1 BJPY

The budget except for item 1) - 5) includes those for PV and other types of new and renewable energy.

RESEARCH & DEVELOPMENT, DEMONSTRATION R&D

Four Projects under the control of the Ministry of Economy, Trade and Industry (METI) are conducted by New Energy and Industrial Technology Development Organization (NEDO) in 2009; i) Research and Development of Next-generation PV Generation System Technologies, ii) Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems, iii) Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation Systems, and iv) Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program). Research and development to resolve technical problems on the grid connection of PV systems has also been continued in 2009 and development of electricity storage technologies has been promoted under the plan towards 2010. Among the PV-related projects listed above, the first three projects are scheduled to be completed in FY 2009. Against this backdrop, NEDO reviewed PV Roadmap Toward 2030 (PV2030) to establish new projects from FY 2010 and released in June 2009 a new roadmap, PV2030+ (Plus).
In the field of basic research, two projects started anew aiming to make a breakthrough for the next generation solar cells under the control of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the promotion of Japan Science and Technology Agency (JST); i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells, and ii) Creative Research for Clean Energy Generation Using Solar Energy. Furthermore, Development of Organic Photovoltaics toward a Low-Carbon Society was selected as one of the 30 themes of advanced researches under the government's Funding Program for World-Leading Innovative Research and Development on Science and Technology.

(1) Research and Development of Next-generation PV Generation System Technologies

This project aims at realizing higher conversion efficiency, further cost reduction and improved durability of solar cells for the establishment of elemental technology to achieve the targeted PV power generation cost set in the PV2030 Roadmap: 14 JPY/kWh in 2020 and 7 JPY/kWh in 2030. FY 2009 is the final year of the project. Based on interim evaluations conducted in 2007, project details were adjusted and 19 themes (cf. 21 themes in FY 2008) have been continued in the field of thin-film CIS, thin-film silicon, dye-sensitized, next-generation ultra-thin crystalline silicon, and organic thin-film solar cells as well as next-generation elemental technology. Final evaluations are scheduled to be held at the end of the fiscal

Fig. 2 - Yokohama Kanazawa Marine Park PV system, 5,6 kW (Yokohama City, Kanagawa Prefecture).

year. All in all, anticipated results were achieved at lab level, including 18,9 % conversion efficiency of multicrystalline silicon solar cells.

(2) Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems

This project is aimed at developing technological infrastructure to support mass deployment of PV systems. Just as last year, various researches including development of evaluation technologies for PV cell/ module performance and reliability and for PV-generated electricity, technological development including highly-recyclable new module structure, support for standardization of Balance-of-Systems (BOS) components, survey on PV technology trend, and PV life cycle assessment (LCA) have been continued. FY 2009 is the final year of the project and final evaluations are scheduled to be held at the end of the fiscal year.

(3) Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation Systems

This is a support project for industry players to pursue technological development. As selected in FY 2008, four technological development programs have been supported under this project; i) Development of thin film amorphous silicon solar cells fabricated on plastic film substrates (Fuji Electric Advanced Technology), ii) Slicing techniques for ultra thin multicrystalline silicon solar cells (Komatsu NTC), iii) Development of enhanced production technologies for thin-film silicon solar cells (including super large area cell production and high-speed production) (Mitsubishi Heavy Industries (MHI)), and iv) Development of selenization process optimization techniques for CIS thin-film solar cells.

(4) Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program)

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. Just as in FY 2008, three groups (34 organizations) have been conducting technological development projects as follows:

1) The University of Tokyo with 9 organizations conducts research and development project of ultra-high efficiency post-silicon solar cells. Subjects are; i) high efficiency quantum dot tandem solar cell manufacturing process technology, ii) ultra-high efficiency quantum dot superlattice solar cells, iii) ultra-high efficiency hybrid, multi-junction solar cells, and iv) high efficiency multi-junction CPV cells.
2) National Institute of Advanced Industrial Science and Technology (AIST) with 13 organizations conduct research and development project for thin film multi-junction solar cells with highly ordered structure. Subjects are; i) Silicon-based triple-junction thin-film solar cells, ii) compound-based quadruple junction thin-film solar cells iii) Study for novel materials and concepts, and iv) Advanced photoenergy application technology.
3) Tokyo Institute of Technology (TIT) with 14 organizations conducts research and development project of thin film full spectrum solar cells with low concentration. Subjects are; i) Band engineering technology, ii) Thin film full spectrum solar cells, and iii) Lightmanagement and transparent-conducting-oxide (TCO) technology.

   Each group plays a role of an international joint research center, and as part of this project, The Second International Symposium on Innovative Solar Cells was held in Tsukuba City, Ibaraki Prefecture in December 2009.

(5) Research and Development of Islanding Detection Testing Technology for Clustered Photovoltaic Power Generation Systems

This R&D project to establish testing technology that will also contribute to the certification of islanding detection systems for grid-connected PV systems has been continued in 2009 in order to address with issues regarding increased PV system grid connection. (Details of this project; see the section of Demonstration)

(6) Projects for basic research

In the field of basic research on solar cells, two R&D projects started anew under the control of MEXT as follows:

1) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells

   This is an individual proposaloriented project through participation of mainly young postdoctoral researchers. Research started with the selection of 14 themes aiming to make proposals for next generation solar cells such as various PV elemental technologies and development of novel materials (research term: 3 - 5 years).
2) Creative Research for Clean Energy Generation using Solar Energy

   This team-based project aimed at establishing breakthrough technology to improve conversion efficiency and overcome degradation and deterioration issues with seven themes selected as follows:

i) New Formation Process of Solar-Grade Si materials
ii) Complete utilization of "light" and "carrier" by the control of interface
iii) Hydrogenated amorphous silicon free from light-induced degradation
iv) High efficiency thin film solar cells with enhanced optical absorption by excitons
v) Device Physics of Dye-sensitized Solar Cells (DSCs)
vi) Bandgap Science for Organic Solar Cells
vii) Efficient Visible Light-Sensitive Photocatalysts for Water Splitting

(7) Revision of PV2030 Roadmap

Circumstances has radically changed surrounding PV utilization and the PV industry since the PV Roadmap Toward 2030 (PV2030) was formulated in 2004. Against this backdrop, NEDO reviewed PV2030 to establish next phase R&D projects and released a new roadmap, PV2030+ (Plus) in June 2009. In the revised roadmap, the target year has been extended from 2030 to 2050 and various targets have been set including covering about 10 % of domestic primary energy demand by PV power generation by 2050, developing solar cells with 40 % conversion efficiency, achieving the 2030 technological development target in 2025 or five years ahead of the schedule set in PV2030, and enhancing system utilization technology development toward mass dissemination of PV systems in consideration of harmony with the PV utilization environment.

DEMONSTRATION

As FY 2008 was the final fiscal year for the Field Test Project on New Photovoltaic Power Generation Technology, new installation of PV system was not implemented. The project accomplished its initial goals and currently, only data collection of selected projects is underway. Six major demonstration programs were implemented in FY 2009: 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) Research and Development of Islanding Detection Testing Technology for Clustered Photovoltaic Power Generation Systems, v) International Cooperative Demonstration Project for Stabilized and Advanced Grid-connection PV Systems and vi) International Cooperative Demonstration Project Utilizing Photovoltaic Power Generation Systems.

(1) Field Test Project on New Photovoltaic Power Generation Technology

In FY 2008, new applications for this project were not accepted. Only data collection of installed facilities under existing programs is underway. Cumulative installed capacity of field tests conducted from FY 1992 to FY 2008 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 power plants feasible. Installations of a 5 MW level PV power plant in Wakkanai City, Hokkaido Prefecture and a 2 MW level PV power plant in Hokuto City, Yamanashi Prefecture were completed and both of the two power plants were connected to the grid. In the Hokuto site, three 400 kW power conditioners with a function to control grid stabilization were installed. Voltage of the power conditioners was changed from medium to high, for which a demonstrativeresearch has continued. The term of this research project is from FY 2006 to FY 2010.

(3) Development of an Electric Energy Storage System for Grid Connection with New Energy Resources

This project is a 5-year project between FY 2006 and FY 2010 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, while securing safety,
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 batteries and nickel hydride batteries have been conducted. In FY 2009, evaluation of performances of 100-kWh lithium ion batteries has been conducted.

(4) Research and Development 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 FY 2002 to FY 2007. Aimed at establishing certification and testing technologies which contribute to certification of devices to detect islanding operations at the time of grid-connection of multiple PV systems, the project has been conducted from FY 2008 to FY 2009.

(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.
In FY 2009, three overseas collaborative projects have been conducted as follows: i) “Demonstrative research on power supply systems to maximize the use of PV and other fluctuating renewable power sources” in Indonesia, ii) Demonstrative research on power supply

Fig. 3 - Solar Silicon Technology Kazusa Solar Factory PV system, 20 kW (Kazusa-Kamatari, Kisarazu City, Chiba).

systems to maximize the use of PV and other fluctuating renewable power sources" in Malaysia, and iii) "Demonstrative research on advanced micro-grid stabilization systems (high quality electricity supply)" in China.

(6) International Cooperative Demonstration Project Utilizing Photovoltaic Power Generation Systems

This program is an international program of demonstration and technological development using PV power generation, which started in FY 1992 and is scheduled to be completed in FY 2009. 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

(1) The Ministry of Economy, Trade and Industry (METI)

1) Subsidy for measures to support introduction of residential PV systems

The Ministry of Economy, Trade and Industry (METI) restarted a subsidy program for residential PV systems in January 2009. Amount of subsidy is 70 000 JPY/kW. Requirements for the subsidy are i) efficiency of PV module is above the designated numerical number (the requirement is set by each technologies), ii) a certain level of quality and performance and support after installation are guaranteed by the manufacturers, etc. iii) maximum output is less than 10 kW and the price of the system is less than 700 000 JPY/kW. With this program, Japan's residential PV market was revitalized, and the number of applications for the subsidy exceeded 100 000 in November 2009. The number of applications for the subsidy program has been steadily growing. This program will be continued in 2010. It is expected that the cumulative number of PV system installations and the cumulative installed capacity will reach approximately 600 000 and 2,1 million kW, respectively at the end of FY 2009.

2) Project for Promoting the Local Introduction of New Energy

This program aims at accelerating introduction of new and renewable energy in local communities by supporting projects for installation of facilities as well as projects for enlightenment 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 organizations.

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, and fuel cells.

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 400 000 JPY/kW. 1 334 systems in total were subsidized between FY 1997 and FY 2008, of which 598 systems were PV systems.

In FY 2009, 485 PV systems in total were newly selected, with total installed capacity amounting to 45 919 kW (excluding one project with 3 000 kW, for which only the design was qualified).

Local governments and nonprofit organizations understand the benefits of introduction of new and renewable energy through this program and are introducing PV systems to school buildings, public facilities and so on.

3) 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, natural gas co-generation, as well as microgrid systems. Amount of subsidy for PV power generation is the lower amount of either up to one third of the installation cost or 250 000 JPY/kW.

The output capacity of eligible PV systems is 50 kW or more (10 kW or more is also eligible in case of installations in remote islands or installations by small- and medium-sized enterprises). 331 systems in total were qualified from FY 1998 through FY 2006, of which 14 systems were PV systems with the capacity of 986 kW in total. Three systems received subsidy in FY 2007 and 162 systems were selected for the FY 2008 program. In FY 2009, 449 PV systems were selected, with a total capacity of 42 607 kW. In 2009, owners of collective housings (e.g. apartment buildings) started to introduce PV systems in their properties.

Besides these programs, METI has been supporting local governments for their projects to formulate their own visions for introduction of new and renewable energy in local communities. Through related organizations, METI also offers some programs such as low-interest loans and tax credits.

The four ministries, namely METI, the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the Ministry of the Environment (MoE) jointly made an announcement on the "Action Plan for Dissemination of PV Power Generation" and have been actively working on the dissemination of PV systems. In 2009, activities of the four ministries were joined by the Ministry of Agriculture, Forestry and Fisheries (MAFF), the Ministry of Internal Affairs and Communications (MIC), the Ministry of Health Labor and Welfare (MHLW), the National Police Agency (NPA) and the Cabinet Secretariat. All told, nine governmental organizations are working on this action plan.

(2) 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 the first half of 2009, MoE formulated "Change in green economy and society", a Japanese version of the Green New Deal, focusing on market expansion of PV power generation and energy-efficient home electric appliances. In the "Project to support active introduction of technological measures for local public organizations", MoE has been providing subsidy for the introduction of new and renewable energy including PV systems and enhancement of energy conservation. The "Model project to create demand for Green Power Certificates in local communities" is expected to boost dissemination of residential PV systems by local governments. As part of the "Project to promote the use of PV and other types of renewable energy", MoE has been promoting the "Project to purchase solar environmental values", which supports maintenance of facilities, on condition that Green Power Certificates issued for commercial PV facilities of private institutions are transferred to MoE. MoE is also promoting the "Supporting project for installing renewable energy in residential area", which provides subsidy for projects by local governments to support the introduction of renewable energy such as PV systems to residential houses. Other projects include the Project for dissemination of eco-houses, Eco-Renovation of Schools, and CDM/JI project survey which is conducted to roll out in 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.

(3) The Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Under the "Guidelines for Assessment of Environmental Friendliness of Government Building Facilities and Renovation Plan" as well as Kyoto 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. The "Model project for environmentally symbiotic residential areas" was completed in FY 2008 and the "Model project to promote eco-CO_2 reduction at houses and buildings" was newly established. For the introduction of technologies such as PV systems to reduce CO_2 emissions, MLIT provides subsidy for private institutions who conduct projects which are highly effective as model projects. Aiming at reducing greenhouse gas emissions, MLIT selected advanced efforts by businesses in construction, real estate and transport industries utilizing renewable energy as model projects to reduce greenhouse gas emissions. Furthermore, MLIT formulated guidelines for setting up plans to reduce greenhouse gases, for those who are in charge of managing port and sewage facilities. The guidelines include a manual to calculate the amount of greenhouse gas emissions as well as introduction of PV systems in port and sewage facilities.

(4) The Ministry of Agriculture, Forestry and Fisheries (MAFF)

The Ministry of Agriculture, Forestry and Fisheries (MAFF) started a subsidy program to install PV systems at facilities for agriculture, forestry and fisheries, in order to promote introduction of renewable energy into these industries. MAFF will support a part of necessary costs to install PV systems at facilities used for agriculture, forestry and fisheries, such as refrigerated warehouses for agricultural products, livestock barns and biomass conversion facilities. PV systems with the capacity of 10kW or above are eligible for the subsidy. Up to half of the installation cost (up one third of installation cost for private institutions) will be subsidized. In order to strongly support introduction of PV systems and other renewable energy facilities in villages dependent on agriculture, forestry and fisheries, MAFF decided to implement a survey on installation of these facilities as well as a demonstrative research on the technology of newly-structured PV systems.

(5) 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 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 locally-supplied building materials at kindergartens, elementary and junior high schools across the nation. By FY 2009, MEXT certified 951 schools as Eco School Pilot Model Projects. Of the 951 schools, installation of PV systems has been promoted at 623 schools.

Fig. 4 - Grand Messe Kumamoto PV system, 10 kW (Kamimasiki-gun, Kumamoto Prefecture).

In 2009, METI formulated School New Deal program and announced a plan to install PV systems in 12 000 public elementary and junior high schools nationwide under the threeyear plan.

(6) Local governments and municipalities

The movement to actively work on environmental issues has been spreading among local governments and municipalities year by year. Over 500 local governments and municipalities established subsidy programs for the installation of residential PV systems. Most of the programs provide subsidy ranging from 20 000 JPY/kW to 50 000 JPY/kW.

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 100 000 JPY/kW in FY 2009 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.

(7) Utilities

While electric utilities continued voluntary programs to purchase surplus PV power, the national government started a new program to purchase surplus PV power, effective November 2009, based on a newly-enacted "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers". Under the new program, the purchase price of surplus PV power was set at 48 JPY/kWh, twice as much as the current sales price of electricity.

Electric utilities established the "Green Power Fund" in October 2000, aiming at disseminating PV systems and wind power generators. From FY 2001 to FY 2008, 1 070 public facilities including schools across Japan were subsidized by the fund and the total installed capacity reached 20 676 kW. In FY 2009, 247 sites were selected, and a total 3 308 kW of PV systems received subsidy as of the end of 2009.

Electric utilities achieved the obligation amount of purchasing electricity generated from new and renewable energy for FY 2008 designated under the RPS Law that was enforced in FY 2003. Usage of electricity generated by new and renewable energy by utilities in FY 2008 was 7 918 TWh in total, including 763TWh from PV power generation. The accredited facilities for power generation using new and renewable energy under the RPS Law was 437 203 systems totaling 5 854 MW, of which PV systems accounted for 436 034 systems and 1 619 MW, respectively.

Electric utilities have continued introduction of PV systems in their own facilities, which represents their commitment to taking the initiative in introducing PV systems. They also announced a plan in September 2008 to construct approximately 30 PV power plants with a total capacity of 140 MW across the nation by 2020 by ten electric utilities. Electric utilities are increasingly setting up specific plans to construct MW-scale PV power plants. Plans with a total capacity of 90 MW or more were announced in 2009.

In preparation for the expected rapid increase in installation of PV systems, utilities started demonstrative researches to evaluate impacts of large-scale introduction of PV systems.

(8) 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. There is also an emerging trend of expanding environmental financing for the projects actively working on environmental issues. Some casualty insurance companies started new services to purchase green power, which gives a low burden on the environment: i) to provide loans for households to install PV systems, ii) to purchase in cash the Green Power Certificates issued for those who installed such PV systems by using loans mentioned in i) above. Tokyo Metropolitan Government (TMG), in partnership with multiple financial institutions, started the "Eco finance project", which makes investment in and provides loans for individuals who live in Tokyo and purchased environment-friendly houses and vehicles, as well as businesses operating in Tokyo who are promoting environmental measures.

INDUSTRY STATUS

In the PV industry, against the backdrop of estimated significant growth in the global market on a mid-term basis and the expected recovery of demand thanks to the measures introduced by the Japanese government such as restart of the subsidy program for residential PV systems and increase in the price of purchasing surplus

electricity from PV system users, a number of businesses expanded their PV-related businesses or entered a variety of PV-related sectors, despite the short-term slump of overseas markets.

Major achievements and events observed in the Japanese PV industry in 2009 are:

- Capacity expansion aiming at gigawatt-level production of PV cells/ modules;
- Establishment of a joint venture between a leading PV manufacturer and a major petroleum company to manufacture thin-film PV modules;
- A number of new entries into PV cell/ module manufacturing business;
- Accelerated improvement in performance of PV cells/ modules.

In addition, it should be noted that Chinese PV module manufacturers also started entering PV market in Japan in full scale. Highlights of PV manufacturers in 2009 are as follows.

Sharp announced an aggressive plan to increase its solar cell production to 770 MW in FY 2009. The company successfully expanded the production capacity of thin-film PV modules and started full-scale production as well. Also through strengthening the development of solar products, the company succeeded in improvement of conversion efficiency on compound solar cells and started the sales of ultra-thin PV modules for mobile phones and other portable devices.

Kyocera signed business collaboration agreements with distributors like **AEON** and **Japan Post Network** in the sale of residential PV systems. Furthermore, the company expanded its production capacity at a PV module manufacturing plant in China to 240 MW/year.

SANYO Electric expanded its production capacity at Shimane plant to 220 MW/year and opened a silicon wafer plant in Oregon, USA. In addition to these business enhancements, **SANYO** established a joint venture company, "**SANYO ENEOS Solar**", with **Nippon Oil Corporation**. On the other hand, upon completion of a takeover bid (TOB) of **SANYO Electric** by **Panasonic**, **SANYO Electric** has become a subsidiary of **Panasonic**.

Mitsubishi Electric upgraded its PV business section to a division in its organizational structure to strengthen the business. In particular, the company is putting emphasis on development and production expansion of high efficiency power conditioners.

Kaneka strengthened the business for residential PV systems in Japan and joined hands with **IMEC** of Belgium to improve solar cell conversion efficiency. Furthermore, the company acquired **Sanvic** to strengthen the business of EVA encapsulation for PV modules.

Mitsubishi Heavy Industry (MHI) made a full-scale entry into the PV market in Japan, planning to release a new type of thin-film microcrystalline silicon tandem PV modules into the market.

Showa Shell Sekiyu completed construction of its second plant for CIS PV modules with production capacity of 60 MW/year. Moreover, the company bought out a plasma production plant of Hitachi to establish its third plant with production capacity of 900 MW/year. The company will install a 1 MW PV system in Niigata Prefecture and Miyazaki Prefecture one by one. In addition, the company announced its entry into PV business in Saudi Arabia.

Honda announced that the company would start full-scale production of CIS PV modules and entered into the PV market in Europe in FY 2009.

Fuji Electric System newly formed operational headquarters for PV business to expand its PV business. **MSK** changed its company name to **Suntech Power Japan**, and established a business alliance with **Yamada Denki**, a major home appliance retailer, to expand its sales network in Japan. The company also has a plan to start sales of PV systems for new residential houses in the coming years.

Fujipream entered into the residential PV market in Japan in full scale, while **Yocasol** entered into residential PV system market in both Japan and North America.

Choshu Industry started its own production of PV modules.

Companies such as **Mitsubishi Chemical**, **TDK** and **SONY** are working on commercializing products with organic or dye-sensitized solar cell (DSC) technology.

Japan Photovoltaic Energy Association (JPEA) started accepting applications for the subsidy for installation of residential PV systems through its umbrella organization **Japan Photovoltaic Expansion Center (J-PEC)** and organizing workshops to assist the development of human resources for PV system installers and construction workers across Japan.

In the area of silicon feedstock and wafer manufacturing, a number of companies are pursuing their plan for the expansion of production capacity, launch of overseas operations, and entry into the PV business. Meanwhile, a Taiwanese manufacturer acquired a Japanese silicon manufacturer. A Japanese manufacturer announced its plan to construct a new plant under the joint venture with a European partner.

Tokuyama completed construction of a new polysilicon manufacturing plant with production capacity of 3 000 t/year and started operation. The company also announced a plan to construct a new plant in Malaysia with production capacity of 6 000 t/year.

Japan Solar Silicon released a plan to increase production capacity of polysilicon for solar cells to 4 500 t/year, planning to commercialize in the coming years.

Ferrotec started supplying multicrystalline silicon ingots in addition to monocrystalline silicon ingots.

SUMCO entered into a business of monocrystalline silicon for solar cells.

Osaka Fuji completed construction of a wafer slicing plant with production capacity of 2,1 million pieces/month.

TKX will expand its production capacity of solar wafer slicing up to 18 million pieces/month by the end of 2011.

Nippon Oil Corporation aggressively expanded its PV business by establishing a joint venture with **SANYO Electric**, followed by additional investment in **Space Energy**. Moreover, the company will establish an integrated holding company in April 2010 together with **Nippon Mining Holdings**, a company developing polysilicon business, expecting synergistic effects for both parties.

AU Optronics (AUO), a Taiwanese company, took its majority stake in **M.SETEK**, a monocrystalline silicon wafer maker and made it one of AUO's subsidiaries.

Shin-Etsu Chemical has a plan to increase production of metallurgical grade silicon, a raw material for polysilicon, in its subsidiary in Australia.

Fig. 5 - Hokuto site of NEDO large-scale PV demonstration facility, 1,8 MW (Hokuto City, Yamanashi Prefecture).

Taiyo Nippon Sanso Corporation and D**egussa Japan** announced a plan to construct a monosilane production plant for solar cells in Yokkaichi City, Mie Prefecture.

In the area of manufacturing PV components, new players entered into this business one after another and backsheet manufacturers such as **DuPont**, **Lintec**, **Mitsubishi Plastics**, **Dai Nippon Printing (DNP)**, **Toray Industries**, **Toppan Printing**, **Mitsui Chemical** and encapsulation suppliers such as **Bridgestone**, **Mitsui Chemicals**, **Kuraray**, **Kurabo Industries** increased their production capacity. To name some cable/ connector manufacturers who are actively developing the business, S**MK**, **Onamba**, **Kitani Electric** and **Yukita Electric Wire** have been promoting production capacity expansion and market cultivation on a global basis. In addition, **Nippon Sheet Glass (NSG)** announced a plan to produce glass specialized for PV modules in Vietnam.

In the area of PV system manufacturing, power supply manufacturers such as **Toshiba**, **GS Yuasa Power Supply**, D**aihen** and **Sanyo Denki** started development of large-sized power conditioners, while heavy electric machinery manufacturers such as **Toshiba**, H**itachi** and **Kokusai Kogyo Holdings** entered MW-scale power generation business. General trading companies are also expanding their PV business, and **ITOCHU**, **Mitsubishi Corporation**, **Sojitz Corporation** and **Hakuto** started sales of PV modules, providing services for PV system installation or organizing power generation projects at home and abroad.

In the area of manufacturing equipment for solar cells, some manufacturers promoted sales alliances with overseas manufacturers and enhanced their production capacity.

Shimadzu Corporation signed an **OEM** agreement with **Schmid** of Germany for supplying equipment to form antireflective films.

Tokyo Electron signed a strategic agreement with Oerikon to become Oerikon's agent for sales of thin-film PV module manufacturing equipment.

ULVAC started sales of a turnkey line for manufacturing tandem junction thin-film silicon solar cells.

NPC completed construction of a new plant for PV module manufacturing equipment.

Nisshinbo Holdings developed compact and energy-saving PV module manufacturing equipment. In addition, various materials makers supporting manufacturing equipment business are expanding their production capacity including carbonfiber heat insulation materials manufacturers such as **Kureha** and **Tokai Carbon**, saw wires manufacturers such as **Tokyo Rope MFG**, **Noritake** and **Tokusen Industry** and metalworking oil manufacturers like **Yushiro Chemical Industry** are expanding their production capacity.

In the area of distribution of PV systems, there has been an increasing recognition that PV systems will become a new product with mass distribution, and the housing industry, construction/ real estate industry, and wholesale/ distribution industry started making a significant move in the PV market. In the housing industry, major prefabricated housing manufacturers have been promoting houses equipped with PV systems as standard equipment. Some housing companies strengthened the sales of houses with PV systems by offering their own financial programs, others started introducing PV systems in their rental houses. They are working on promoting eco-friendly PV houses with storage batteries as well. In the construction and real estate industry, developers started introducing PV systems in their condominiums and buildings to make their facilities greener. In the distribution industry, a number of home electric appliance stores such as **Yamada Denki** and **Kojima**, retailers including major hardware stores, major supermarkets and wholesalers started sales of PV systems for residential, public and industrial applications and expanded their sales networks. In the gas industry, gas companies actively promoted sales of double-generation systems that generate power in combination of fuel cells or gas co-generation systems with PV systems.

Awareness of dissemination of PV systems has been developed among PV system users backed by the subsidies and tax exemptions offered by the government for introduction of PV systems in public and industrial facilities. Accordingly, PV system installations in public facilities, industrial facilities, commercial facilities and electric utility facilities have increased. In particular, installation of PV systems on the rooftops of factories or warehouses with large open spaces has been promoted, creating a market for PV systems for large-scale industrial facilities. In addition, there has been a remarkable trend that retailers or broadcast stations like NHK have started installing PV systems in their facilities all over Japan.

MARKET DEVELOPMENT

In the newly-built residential house market, pre-fabricated house manufacturers are enhancing efforts in the sale of houses with

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. Major housing manufacturers are offering energy-saving and environment-friendly houses equipped with PV systems. 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. In 2009, large-scale home electric appliances stores and large-scale retail stores started entering this market.

As for medium- to large-sized PV systems for non-residential use, such as for public and industrial facilities, field test projects were completed, which were shifted to the Project for Promoting the Local Introduction of New Energy and the Project Supporting New Energy Operators. A large number of MW-level PV systems installed by electric utilities were selected for these projects. 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, PV systems have been more diversely installed at facilities owned by electric utilities for power generation, agricultural facilities (green-houses), 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 nation-wide and installing additional PV systems to existing PV-equipped facilities. Installation of large-sized PV systems is also on the rise. As installations of several hundred kW to MW-level PV systems on large roof areas of factories and warehouses are also on the rise, the market of PV systems for large-scale industrial facilities started growing.

FUTURE OUTLOOK

The Japanese government has been strengthening its efforts to realize a full-scale dissemination of PV systems to achieve a low-carbon society. The government restarted a subsidy program for residential PV systems, which was terminated in 2005, and enacted the “Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers”, legislating the purchase of surplus PV power. The new program to purchase surplus PV power is assumed to accelerate dissemination of PV systems, consisting of three pillars as follows: i) to oblige electric utilities to purchase surplus PV power; ii) to increase purchase prices; and iii) to evenly share the burden of purchase costs by the whole nation. Basic purchase price is set at 48 JPY/kWh for residential PV systems, twice as much as the current sales price of electricity. This program works as a significant incentive to purchase residential PV systems. The new power purchase program started on November 1, 2009 for the purchase period of ten years. Purchase prices will be reviewed and reduced annually. With the new surplus PV power purchase program and the subsidy program for residential PV systems, the Ministry of Economy, Trade and Industry (METI) aims to almost halve the price of residential PV systems in three to five years.

The introduction of these stimulus measures to expand dissemination of PV systems has large impacts on the PV industry and the distribution industry. Corporations are actively promoting efforts on the PV power generation businesses. In the area of distribution of PV systems, in particular, there has been an increasing recognition that PV systems will become the new products with mass distribution. Housing industry, construction/ real estate industry and distribution industry started making a significant move into the PV market. In the housing industry, major prefabricated housing manufacturers are promoting to equip PV systems as standard equipment for their houses. They strengthened their sales of houses with PV systems and also started introducing PV systems in their houses for lease. In the construction and real estate industry, developers started introducing PV systems in their condominiums and buildings in order to make these facilities greener. In the distribution industry, a number of home electric appliances stores and major supermarkets started sales of residential PV systems and expanded their sales networks. In the gas industry, gas companies are actively promoting sales of double power generation systems, consisting of PV systems and fuel cells or gas cogeneration systems.

PV system users got to have higher awareness of dissemination of PV systems and were encouraged to introduce more PV systems as the national government provides subsidy and preferential tax treatment for PV systems for public and industrial applications. Accordingly, more PV systems were installed in public, industrial and commercial facilities as well as electric utility facilities. In particular, installation of PV systems on the roofs of factories and warehouses with large open spaces has made progress, which may lead to creating a market for PV systems for large-scale industrial facilities. Thus, a new program to purchase surplus PV power based on the legislation and restart of a subsidy program for residential PV systems have been a significant driving force for the Japanese PV market to make a step forward to achieve full-fledged dissemination of PV systems. The Japanese PV market, of which the installed capacity had been hovering around 200 - 300 MW levels, started rapidly growing once again, stepping forward to establish a domestic market size of 1 GW at an early date. Also, as the government was changed from that of the Liberal Democratic Party (LDP) to that of the Democratic Party of Japan (DPJ), the DPJ-led government has started taking actions to implement a program to purchase the entire electricity generated by renewable energy. It is expected that the stream of the introduction of PV systems will be further strengthened and expanded to achieve a low-carbon society.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
JINSOO SONG, KOREA INSTITUTE OF ENERGY RESEARCH (KIER)

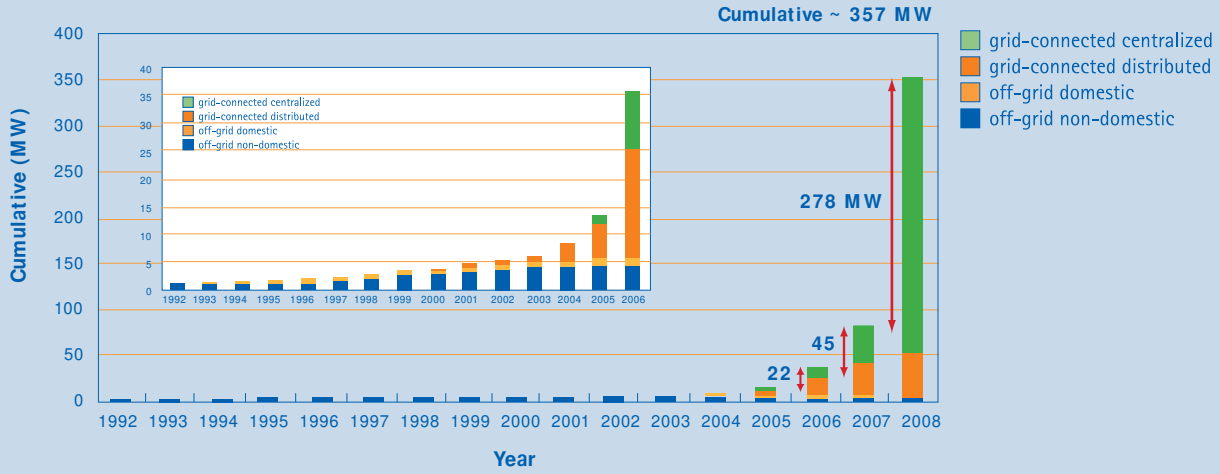

Fig.1 - The cumulative installed PV power in 4 sub-markets as of 2008.

Crystalline silicon solar cells

Poly-silicon	Ingot & wafer	Solar Cell	Module	Systems
OCI KCC	Woongjin Energy Rexor, Glosil, Neksolon, Neosemitech Naratech etc.	Hyundai Heavy Industry, Shinsung Holdins, LG Electronics, KPE, Millinet Solar, STX, Hanhwa, Samsung, etc.	Hyundai Heavy Industry, Symphony Energy, KD Solar, S-Energy, etc.	Kyungdong solar, Hyundai Heavy Industry, S-Energy, Symphony Energy, Hex power, Dass Tech., Willings, LG CNS etc.

Thin-film solar cells

Source/Materials	Solar Cell/Module	Equipment
SODIFF, Dong-jin Chem. KCC (glass)	KISCO, Alti-Solar (20 MW/yr, a-Si:H) Samsung, LG (R&D, a-Si:H, CIGS)	Jusung Eng., SEMES, SFA, AVACO, etc.

Fig. 2 - PV value chain and major companies in Korea.

GENERAL FRAMEWORK

Recently Korea 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. The government budgets in 2009 for renewable energy R&D were 241 billion KRW, which is a small increase over the 195 billion KRW in previous year. The PV R&D budgets in the same year were 58,1 billion KRW, which is 25 % increase from the previous year.

The total solar cell production capacity has reached about 1GW/year in 2009. The capacity expansion of exiting companies and new entries of several big companies should be main driving force of enhancing solar cell and module production. The Korea's PV installation marked a tremendous jump to 278 MW in 2008, which is about 350 % increase over the previous year and records the fourth in the world. The Feed-in-Tariff (FIT) program shares most of current PV dissemination. The PV installation in 2009, however, was shrunk over the previous year due to the reduction of government budget mainly in the FIT programs. The Korean government formulates various strategies in order to boost PV dissemination and to activate PV industries.

NATIONAL PROGRAMME

Korea's National PV programs have been based on the 2nd 10-year basic plan for New & Renewable Energy (NRE) RD&D established to enhance the level of self-sufficiency in energy supply, to meet the challenging of climate change and to consolidate infrastructure of NRE industry. The Korea's PV programs categorized into four major sub-programs; PV R&D programs, PV Infrastructure establishment & human resource education program, PV International cooperation programs, and PV dissemination programs. Under the PV R&D programs, various types of R&D projects have been allocated to industries, research institute and university. The total budgets for

TABLE 1 - MAJOR PV MANUFACTURING COMPANIES AND THEIR PRODUCTION CAPACITY AS OF 2009.

	COMPANY	BUSINESS AREA	CAPACITY
Feedstock materials and gases	OCI	Poly-Si	16,5000 ton
	KCC	Poly-Si	100 ton
	SODIFF	SiH4	300 ton
Ingot & wafers	Woongjin Energy	Ingot (single)	1,400 ton
	Rexor	Ingot (single)	200 ton
	Glosil	Ingot (multi)	150 MW
	Neksolon	Ingot & wafer	120 MW
	Neosemitech	Ingot & wafer	100 MW
	Naratech	Ingot & wafer	50 MW
Cells	Hyundai Heavy Industries	c-Si	330 MW
	Shinsung Holdings	c-Si	100 MW
	LG Electronics	c-Si	100 MW
	KPE	c-Si	96 MW
	Millinet Solar	c-Si	90 MW
	STX Solar	c-Si	50 MW
	Hanhwa	c-Si	30 MW
	Samsung	c-Si	30 MW
	GETWATT	a-Si thin-film	20 MW
	Alti-Solar	a-Si thin-film	20 MW
Modules	Hyundai Heavy Industries	c-Si	220 MW
	Symphony Energy	c-Si	100 MW
	KD Solar	c-Si	80 MW
	S-Energy	c-Si	60 MW

Fig. 3 - The 15 MW PV power station installed in Gochang-gun, Jeolla North Province in September 2008 under the FIT program. The systems are operating by tracking mode.

Fig. 4 - The PV power plant map in Korean Peninsula as of February, 2009. The total number of PV plant reaches to 963 and cumulative PV power generation is 287 GWh by the early of 2009.

PV R&D programs amounts 2,167 billion KRW until 2009. Five main programs are operating under the PV dissemination programs; PV subsidy, 1 million green home, public building obligation, regional dissemination and feed-in-tariff programs.

RESEARCH & DEVELOPMENT

The government budgets in 2009 for renewable energy R&D were 241 billion KRW, which is a small increase over the 195 billion KRW in previous year. The PV R&D budgets in the same year were 70,6 billion KRW, which is 25 % increase from the previous year. The 32 new and 25 continuous 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 R&D budget for 32 new projects amounts to 31,2 billion KRW. The representative “Strategic R&D” projects funded newly in 2009 are “Development of commercialization technologies of flexible CuInGaSe2 thin-film solar cells using metal foil substrates” and “Development of large area dye-sensitized solar cells with high reliability”. The second phase R&D support has been continued in the projects initiated in 2008. It includes “Development of mass production facilities for c-Si solar cells”, “Development of commercialization technologies of large area silicon and CIGS thin-film modules”, and “High efficiency a-Si/c-Si hetero-junction solar cells”.

INDUSTRY STATUS

Production of Feedstock and Wafer: After successful commercialization of poly-silicon feedstock in 2006, the OCI Co., (former DC Chemical Co.) has expanded their annual production capacity up to 165,000 ton in 2009. New entries have started their pilot production of

TABLE 2 - THE TOP 10 VLS-PV POWER PLANTS IN KOREA AS OF THE END OF 2008.

	LOCATION	CAPACITY (MW)	CONSTRUCTION DATE	CONSTRUCTOR
1	Sinan-gun, Jeolla South Province	24,0	Sept. 2008	Dongyang Express Construction
2	Gimcheon-si, Gyeongsang North Province	18,4	Sept. 2008	Samsung Everland
3	Gochang-gun, Jeolla North Province	15,0	Sept. 2008	Gochang Solar Park
4	Taean-gun, Chungcheong South Province	13,8	June 2008	LG Solar Energy
5	Yeonggwang-gun, Jeolla South Province	3,0	May 2008	Korea Hydro & Nuclear Power Co.
6	Samnangin, Gyeongsang South Province	3,0	May 2008	Korea Western Power Co.
7	Jindo-gun, Jeolla South Province	3,0	June 2008	Samsung C&T
8	Jangsan, Jeolla South Province	3,0	April 2008	Jangsan Solar Tech.
9	Boseong, Jeolla South Province	2,9	Sept. 2008	Baekyang Solar Tech.
10	Gunwi-gun, Gyeongsang North Province	3,0	Sept. 2008	Gunwi Solar Tech.

poly-silicon feedstock in 2009. The Woonggin Energy recorded the biggest capacity in silicon ingot production.

Production of Photovoltaic Cells and Modules: The total solar cell production capacity in Korea has reached 1 GW scale in 2009. The Hyundai Heavy Industry expanded their capacity up to 330 MW and 220 MW in the c-Si solar cells and modules, respectively. The remaining several companies, KPE, Shinsung Holdings, STX Solar, and Millinet Solar, also expanded capacity currently ranging 50 to 100 MW. The LG Electronics Co. has started 100 MW/yr c-Si solar cell production line from 2009. The Samsung Electronics starts the operation of a 30 MW/year R&D line for crystalline silicon PV cells and modules, aiming to become the world's top crystalline silicon solar cells and module manufacturer by 2015. 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. Major PV manufacturing companies and their production capacity as of 200 are summarized in Table 2. Many other companies are concerned about thin-film PV including silicon and CuInGaSe2. The Korea Photovoltaic Industry Association (KOPIA) was established in December, 2008. The KOPIA consists of more than 50 PV associated companies in the field of materials, cells & modules, balance of systems, manufacturing equipments & components, and system design & installation. The main activities of KOPIA are information offering, system reform, overseas marketing, seminar and forum hosting, news letter publishing, etc.

IMPLEMENTATION AND MARKET DEVELOPMENT

The Korea's PV installation marked a tremendous jump to 278 MW in 2008, which is about 350 % increase over the previous year and records the fifth in the world. The cumulative installed power of PV systems in Korea therefore tremendously increased to 357 MW by the end of 2008. The feed-in-tariff (FIT) program has been main driving force to PV market expansion of Korea in 2009. The total number of PV plants installed under the FIT program has reached to 969 as of the early of 2009. The cumulative PV electricity generation is about 287 GWh. Figure 3 shows regional distribution of PV power plants in Korean Peninsula. The Jeolla provinces, the south west part of Korea, have recorded the highest cumulative installation capacity up to 153 MW. The South Chungcheong and North Gyungsang provinces followed next and their plants capacity reaches about 70 MW as of February of 2009. Listed in table 1 are top 10 VLS (Very Large Scale)-PV power plants installed in November, 2008. The largest plant is 24 MW PV system installed in Shinan, the southern part of Jeolla province. The systems are operated by horizontal axis tracking mode. In 2009, the new PV installation has shrunk to 167 MW, which is less than half over the previous year. The 139MW PV modules have been newly installed in 2009 under the FIT program and 29 MW installed under the dissemination programs such as “1 million Green Home Program”, “Public building obligation program”, and “Subsidy programs for private and regional sectors”.

FUTURE OUTLOOK

A great domestic market expansion in 2008 has pushed many Korean companies to enter PV industry. As a result, the supply chain of crystalline silicon PV has completed from feedstock materials and system installation. The solar cell production capacity reaches 1 GW/year as of the end of 2009 and expected to expand more rapidly in the near future. The main driving forces of these capacity expansions are new entries of conglomerate companies such as LG and Samsung, which are currently starting production of crystalline silicon cells and modules. The PV installation in 2009 was reduced over the previous year due to the introduction of FIT quota and financial crisis. The PV market Creation Plan including RPS (Renewable Portfolio Standard), recently unveiled by Korea's Ministry of Knowledge Economy (MKE), would allow the Korean PV installation market steadily to increase by 2012.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS IN MALAYSIA
BADRIYAH ABDUL MALEK, MINISTRY OF ENERGY, GREEN TECHNOLOGY & WATER (MEGTW)
IR. AHMAD HADRI HARIS, MBIPV PROJECT, MEGTW

Unit Cost Grid Connected PV System in Malaysia

Fig. 1 - Trend of cost reduction of grid-connected PV systems.

GENERAL FRAMEWORK

Malaysia aims to become a developed nation by 2020. Hampered by the Asian financial crisis in 1997-1998 and the recent global economic downturn in 2008-2009, Malaysia now needs to grow at a faster rate from 2010 onwards in order to achieve the developed nation status. Thus, Malaysia is now identifying several new economic activities as the new driver for further economic growth, whereby solar photovoltaic industry is now being seriously considered. By 2020, Malaysia aims to be 100 % electrified whereby solar hybrid systems and other renewable energy technologies are expected to provide the electricity in rural and remote areas of Malaysia. Therefore, the PV technology market to date in Malaysia is largely dominated by off-grid solar hybrid systems that are mostly funded by the Government.

Under the new Renewable Energy Action Plan, Malaysia has targeted grid-connected PV technology to provide a viable and sustainable source of electricity and new economic opportunity. Starting from July 2005 under the 9th Malaysia Plan, the Malaysian Government under the auspices of the Ministry of Energy, Green Technology and Water with support from United Nations Development Programme (UNDP) and Global Environment Facility (GEF) has been promoting grid-connected PV applications through the Malaysia Building Integrated Photovoltaic (MBIPV) Project. The MBIPV Project has carried out various public and targeted promotional as well as educational campaigns. Since then, the public has been very receptive to the financial incentive programmes administered by MBIPV Project and the responses to implement grid-connected PV applications have exceeded the expectations.

In April 2009, the Prime Minister of Malaysia has brought Green Technology to the mainstream through the creation of a Green Technology portfolio under the Ministry of Energy, Green Technology and Water, as a commitment to a greener environment and to achieve energy security in the country. The key stakeholders responsible for national renewable energy development in Malaysia are Ministry of Energy, Green Technology and Water (MEGTW); Economic Planning Unit (EPU); Ministry of Finance (MOF); Ministry of Science, Technology and Innovation (MOSTI); Malaysian Industrial Development Authority (MIDA); Malaysia Energy Centre (PTM); Energy Commission (ST); Tenaga Nasional Berhad (TNB - power utility); Sabah Electricity Sdn Bhd (SESB - power utility); and Sarawak Energy Berhad (SEB - power utility).

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

Fig. 2 - An employee handling the CdTe PV module at First Solar plant in Kedah, Malaysia (photo: First Solar Malaysia Sdn Bhd).

Fig. 3 - Main gate to Q-Cells Malaysia Sdn Bhd (photo: Q-Cells Malaysia Sdn Bhd).

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. 2009 is the penultimate year of the MBIPV project whereby most of the results and impacts can be seen.

The Prime Minister of Malaysia in his speech to announce the National Green Technology Policy on 24th July 2009 mentioned that the feed-in tariff mechanism would be implemented in the 10th Malaysia Plan (2011-2015) to catalyse RE development in the country. On 23rd October 2009, the Prime Minister in his National Budget 2010 speech has also announced the establishment of a Green Technology Fund of 1,5 BMYR to provide soft loans to companies that supply and utilise green technology. The scheme will commence on 1st January 2010 and is expected to benefit 140 companies. To further highlight the country's commitment towards climate change mitigation, the Prime Minister of Malaysia who attended the COP-15 meeting in Copenhagen announced on 17th December 2009 that Malaysia would voluntary reduce up to 40 % of CO_2 emissions intensity of GDP by 2020 compared to 2005 levels. This commitment is contingent upon receiving the transfer of appropriate technology and sufficient financing from Annex 1 countries.

R&D, D

A task force on renewable energy chaired by a Deputy Minister has been established in the Ministry of Science, Technology and Innovation (MOSTI) to drive R&D and deployment of RE technologies. In 2009, 60 MYR has been allocated to prioritise R&D activities in identified RE areas which are close to commercialisation, including solar PV technology. To date, the major areas of R&D in PV conducted by universities in Malaysia are inverters, PV cells (crystalline and thin film), concentrator (heliostat technology), hybrid systems and energy conversion tracking system. The R&D on PV cells and thin films are spearheaded by the Solar Energy Research Institute (SERI). The concentrator technology development focuses on novelty of using low cost mirrors and is currently at applied research stage. The key six universities in Malaysia involved in PV are Universiti Kebangsaan Malaysia (UKM), Universiti Teknologi Mara (UiTM), Universiti Malaya (UM), Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM), and Universiti Tunku Abdul Rahman (UTAR). Most of the researches are funded by the Ministry of Science, Technology and Industry (MOSTI) under the national Science and Techno Funds.

IMPLEMENTATION

The MBIPV Project is administered by the Ministry of Energy, Green Technology and Water Malaysia (MEGTW) with support from United Nations Development Programme (UNDP) and Global Environment Facility (GEF). The MBIPV Project has been holistically designed to cover promotional, market, policy, and industry developments. The main focus of MBIPV Project in 2009 has been to assist the Ministry with the formulation of Renewable Energy Policy and Action Plan. In addition, the MBIPV Project supported the Economic Planning Unit in indentifying solar PV industry as a new source of economic growth for Malaysia. In terms of application, the grid-connected PV systems in Malaysia today are allowed to be connected to the utility distribution system at the low voltage level on a net-metering basis. All grid-connected PV systems which received the government incentives are monitored by the PV Monitoring Centre whereby the system performances can be viewed from its website, http://pvmc.uitm.edu.my.

INDUSTRY STATUS

The local PV service industry development is administered by MBIPV Project through a voluntary scheme called Approved PV Service Provider (APVSP), whereby the PV companies are required to fulfil various quality requirements in order to be given an annual license and to be listed in the project directory. By end of 2009, there were 18 additional companies registered as APVSP making a total of 26 APVSPs available throughout Malaysia. These 26 companies engage a total of 132 fulltime staff in PV business. Collectively these companies have installed more than 410 kW of grid connected PV systems.

By the end of 2009, there are four major foreign direct investments (FDIs) in PV manufacturing in Malaysia. This is excluding Renesola Malaysia which has ceased its operation in December 2008 due to the global economic downturn, and has since consolidated its operation in China. In late 2009, First Solar announced the expansion of another eight production lines at its manufacturing facility in Kedah. This will increase First Solar's annual capacity by another 424 MW which and is expected to come online by 2011.

In 2009, there were 2 local PV assembly plants established in Malaysia which have a total production capacity of 33 MW whereby the production will commence by early 2010. 2 more PV assembly plants are currently being planned to be setup in 2010, making a total of

TABLE 1 – MAJOR PV FDIS IN MALAYSIA

COMPANY	PRODUCT	INVESTMENT (MYR)*	NAMEPLATE CAPACITY	JOBS CREATED	STATE	STATUS
First Solar	CdTe Modules	2 billion	848 MW (exclude capacity expension)	2 400 (2 400)	Kedah	In operation
Q-Cells	Solar cell, wafering & ingot	5 billion	500 MW	3 500 (500)	Selangor	In operation
Sunpower	Solar cell, wafering	5 billion	1 000 MW	5 500 (70)	Malacca	Under construction
Tokuyama	Polysilicon	1,8 billion	3 000 tons	500 (N/a)	Sarawak	Initial planning

** 1,0 MYR = 0,2036 EUR = 0,2919 USD (as at 21 December 2009, middle rate)*

4 PV assembly plants with a total production capacity of approximately 158 MW. The estimated total number of employees engaged in these 4 plants is 300 people.

MARKET DEVELOPMENT

As of end 2009, Malaysia has a cumulative installed grid connected PV capacity of approximately 1 063 kW and off grid PV capacity of about 10 MW. The grid-connected PV market is driven largely by financial incentive programmes administered by the MBIPV Project (namely the SURIA 1000 Programme, Demonstration and Showcase Incentive Programmes). Collectively, these financial programmes will generate an estimate of 1 700 - 1 900 kW of grid-connected PV systems by end of 2010. Although the off-grid PV market is the current dominating market, it is envisaged that by the end of 10th Malaysia Plan in 2015, Malaysia should have at least 55 MW of grid-connected PV systems. This quantum leap is expected to come once the proposed national feed-in tariff is introduced in 2011, which is the start of the 10th Malaysia Plan. For the feed-in tariff to be in place, the legal framework for the Renewable Energy needs to be enacted by second half of 2010.

FUTURE OUTLOOK

As of the third quarter of 2009, Malaysia's gross domestic product (GDP) was 1,2 %. On 1st December 2009, the Ministry of Finance revised the forecasted GDP from 2 % - 3 % to 5 % for 2010. The drop of GDP in 2009 was due to the global economic crisis and the Government has intended to fast track several significant projects in the country in 2010 so that the 5 % GDP target is achievable.

While Malaysian PV market will have a modest growth once the feed-in tariff is introduced, the PV industry in Malaysia is gaining international position due to the foreign direct investments by major international players. By end of 2010, Malaysia will have an estimated total PV production capacity of 1 300 - 1 500 MW per annum and by end of 2011, the production capacity will be almost 3 000 MW per annum.

Fig. 4 - Solar PV incorporated into the car porch roof of a house in Damansara Heights, Kuala Lumpur (photo: courtesy of the house owner).

MEXICO

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

Fig. 1 - 6,5 kWp PV Grid-Connected system at the Technological University of Morelos (photo: UTM).

GENERAL FRAMEWORK

Very encouraging news from Mexican PV market behaviour can be reported for 2009. After a quasi stagnant performance shown in previous years, in 2009 the PV market showed a notable growth. It seems that now the PV activity moves forward on several fronts.

First, the number of PV grid connected systems almost three-folded the cumulative installed capacity, reaching the first MWp of installed capacity for this application.

Although the rural electrification program via renewable energies has not been restarted yet, sound activities in the PV Grid connected systems area, such as human resource creation and continuous training have been taking place. Nowadays, hearing people asking for solution to diminishing the bills from electric consumption is a common matter.

The number of grid-connected PV commercial applications has also multiplied. Several large roof-mounted PV systems have been installed on stores and buildings of big companies. Besides, these companies have plans for future projects both to improve the energy efficiency in their industrial processes, and to increase the use of renewable energy, which includes the PV technology.

As of the end of 2009, an American car maker had installed a 400 kWp ground-mounted PV system in its manufacturing plant facility located in the northern State of Coahuila. Another grid-connected PV application registered during 2009 is a medium scale 12 kWp roof-mounted system. This system was installed on the roof of the Renewable Energy Department building of the National Utility (CFE, acronym in Spanish) office sited in Morelia, Mexico. Even though the total cumulative capacity of grid-connected PV systems denotes a modest growth, the relevance of 2009 results is that there is a clear message of increased interest in the grid-connected PV systems arena.

NATIONAL PROGRAMME

The rules of the Law of Use of Renewable Energy and Financing of the Energy Transition were promulgated during the second semester of 2009. It is expected that through the enforcement of this new regulation the number of renewable energy projects including the PV technology will increase both in quantity and installed power.

The PV technology continues to be used to provide renewable energy based services for isolated rural communities, and represents the most reliable alternative for rural electrification of remote isolated communities. The rural electrification programme that had been announced a long time ago remains in a delay status.

RESEARCH AND DEVELOPMENT

Academic research activities related to PV materials continue in progress. The Electrical Research Institute has been awarded by the Mexican National Council of Science and Technology (CONACyT, acronym in Spanish), to set up a testing bench for solar home systems. It is expected that through this project a mechanism of quality assurance can be made available once the Federal Government

Fig. 2 - 60 kWp Grid Connected System at the Autonomous Metropolitan University Campus Iztapalapa (photo: UAM-I).

launches the rural electrification program. Also during 2009, the National Autonomous University of Mexico (UNAM, acronym in Spanish), was awarded with a project related with CdTe/CdS Technology Transfer to industry.

Several studies related to PV technology deployment were carried out in 2009. Two of them can be mentioned: a study to estimate the penetration limits of PV technology in the north-western city of Mexicali developed by the Electrical Research Institute of Mexico (IIE, acronym in Spanish), and a study to explore the market niches for grid-connected PV systems in the Mexican domestic market, financed by the German Aid Agency.

IMPLEMENTATION

The follow-up monitoring of grid-connected PV systems located in Mexico City, La Paz, and Mexicali, continued during 2009. With the financial support of the GEF, through the local UNEP office the impact of a major roof-mounted PV generator cluster on the sub-distribution network was assessed. This cluster pertains to a low-income community located in a north-western region of Mexico.

The IIE installed a 9 kWp system at the Regional Wind Technology Center (CERTE, acronym in Spanish), in Juchitan, Oaxaca. The system will meet almost all the electricity load demanded by the administrative building.

The Second International Colloquium for Promotion of PV Technology was held during the third quarter of 2009. More than 100 medium and small size industries related with PV participated in the Colloquium. At the meeting, the National Development Bank (NAFIN, acronym in Spanish), offered its leadership to promote that private banks and
PV industry representatives analyse and develop financing mechanism and business opportunities for grid-connected PV systems.

Fig. 3 - 9 kWp Grid Connected System at the Regional Wind Technology Center Oaxaca (photo: IIE).

As in previous years, the actions carried out within of the PV Grid Connected Project GEF/PNUD-IIE were focused on technology promotion, regulatory issues, and professional training. A diploma course on grid-connected PV systems was offered during 2009. The interest of CFE on grid-connected PV systems is evident through the enthusiastic participation of engineers of the utility.

In November 2009, the workshop 'Road Map of Photovoltaic Technology in Mexico' was held. The workshop pursued the following goals: (1) to develop a common vision about what the national PV industry should be for the coming years, (2) to identify the major barriers that the domestic PV industry currently faces, and which are impeding it to advance towards a state of more accelerated expansion, (3) to

Fig. 4 - 21, 6 kWp Grid Connected System in public park in city of Puebla (photo: Alternativa Energética SA de CV).

analyze the strengths and weaknesses of the domestic photovoltaic industry, (4) to identify the strategic elements that will enable the domestic photovoltaic industry for reaching a higher competitiveness degree in the international market, and (5) to promote alliances among Mexican PV companies in order to face international competition.

Puebla City Council is implementing the first grid-connected PV system for public lighting in Mexico. The project has been conceived to illuminate a public park, making use of high-efficiency LED lamps. The PV system will be able to partially meet the electricity needs to power the lamps during the night. The system will be connected to grid in early 2010.

MARKET DEVELOPMENT

According information coming from the main PV companies (suppliers, installers and systems integrators the best estimation of Mexican PV market size was around 3,27 MWp for 2009. No precise information about market segmentation has been given, but it is estimated that grid-connected PV systems alone contributed with at least 796 KW. By the end of 2009, the cumulative PV capacity installed in Mexico was around 24,97 MWp.

FUTURE OUTLOOK

One of the biggest supermarket store chain continues with its plan for installing more the PV grid-connected in their stores. During 2009 they installed a 200 kWp system. The colloquiums to promote the PV Technology in Mexico and financing mechanism for PV systems workshops will continue during the coming years. This kind of events has a very positive effect on information dissemination, and help in the construction of confidence towards the PV technology as alternative for distributed generation. Grid-connected PV training activities will also continue under the umbrella of the GEF/UNDP-IIE project.

At the time the Law of Use of Renewable Energy and Financing of the Energy Transition is enforced the number and size of PV applications will be increased considerably.

Regarding the PV industry in the country, the consensus among the main actors is that the Mexican PV industry will explode in the coming months. This feeling is in accordance with the size of the Mexican market in 2009, that the growth had more than doubled in comparison to what was reported the previous year.

On the regulation side, The Energy Regulatory Commission issued the draft of the “Contract Model for Renewable Energy Source Interconnection or Cogeneration Scale,” for revision and comments. This contract model will replace the former one. With the proposed changes in the new contract, it will be possible to interconnect PV systems up to 500 KW at the medium voltage networks.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS

OTTO BERNSEN, NL AGENCY, DIRECTORATE ENERGY & CLIMATE CHANGE, MINISTRY OF ECONOMIC AFFAIRS
WILLEM VAN DER HEUL, MINISTRY OF ECONOMIC AFFAIRS

Fig. 1 - Helianthos, a Vattenfall company.

GENERAL FRAMEWORK

In the third year of the centre - left government in the Netherlands the plans concerning photovoltaic solar energy are taking shape. The current contribution of PV to the total electricity consumption in the Netherlands is well below 1 % (source: CBS statline) of the total electricity consumption. The national policy program, "Clean and Efficient" does not mention specific targets for PV. Instead it aims at improving the market conditions for this diverse set of technologies in anticipation of lower module prices. The government initiated a new feed-in premium scheme in 2008, called SDE (Stimulation Sustainable Energy Production), which was adjusted in 2009 to allow for larger PV systems up to 100 kWp, but only to a maximum of one third of the total available yearly budget.

The overall aim of the national energy policy is an annual energy consumption reduction of 2 %, a reduction of CO_2 emission of 30 % by 2020 (compared to 1990) and a contribution of 20 % of renewable energy to the total primary energy consumption in 2020. The way to achieve these goals is through a process of "energy transition" which can be divided into three steps. In the short term, the policy in the Netherlands is focused upon wind energy (on shore and off shore) and biomass while solar PV is foreseen to have a larger potential in the medium and especially in the long run beyond 2020. More R&D is needed to lower the costs of the relative expensive top of PV as soon as possible. Therefore, R&D for PV continues to receive a steady flow of funds over the years while more competitive products are being developed.

Due to the economic crisis, the last year has been a turbulent one for the PV industry with lower outputs, layoffs, takeovers and fierce competition on the market with falling prices and the entrance of many newcomers in the field of PV project development and installation. Nevertheless, an effort has been made by all parties to keep R&D expenditure at the same level as in previous years to secure the future potential of PV.

NATIONAL PROGRAMMES

In 2009, the initial SDE budget for PV reached 88 MEUR which corresponds to 20 MW of which only a part was installed during the same year. Due to the overwhelming public interest for the SDE, on top of this amount an additional budget of 50,8 MEUR was allocated in 2009 to allow for another 11,8 MW installed capacity over the coming years. The total budget for the SDE is established each year and the prices are adjusted according the changing market electricity prices. The grants last for 15 years after the start of production which may take several years. Therefore it is difficult to give an estimate for the yearly growth of the national PV market because of this delayed effect. In 2009, this optional time period was limited to one and half years. The CBS data over 2009 are expected later this year but the preliminary figures from Certiq B.V. (the Green certificate issuing body, related to the national grid operator Tennet) show already a steady increase since the start of the SDE scheme which continued into 2009.

In 2009 the SDE adjustment resulted in a first category of small PV installations between 0,6 kWp and 15 kWp with a basic 0,526 EUR/kWh (of which 27,3 EUR is returned by the utility and 25,3 EUR is subsidy) and a second category of PV systems larger then 15 kWp and up to 100 kWp with a basic 0,459 EUR/kWh (of which 0,076 EUR is returned by the utility and 0,383 EUR is the actual subsidy). Special attention in execution of the scheme is being paid to the monitoring of the quality and performance of the installed PV systems.

For 2010 a total SDE budget is planned of 93 MEUR of which 69 MEUR goes to the first category of small PV installations and 24 MEUR to the second category of PV larger systems.

Apart from the limited PV subsidy for households there are other fiscal advantages. An energy investment deduction (EIA) is available for companies that invest in energy saving measures and for PV up to a maximum of 3 MWpeak a year. Only a tiny fraction of the total amount is accounted for by PV. Under certain conditions, “green loans” from the banks are applicable for PV systems which offer more favourable terms.

In addition to the national schemes, some regional governments have established their own subsidy schemes. The Province of Friesland (Fryslân) for example granted a total of 1,1 MEUR for PV installations in 2009. Regional plans and activities to promote PV technology have become more ambitious and explicit during the last year. In 2009 an innovation support program “Peaks in the Delta” was granted for the development of a PV technology roadmap specifically for the Southeast Netherlands.

Fig. 2 - Installation by Oskomera on the Town Hall in Genk.

The national innovation program for build integrated PV started end 2009. The aim of this program is to promote the development of new PV applications in the built environment (e.g. roof integration, design techniques).

RESEARCH AND DEVELOPMENT ACTIVITIES

In the Netherlands research is being conducted into the different technology families for PV, such as organic solar cells, thin film and silicon wafer technology because each technological domain holds different potentials. Beside incremental improvements of PV modules and production processes there still seems to be room for fundamental steps.

The total expenditure on PV R&D remained roughly the same as in 2008 with a figure close to 12 MEUR. The bulk of this amount is divided between the EOS (Energy Research Subsidies) program and the national energy research institute ECN. It has become a tradition for EOS and ECN to organise a yearly “Sunday” presenting major projects and reflect on new developments.

In addition, there are other funding schemes but which are not accounted for in this brief overview. During 2009 there was no specific call in the European 7th Framework for PV but some projects were granted, such as HIFLEX , concerning highly flexible organic photovoltaics and is led by the European Research Centre at the ECN campus.

The projects granted in 2009 in the EOS program reflect the increasing diversity in topics and interest from other disciplines for PV related issues, such as biochemistry and software engineering. Special mention is made of the Agricultural University of Wageningen and the University of Leiden which have joined the already successful players in PV R&D.

Several projects and persons earned prizes and international recognition in 2009 for their efforts. The PV unit of the national Energy Research Centre (ECN) won a European Innovation Prize for its work on the Back-Contact Solar Module Assembly Line and establishing a new efficiency record of 17 % for a multi-crystalline silicon solar panel together with REC in Norway. At the Technical University of Eindhoven, Prof. Dr. Ir. Richard van de Sanden, leader of the Plasma Materials Group, received a prize for bridging the gap between fundamental research and industry, which resulted in many joint patents.

INDUSTRY STATUS

As in many countries around the world the Dutch PV sector was hard hit by the financial crises in 2009, particularly the very fast growing companies with a considerable amount of outstanding loans. The market for PV suddenly declined which led to lay offs and lower production levels. At the same time the economic crises may also have caused some companies from other industrial sectors to reconsider the future PV growth market, especially when they found themselves already in declining markets.

The former flagship of sustainable development in the Netherlands project developer Econcern went under and had to sell two of its PV projects (total 21 MW) to Scheuten Solar and turned the majority of its activities over to Eneco, one of the leading utilities. With the earlier participation of the utility Delta in Solland Solar and the take over of thin film manufacturer Helianthos by Nuon it can be said that the utilities in the Netherlands are firmly on board the production side of PV. In 2009 Nuon/Helianthos opened a thin film pilot plant in Arnhem; see Figure 1. The ECN spin off RGS Development established a pilot production line for ribbon-growth-on substrate (RGS). Solland Solar planned to open another production line in 2009 but instead production was limited.

More players entered the PV market for installation activities and project development than the market could absorb. However, some of these companies have successfully expanded their business internationally and the entire industry by now has a clear international character with strong European, Asian and American ties.

DEMONSTRATION PROJECTS, IMPLEMENTATION AND MARKET DEVELOPMENT

Several cities in the Netherlands have their own PV projects in newly built areas or renovation projects. One of the largest is a joint initiative from three cities Heerhugowaard, Alkmaar and Langedijk (HAL) which was opened in 2009 and aims to install 5 MW on roof tops. The project is supported by the European Framework Program Sun Cities.

In March 2009, several universities and the Province of Friesland organised a kick off meeting called, “PV Embedded,” for companies to become acquainted with new product combinations of PV.

Lately, Dutch universities have invested in more sustainable buildings on their campuses including PV. Architects are increasingly interested in PV as part of the building design and Oskomera Solar Power Solution, among others, has been successful in targeting this high-end market, especially in the Netherlands and the UK. Of course, installing PV modules high up the roof of a public building is still current; see Figure 2.

FUTURE OUTLOOK

The bulk of the PV market is still well served with multi-crystalline modules and will continue to grow when the economy recovers. A new perspective is being offered by thin film technology that has attracted attention and support from unexpected quarters, such as the semiconductor and chemical industry. New high volume production lines are already being implemented and pilot plants are being built for the production of more efficient thin film PV. This second generation thin film technology is also finding its way into the first generation PV fabrication processes in order to save valuable materials. As a result, the former distinction between first and second generation PV is rapidly fading.

With its multi-functional characteristics and design features thin film PV is also on its way to become an enabling technology in many different sectors. To foster this development new value chains are necessary in the near future where PV has a clear role and added value. There will be room for more service oriented companies to develop these niche markets alongside the large PV parks being established in the more sun rich regions.

International cooperation in a highly dynamic field such as PV is important. In addition to the international networks the Netherlands is looking to its neighbours for closer collaboration along the borders with NordrheinWestfalia (NRW) and Flanders (FL). In both regions, new PV research centers are planned in the cities of Heerlen and Eindhoven.

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
TROND MOENGEN, THE RESEARCH COUNCIL OF NORWAY

Fig. 1 - Solar panelled wall at NTNU in Trondheim. Although central Norway is only about 500 km south of the Arctic Circle, solar energy may be a viable energy source for more than just isolated log cabins even in these high latitudes. To test this on large-scale buildings a double facade with photovoltaic (PV) panels has been built on the campus of the Norwegian University of Science and Technology in Trondheim. A monitoring programme has been started to evaluate the performance of the PV panels and their influence on the indoor air climate.

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, (approximately 180 MEUR in 2009) Enova is the main instrument with regard to improve energy system efficiency and increase renewable energy production.

Norway has still 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.

The state owned company Innovation Norway promotes nationwide industrial development, and helps release the potential of different districts and regions by contributing towards innovation, internationalization and promotion. During the last ten years, Innovation Norway has contributed with approximately 12 MEUR to the establishment of several PV-related industries. The NorSun wafer production facility in Aardal is among the recipients.

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 appr. 17-18 MNOK for 2009. 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.

During 2009 the Norwegian Research Centre for Solar Cell Technology came into operation. All of Norway's leading research groups and industrial partners in solar cell technology participate in the centre. The research activities are grouped into six work packages, five of which involve competence-building: mono- and multi-crystalline silicon, next-generation modeling tools for crystallizing silicon, solar-cell and solarpanel technology, new materials for next-generation solar cells, and new characterization methods. The sixth is a value-chain project that will apply the findings of the other five work packages to produce working solar cell prototypes. The centre will have annual budgets in the range of 7-20 MNOK in the coming eight years.

Fig. 2 - Integrated solution in Trondheim.

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 600 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 with PV applications, focusing on stand-alone systems. System technology and advanced storage systems are main parts of this activity. IFE has an international expertise on characterization, development and processing of solar cells based on crystalline silicon. The activity is built mainly around the solar cell laboratory at IFE, which contains a dedicated line for producing silicon-based solar cells, and is unique in the Nordic countries. Additionally, a solar cell characterization laboratory is also present for measuring all types of structural, electrical and optical properties.

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. A team of 55 researchers is developing new PV cell technology that will increase cell efficiency dramatically. Professor Bengt Svensson, manager of the team, claims that the concept they are working with has a theoretical efficiency of 80 %, but will in practice hopefully offer efficiencies of 50-60 %, within the next 10-15 years.

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 centred around two aspects; - new sources and production methods for silicon to solar cell applications and - fundamental research on materials for photovoltaics. In their work on new sources for feedstock to the solar cell industry, they are involved in a number of EU projects and programmes in collaboration with European industry, universities and research institutes. Here can specifically be mentioned the strategic targeted project FoXy within the 6th framework which is coordinated by SINTEF and has a wide range of participants from across Europe. FoXy ended in 2009, and brought a number of interesting results. The scientists managed to develop a new, less expensive grade of raw material for solar cells, with the same efficiency as current solar cells. More than 50 people at SINTEF are involved in research on solar-cell materials. More information: www.sintef.no

University of Agder 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 running in partnership with Elkem Solar. The programme will be financed also by The Research Council of Norway and the City of Kristiansand. In

Fig. 3 - Solar panelled wall at NTNU.

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, intermediate band gap cells and spectrum splitting schemes, and in order to better understand system behaviour. Upcoming activities include a study of degradation of crystalline PV modules, and research in power electronics for PV applications. The research group on PV technology is about 10 persons, including 3 professors, 1 post doc. and 4 Ph.D. students. The university has a study program in renewable energy at bachelor, master and Ph.D. levels. This route can lead to a specialization in PV technology at the Ph.D. level.

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 light-houses/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, the Norwegian Coastal Administration made approximately 1840 installations with a total of 3600 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 230-250 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 2009.

INDUSTRY STATUS

Elkem Solar. Through the developed metallurgical route, ES has the potential to be an important player in this market. During the last years of development, feedstock from ES has been tested industrially. Silicon from ES (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 organization, ES is now building up production capabilities. 4,2 BNOK has been invested in a industrial production plant in Kristiansand. The plant started ramp up production during 2009. Total capacity will be about 6 000 tons Si and the plant has 270 employees.

Renewable Energy Corporation (REC). REC is one of the world's largest producers of silicon materials, PV wafers, cells and modules, and engage in project development activities in selected segments of the PV market. 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. Their production facilities include the silicon materials plants in Moses Lake, Washington and Butte, Montana in the USA. The wafer production sites are located in Glomfjord and Herøya, both in Norway. Cells production is in Narvik, Norway and solar modules are produced at a manufacturing plant in Glava, Sweden.
A new integrated wafer, cell and module manufacturing complex is soon completed and ready for ramp-up in Singapore. The new plants will more than double REC's current production capacity. The first plant will come online during the first quarter of 2010.
REC had revenues of 8 191 MNOK and an operating profit of 2 529 MNOK in 2008. More than 3 000 employees work in REC's worldwide organization.
The major shift in the global economy also affected REC in 2009, and in the summer REC raised 4,5 BNOK in a fully subscribed rights issue to strengthen its financial flexibility.

NorSun AS is a Norwegian solar energy company that manufactures and markets high performance monocrystalline silicon ingots and wafers. Annual production capacity at the company's modern production facilities in Årdal, Norway and Vantaa, Finland is expected to exceed 200 MWp by the end of 2009. The company 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. In March 2009, Norsun raised 1,15 BNOK in new financing to expand production of silicon ingots and wafers for high efficiency solar cells.

Metallkraft AS. The wafer cutting process requires large amounts of cutting slurry. The slurry consists of abrasive silicon carbide particles and glycol, and is quickly polluted during the cutting process by silicon shavings, metal particles from the saw wires and water. Metallkraft AS has developed a technology that turns the spent slurry into commercially interesting products.
Metallkraft has factories in Kristiansand in Norway and Yangzhou, both in full production. A third plant in Singapore starts serving REC ScanWafer with the Metallkraft recycling services as of April 2010.

Fesil Sunergy AS. Fesil Sunergy AS was established late in 2006 by Delta Sunergy BV, Delta N.V. and Fesil Venture AS. During 2009, the company is has been building a pilot plant for production of solar grade silicon in Trondheim, based on its SOLSILC process. The plant will have a capacity of 100 tons per year. Production start is planned during first quarter 2010. Meanwhile, the company is also planning a full scale production plant near Trondheim. Estimates are that this plant will have an annual capacity of 7 000-10 000 tons of solar grade silicon per year, from 2011/2012.

PORTUGAL

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

Fig. 1 - 10 MW one-axis tracking c-Si Power Plant in Ferreira (photo Tecneira).

GENERAL FRAMEWORK

During 2009, there was no significant change in the general energy policy framework. Promoting Energy Efficiency and Renewable Energies (RE) are the major national priorities, as stated in the government's Strategy for Energy (Cabinet Resolution 169/2005).

After being re-elected in September 2009, the government announced an even more ambitious programme for deployment of RE, in accordance with the recently approved 2009/28/EC Directive. Under this framework, a mandatory target of 31% for the overall share of energy from renewable sources in gross final consumption of energy in 2020 was set for Portugal.

In order to be able to achieve this target, the government set new goals for renewable electricity (RES-E). Table 1 compares these goals with the former ones (2010) and the current installed capacity for some of the most abundant resources. Wind and hydropower will form the bulk of the new capacity, but solar technologies, including PV and Concentrating Solar Power (CSP), will have a significant contribution as well.

TABLE 1 - RES-E TARGETS

RENEWABLE SOURCES	CURRENT CAPACITY 2009 (MW)	FORMER OBJECTIVES 2010 (MW)	NEW OBJECTIVES 2020 (MW)
Wind	3500	5100	8500
Large Hydro	4800	5000	7000
Mini-hydro	600	600	750
Solar (PV + CSP)	100	200	1500

NATIONAL PROGRAMME

A feed-in tariff mechanism is the main instrument for promoting renewable electricity. There are currently three different frameworks under the special regime production: the Independent Power Producer (IPP), in force since 1988, the Producer-Consumer (2002) and the Micro-generation scheme (2007). The main characteristics of these schemes are summarised in Table 2.

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).

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 (LNEG - National Laboratory for Energy and Geology; IN+ - Centre for Innovation, Technology and Policy Research), Energy Agencies (ADENE and regional agencies), utilities (EDP, the largest national energy company) 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), LNEG 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).

TABLE 2 - CURRENT PV FRAMEWORK

LEGAL FRAMEWORK	INDEPENDENT POWER PRODUCER (DECREE-LAW 312/2001 AND 225/2007)	PRODUCER-CONSUMER (DECREE-LAW 68/2002)	MICRO-GENERATION (DECREE-LAW 363/2007)
Maximum capacity per system	No upper limit	150 kW	5,75 kW
Starting Tariff	**Building integrated** · Less than 5 kW - 0,469 /kWh · 5 kW to 150 kW - 0,354 /kWh **Ground based** · Less than 5 kW - 0,447 /kWh · More than 5 kW - 0,317 /kWh	Up to 150 kW - about 0,291 /kWh (2008)	**Premium tariff** - 0,65 /kWh applicable to · Up to 3,68 kW production capacity and · Up to 2,4 MWh sold per year and · At least 2m2 solar water heating system installed **Regular tariff** - Annual BT regulated tariff
Starting tariff revision	Constant value based on formula incorporating technology and operation mode	Starting tariff corresponds to annual energy component of the BTE (low voltage special) regulated tariff plus a premium of 0,20/kWh	· Premium tariff revised down 5 % for each 10 MW added capacity nationwide · Regular tariff revised annually
On-going update	Monthly updated at inflation rate	· Monthly updated at inflation rate · Annually updated with revised BTE regulated tariff	**Special regime (Premium tariff)** · Fixed for first 5 years after installation · Years 6 to 15 corresponds to starting tariff of new units licensed that year **General regime (Regular tariff)** - Annually set at BT regulated tariff
Time frame	Tariff secured for 15 years or 21MWh/kW capacity (becomes active for +1.400 hours annual load factor)	Tariff secured for project life (revised after year 10 after which premium is cut by 0,10 /kWh)	Premium tariff secured for the first 15 years, after which will equal the regulated tariff.
Capacity cap	· Building integrated - 50 MW · Ground based - 150 MW (shared with CSP)	Not defined	10 MW for 2008, growing at 20 % annually. 90 MW expected by 2020
Other restrictions		Producer must consume (or sell to third parties) 50 % of the power generated	· Up to 50 % of contracted consumption capacity can be injected to the grid, except for condominiums · 30 % CAPEX deductible on income tax up to 777

Fig. 2 - Dye Sensitized Solar Cell prototype (photo SolarSel project).

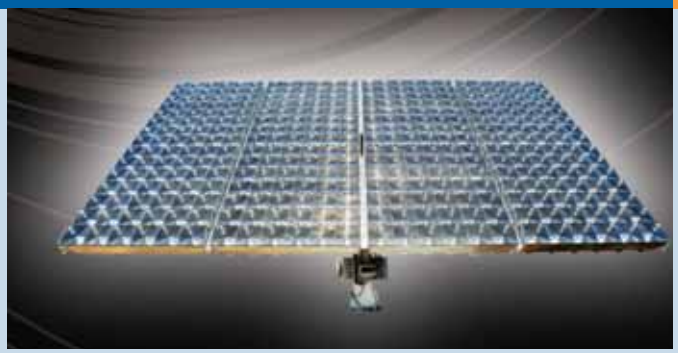

Fig. 3 - MagPower's CPV systems based on III-V triple junction cells and Fresnel concentrating optics.

TABLE 3 - PV MODULE MANUFACTURERS

COMPANY	MAXIMUM CAPACITY (MW)	CURRENT CAPACITY (MW)	PRODUCTION IN 2009 (MW)	TECHNOLOGY
Open Renewables	60	45	n.a.	c-Si
Martifer Solar	100	50	15	c-Si (poly)
SolarPlus	7	6,1	5,5	a-Si (double junction)
Goosun	10	10	4	c-Si (poly)
Fluitecnik	20	20	9	c-Si (poly)

A few R&D projects are underway, involving universities, national laboratories industry and utility consortiums:

- "SolarSell project": development of a Dye Sensitized Solar Cell, using an innovative seal, for potential application in BIPV (Figure 1). Consortium: FEUP (Porto University), EFACEC, CIN and EDP.
- "MagPower project": development and demonstration of an innovative high-concentration PV system (CPV), based on III-V triple junction cells and Fresnel concentrating optics (Figure 2). Consortium: MagPower and EDP.
- Development of a multi-technology CPV demonstration platform. Consortium: EDP, LNEG, CPV manufacturers, universities and research centres.
- "Solar Tiles project": development of a fully-integrated PV ceramic tile based on thin films, directly deposited on the tile. The project is being carried out by an industry-university consortium and is expected to produce the first prototypes in 2011.

IMPLEMENTATION

In 2009, about 23 MW additional capacity was realised under the IPP framework, including 4 large-scale solar projects: three in Ferreira do Alentejo municipality (1,44, 5 and 10,1 MWp - photo 3) and one in MARL, the Lisbon region Supply Market (6 MW).

Under the micro-generation scheme, as of 31st December 2009, about 3 960 units with 3,5 kW average unit capacity were installed and operating, with the following share:

- PV: 3 792 units (95,8 %)
- Wind: 145 units (3,7 %)
- Hybrid PV+Wind: 19 units (0,5 %)
- Micro-hydro: 2 units (0,05 %)

The total power capacity installed under this scheme is near 14 MW, 96 % of which are PV (13,355 MW). About 11 MW were concluded in 2009.

INDUSTRY STATUS

There are currently five PV module manufacturers in Portugal (c-Si and a-Si) as shown in Table 3.

Two companies are developing and manufacturing concentration systems:

- WS Energy: systems based on the Double-Sun® technology (1,93x, aluminium flat-plate reflectors), to be mounted on solar trackers SungravityControl® with web-based diagnosis. The maximum annual production capacity is about 2400 systems, corresponding to approximately 6 MWp. 400 units (0,7 MWp) were produced in 2009. The company launched recently the HSUN® Project for the development of 22x CPV, which should be available by the end of 2010.
- MagPower: CPV systems based on III-V triple junction cells and Fresnel concentrating optics. The company has recently installed its new factory facilities in Cacém, (near Lisboa), designed for a production capacity of 54 MWp/year, using a fully robotized line of production for manufacturing the CPV and assembly of panels and trackers. Magpower is also preparing a new industrial facility in California - USA, for a production capacity of 100 MW/Year, mainly oriented to the US market.

MARKET DEVELOPMENT

Despite the world financial crisis, in 2009 the Portuguese PV market continued to grow (34 %) to attain a total cumulative PV power capacity slightly above 100 MW (see table 3 and graph). The new additional capacity came mainly from on-grid IPP generators (23 MW) and micro-generators (11 MW). Grid-connected systems have a 97 % share of the total installed capacity.

FUTURE OUTLOOK

The government set very ambitious targets for renewables in 2020, namely 1500 MW for solar (PV + CSP), which represents fifteen times the current installed capacity. This requires a much more stable and

Fig. 4 – a-Si module factory (photo SolarPlus).

Fig. 5 - c-Si module factory (photo Goosun).

coherent framework regarding the different schemes available for PV market deployment.

As far as the IPP scheme is concerned, which has been practically frozen since 2005, removal of the licensing barriers already identified by the main actors (promoters, installers, system integrators, financial institutions) is crucial to allow a stable market and to increase investor's confidence. Those barriers are mainly the capacity cap as well as a too complex and time-consuming administrative process.

The micro-generation scheme, as it stands currently, will not be able to provide more than 90 MW by 2020, unless some of its rules are revised, namely restrictions regarding maximum annual capacity and monthly applications (request for system implementation). Since the beginning of the scheme in April 2008, which runs in a fully web-based tool, more than 13 thousand requests were registered but only 60 % of them paid the registration fee and went on with the licensing process. Many promoters are complaining about the transparency and effectiveness of the procedure and have requested its revision.

There are already positive signs that the government will start revising the overall PV framework in 2010.

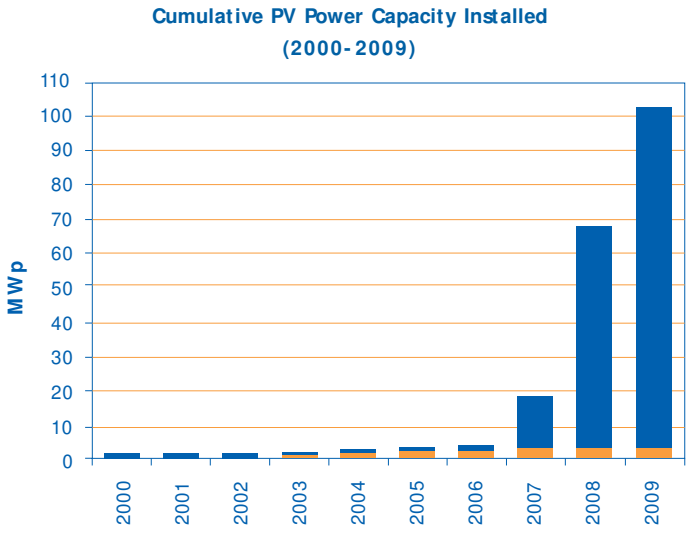

Fig. 6 - Cumulative PV Power Capacity Installed in Portugal (2000-2009).

TABLE 4- ANNUAL AND CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (2000-2009)

YEAR	OFF-GRID (MWp)	ON-GRID (MWp)	TOTAL ANNUAL POWER (MWp)	CUMULATIVE POWER(MWp)
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
2009*	0,10	34,15	34,25	**102,2**

**Data for off-grid installation are estimated*

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
FERNANDO SANCHEZ SUDON, CENTRO NACIONAL DE ENERGIAS RENOVABLES, CENER

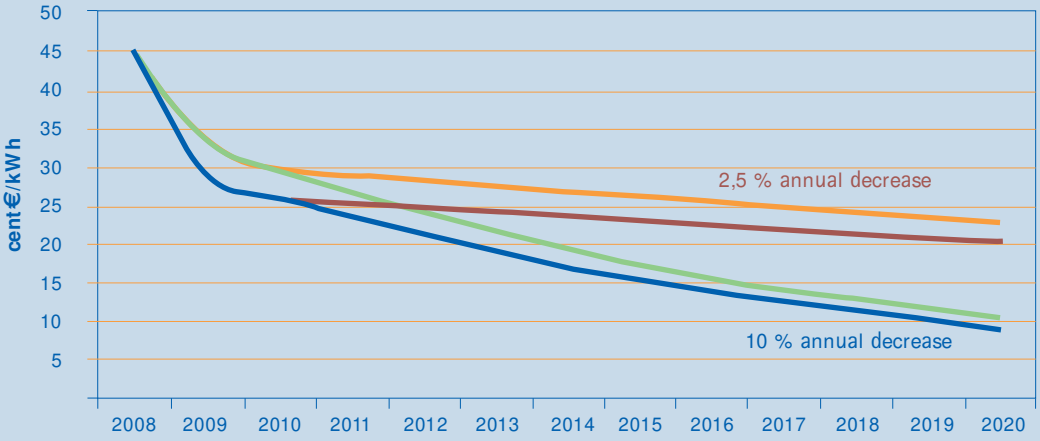

Fig. 1 - Evolution of the rate for photovoltaic installations according to the Royal Decree application.

GENERAL FRAMEWORK

2009 has seen the application of the new regulatory framework that was established in the Royal Decree 1578/2008, with the purpose to rationalize the deployment of PV in Spain, and in order to control the impact of the feed in tariff in the national economic situation.

The new regulatory framework implies a 30 % reduction of the feed-in tariff and further progressive cuts, which could reach 10 % annually. A quota of 500 MW in 2009 and similar for the next three years has been established, together with the creation of a register for allocating new capacity. This register establishes four calls annually with separate segments; one related to ground-based solar plants, the other to building integrated installations. In case that the call is covered, a reduction of the tariff is foreseen. The first call in 2009 established a price of 0,29 cEUR/kWh for ground mounted installations and 0,33 cEUR/ kWh for building integrated installations.

As a result of the new situation, in 2009, 2 488 installations were authorised, with a total capacity of 502 MW. This is in contrast to the capacity installed in the previous year; 2 755 MW, according to the National Energy Commission's data.

These new regulatory conditions, combined with the global financial crisis, have dramatically altered the sector's industrial fabric, with 20,000 jobs lost since the reforms; according to ASIF, the national PV industry association.

NATIONAL PROGRAMME

This regulatory framework for the deployment of the PV market now in place in Spain, is described in the Royal Decree 1578/2008 that defines a quota of 500 MW for the years 2009, 2010 and 2011. The tariffs will be decreasing in case that the call made every three months is completed. There is a tendency to increase the installations of PV in buildings and decrease the installations on ground. The evolution of the tariffs expected, depending on the percentage of reductions up to 2020, is shown in Figure 1.

Fig. 2 - 20 MW Solar Farm, Jumilla (photo ASIF).

Fig. 3 - PV facade on a kindergarten in Barcelona (photo ASIF).

Nevertheless, in this moment there is a discussion on how the target for 2020 is going to be defined, and also, what will be the regulatory framework and the tariff system for that period after 2011.

R & D, D

No changes in the main lines for R&D have occurred since 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
- ISFOC, devoted to testing of concentration PV systems
- Other Universities and private centres and companies.

IMPLEMENTATION

The vast bulk of Spain's installed PV capacity is in multi-megawatt ground-based arrays, often rated in tens of megawatts. 37 % of the facilities in the ground have tracking systems, of which 24 % are two axis tracking and 13 % single axis tracking. The new regulatory framework has established a better price for roof and facades installations, and it is expected that these types of PV installations will take a bigger share of the market in the future. In 2009, almost 50 % of the new, authorised installations will be integrated in the built environment, with a further increase in the share in the coming years.

INDUSTRY STATUS

The drastic change in market deployment in 2009, compared to 2008, has produced a relevant impact on the PV industry, with an important job reduction due to the new targets established, as well as the impasse created with the new situation, which produced a market paralysis for almost six months. Nevertheless, once the new framework is stabilised with a market of 500 MW, the situation is expected to recover slowly.

There are over 40 manufacturers of cells, modules and inverters in Spain. It is also worth mentioning that there is an operation initiation at commercial scale of several thin film PV manufacturers.

MARKET DEVELOPMENT

The quota of 500 MW during the years 2009, 2010 and 2011 defines the expected evolution of the market in Spain for the next three years. The evolution of the market after 2011, up to 2020, has to be defined in the coming months.

Fig. 4 - 7 MW PV farm integrated within an olive tree grove; Alcaudete - Jaén, Andalucia (photo ASIF).

Fig. 5 - PV integration in facade in San Fernado, Cádiz (photo ASIF).

It is worth noting that the new regulatory framework is intended to increase the installations of PV in buildings, in detriment to the installations in ground.

FUTURE OUTLOOK

Despite the drastic reduction suffered in the market in 2009, compared to the previous year, the new stable framework and the discussions that are taking place, to the definition of the new national Renewable Energy Plan that is defined to comply with the compromise of reaching 20 % of primary energy from renewables, Spain still envisions a good frame for the deployment of PV.

The continuous cost reduction in the PV sector opens the opportunity to reach grid parity in a few years, and this will imply a new situation, that for sure will increase drastically the penetration of PV in the portfolio of energy solutions.

SWEDEN

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

Fig. 1 - Roof top PV system on new office building in Hammarby Sjöstad, Stockholm (photo: Fasadglas AB).

GENERAL FRAMEWORK

Carbon emissions from the Swedish electricity production (approximately 150 TWh per year) are low in comparison to other developed countries. About 50 % of the electricity is generated by nuclear power whereas hydropower accounts for 40-45 %, depending on precipitation. Wind power is one of the most rapidly growing power production technologies at the moment, and there are ambitious targets for a further expansion of the technology in the coming years. 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 are suited for promotion and 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 current guideline to accomplish this is to create favourable conditions for efficient use of energy and cost-efficient power and heat production with minimum negative impact on health, environment and climate.

The PV market is still small in Sweden compared to many other countries. However, there is a long tradition of using off grid applications. Additionally, Sweden hosts world renowned researchers coupled to increasing industrial activities with a lot of potential. 2009 has been a difficult year with a lot of turmoil for the PV business in Sweden, as in the rest of the world. However, general public and media as well as politicians and investors are showing an increasing interest in the field. With a new subsidy programme, new exciting research projects and industrial initiatives, the stage is set for a bright and exciting PV future in Sweden.

NATIONAL PROGRAMME

The **Swedish Energy Agency** (www.swedishenergyagency.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 sustainable energy system and to secure energy supply. Main emphasis is on energy efficiency and on the development and promotion of renewable energy such as biomass, hydropower, wind power and PV.

There are no national goals or official visions for solar energy in Sweden. However, the strategy of the Swedish Energy Agency is that PV should become an established technology in the energy system, a natural part of the urban environment. Furthermore, there should be a successful Swedish PV industry with a strong connection to the Swedish state of the art research.

PV is part of the national long-term energy research programme, which is managed by the Swedish Energy Agency. The budget for the programme was increased for 2009 to about 100 MEUR. The agency provides funding for PV research, co-financed technological

Fig. 2 - 100 kWp of PV modules integrated in the roof of two buildings in Malmö.

development, demonstration and business development. The budget for PV R&D is in the range of 2-2,5 MEUR per year, depending on which projects that 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.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The thin film CIGS research at Uppsala University started in the 1990s (www.asc.angstrom.uu.se). 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. Recently, there are a couple of new industrial actors working with CIGS that are starting up and that are interested in the results of this research.

There are several research projects in Sweden working with 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.

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 a very low cost per Watt.

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 another is hybrid systems combining PV and solar thermal technologies.

The Solar Energy Research Center at Högskolan Dalarna (www.du.se/serc) also deserves to be mentioned. They have worked with solar energy including PV for many years and they have a master's programme in solar engineering.

The **SolEl programme** is a national R&D programme with a focus on PV systems and their applications. The programme is financed by the Swedish Energy Agency, Swedish utilities, manufacturing companies (PV and other) as well as building companies and property owners. The current phase continues 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 dissemination of information.

As a part of the efforts in disseminating information, 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 to different actors. 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.solelprogrammet.se).

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 for companies to profile themselves as environmental friendly. 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. During 2009 there was an increased interest in PV and other micro generation technologies from the utilities, since they have experienced an increased attention on this issue from their customers customers, as a result of the new support programme.

Fig. 3 - CIGS PV research at Ångström solar Center in Uppsala (photo: Adam Hultqvist)

Fig 4 - Solar powered art installation in the Rosendal Garden, Stockholm, Sweden. Designed by the artists Karin Lindh and Mats Karlsson.

IMPLEMENTATION AND MARKET DEVELOPMENT

The market for PV in Sweden has traditionally been dominated by domestic stand-alone PV systems and there is a stable market for these systems in Sweden. However, the market for grid-connected PV systems relies completely on supporting incentives.

Since 2005 there has been increasing activity on the Swedish PV market. This is due to an investment subsidy for PV systems on public building that was introduced in 2005 and ended 2008. This subsidy has had an important impact on the Swedish PV market. In 2004, only 300 kW was installed with the major part off grid. In 2008, 1,7 MW was installed with mostly grid connected systems, reaching a cumulative installed PV capacity of almost 8 MW. The increased market size meant that several new actors were established. For 2009, it was announced that a new subsidy was going to be introduced, but this was not in place until 1st July 2009. Consequently there was no activity on the market for grid connected PV systems during the first half of 2009 since all of the stakeholders were waiting for the new subsidy. The situation was further impaired by the financial crisis and many companies experienced difficulties.

The new subsidy programme is similar to the previous but it is now open for everyone to apply and it has been lowered from 70 % to a maximum of 60 % of the investment cost. The budget is about 5 MEUR per year for 2009-2011. The interest for the subsidy has been considerable and since a lot of the stakeholders had been waiting for the call they had already prepared PV system proposals in advance, which resulted in a rush of applications as the subsidy was enforced. The first 5 MEUR was applied for within the first few days. Due to the high interest it was decided by the government to make another 5 MEUR available for 2009. By the end of 2009 the total amount of subsidy funds requested by the applications was comparable to the total budget for the whole subsidy period, i.e. about 20 MEUR.
The high interest for the PV subsidy created a lot of attention to PV in Sweden, especially among private households, since they also are included by in the subsidy as well. This can also be seen in the data applications for 2009 where about half of the granted applications are assigned to private households. In summary, the PV market for 2009 decreased dramatically from 2008, but it will take off again in 2010 to reach a new all time high. The key issue for the Swedish PV market is a stable and long term framework that can create transparent and secure conditions for all actors at the same time as being effective. One issue that remains is how PV owners should be compensated for the electricity that they feed into the grid. The regulatory framework of today does not favour small power systems since the fixed cost that is required in order to sell electricity to the grid is high compared to the small amount of money that the system receives for its production. This is a critical issue for the private household PV market and a solution is urgent since the interest and number of systems quickly increases for this group. The government is aware of these problems. In 2007, a commissioner was appointed to investigate possible solutions on how to improve the conditions for the connection of renewable electricity generation to the grid. The recommendations was delivered in early 2008 and 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. When the proposal for the new change in the law finally became public during the fall 2009, it did not contain the most important part about net-billing. However, there is a broad support for net-billing for the smallest systems, also from utilities and grid operators and this issue will be further investigated during 2010.

INDUSTRY STATUS

The Swedish PV industry has grown significantly over the last couple of years. Today, there are five companies in Sweden that produce and mainly export PV modules. They all work with crystalline silicon.
As for the many of the module manufacturers in the world, 2009 became a harsh year due to the dramatic changes on the global PV market with production capacity exceeding demand and rapidly falling prices.

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). A growing number of small to medium-sized enterprises exist, which design, market and sell PV products and systems. Many of the latter depend almost exclusively on the Swedish market and they also experienced difficulties during 2009 due to the late introduction of the new subsidy programme.

Despite the troubles for many companies there are also several positive highlights. One example is the increased activity in the CIGS field around Uppsala and Stockholm. The research by the thin-film solar cell group in Ångström Solar Center have earlier resulted in the spin off company Solibro, that today is owned by Q-cells and is producing CIGS modules in Thalheim, Germany. Solibro's R&D company, **Solibro Research AB**, is however still located in Uppsala where approximately 30 people work. 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. Apart from these companies there are also other industrial actors that are starting up activities in the CIGS field and that are interested in the research at Ångström Solar Center.

Low-concentrating combined photovoltaic/thermal systems are a Swedish niche, in which research and development has been conducted for more than ten years. **Absolicon AB** is the company that have come furthest in commercialisation, and have for example sold systems in Spain. **Global Sun Engineering** and **Solarus** are examples of two other companies in this niche.

FUTURE OUTLOOK

After a rough year in 2009 for the Swedish PV market and industry, things are now expected to change for the better during 2010 as a large share of the projects that receive funding from the new subsidy will be initiated. This will provide some comfort to the companies that are dependent on the domestic market and it will also enable new actors to enter. It is especially interesting to see that many actors are developing products and system packages for the household market. With an increased interest from the household market it will also be highly interesting to follow the discussion about grid-connection of PV systems and compensation for excess electricity. This is a decisive issue if PV is going to be a future alternative for the Swedish households.

The current subsidy for PV runs until the end of 2011. This means that there is still uncertainty regarding long term support for a Swedish PV market. There is a need to develop a long term strategy for supporting PV in Sweden. There is potential for PV to both build a successful industry and in the long run become an important energy technology in Sweden.

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
BY STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.
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Fig. 1 - Photovoltaic Facade in Zurich. The corporate building of Migros cooperative in Zurich comprises a successful building integration of a 38 kW facade system (photo + project: energiebüro®ag / Zurich / Switzerland - for solar power plants).

GENERAL FRAMEWORK

The Swiss energy research strategy is defined by a energy RTD master plan updated every four years, with 2009 as the second 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 whereas support for new pilot and demonstration systems continued to be very limited. Industry development continued to be strong in spite of the global economic downturn which also affected the photovoltaic sector.

Turning to energy policy, 2009 saw the first disbursements within the new feed-in tariff scheme for new renewable energy technologies including photovoltaics. A large number of projects had been announced previously and photovoltaics constituted by far the largest amount of projects (~ 80 %). Due to the cap for the amount of support attributed to photovoltaic projects (see below), many of these had to be put on a waiting list.

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 MCHF. This amount is divided into maximum contributions for different renewable energy technologies (hydropower up to 10 megawatts, biomass, photovoltaics, wind and geothermal energy) depending on specific generation costs. 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. During 2009, discussions on how to increase the total envelope and eventually remove the cap have been ongoing in the Swiss parliament. As a short term measure in the context of the economic recovery measures, a national subsidy programme for photovoltaic systems of 20 MCHF was launched in order to stimulate investment activities and to favour deployment of small scale systems which were on the feed-in tariff waiting list. Photovoltaic market promotion programmes of regional governments supported this effort towards increased deployment.

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated

Fig. 2 - Mechanical testing for PV module certification. The University of Applied Sciences in Lugano has built a new laboratory for module testing according to IEC standards (photo ISAAC, SUPSI, Switzerland).

Fig. 3 - Mobile test equipment. With the support of the utility of the Canton of Zurich, the Uni-versity of Applied Sciences in Winterthur has built a mobile test unit which allows PV module testing at the site of a PV plant (photo EKZ, Zurich).

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 2009. On the technical level, thin film solar cells and building integration are the foremost topics of priority (Fig. 1). 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. 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 2009, the interdepartmental platform for the promotion of renewable energy and energy efficiency in international co-operation – REPIC – started the second year of its present 3-year term (www.repic.ch). This platform supported different photovoltaic projects of Swiss entities in developing countries.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In the second year of the present RTD master plan, overall 55 projects, supported by various national and regional government agencies, the research community and the private sector, were conducted in the different areas of the photovoltaic energy system. Innovative solutions, market orientation, cost reduction, industrial viability and transfer as well as increased efficiency and reliability are the main objectives of the technical R&D.

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (amorphous and microcrystalline silicon, compound semiconductors, dye-sensitised and organic solar cells). During 2009, emphasis on transfer from R&D to industrial processes, manufacturing and products continued. Work on thin film silicon at the Swiss Federal Institute of Technology (EPFL) in 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. Work increased in the area of heterojunction silicon solar cells. In the area of thin film silicon, strong co-operation with the companies VHF-Technologies and oc oerlikon continued. During 2009, a new R&D laboratory in cooperation with Roth&Rau was inaugurated.

With regard to CIGS solar cells, the Swiss Federal Laboratories for Materials Testing and Research EMPA focused the work on high efficiency flexible CIGS cells on plastic and metal foils. During 2009, 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 at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. Exploratory work was undertaken on new solar cell concepts (organic and extremely thin absorber (ETA) cells) at 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 nanotechnology, 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 (Fig. 2 and 3) and recently includes the 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

Fig. 4 - 8,2 kW Private PV system in Müstair. The number of smaller PV systems has increased during 2009 (project development and photo: solarstatt Raimund Hächler).

boat PlanetSolar (www.planetsolar.org), both of which plan to travel around the world by air respectively on water in the coming years, have strongly progressed in their construction phase.

International co-operation continues to form a strong pillar of the R&D activities with 10 projects running in the 6th and 7th framework RTD programmes of the European Union during 2009. During 2009, a second joint call was launched together with other European PV RTD programmes in the field of grid integration of photovoltaics. The co-operation within the IEA PVPS programme has remained a further strategic activity.

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

In 2009, implementation of photovoltaic systems occurred either through the feed-in tariff model (see above), as part of a national or regional subsidy programme or in the framework of voluntary green power marketing schemes promoted by a number of electricity utilities. The Swiss legislation explicitly foresees the possibility of switching between the feed-in tariff and the voluntary green power marketing approach. The capped nature of the feed-in tariff scheme has thus resulted in a variety and regionally different situation of applied support schemes all of which have considerable shares of the limited market volume.

INDUSTRY STATUS

Since a few years, Swiss industrial PV products cover 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 330 MW/year and presently ranks 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 wiresawing machines from Applied Materials Switzerland 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.

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, Pramac). Furthermore, Swiss Solar Systems (3S) is building some of the world's largest PV module laminators whereas Komax is active in various steps of the module manufacturing chain. 3S and Meyer Burger announced their merger in 2009.

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 continues to be high and is estimated to more than 1 500 MCHF in 2009.

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 of utilities, has experienced a strong development in the framework of the new feed-in tariff support scheme. The annual market volume for grid-connected systems is

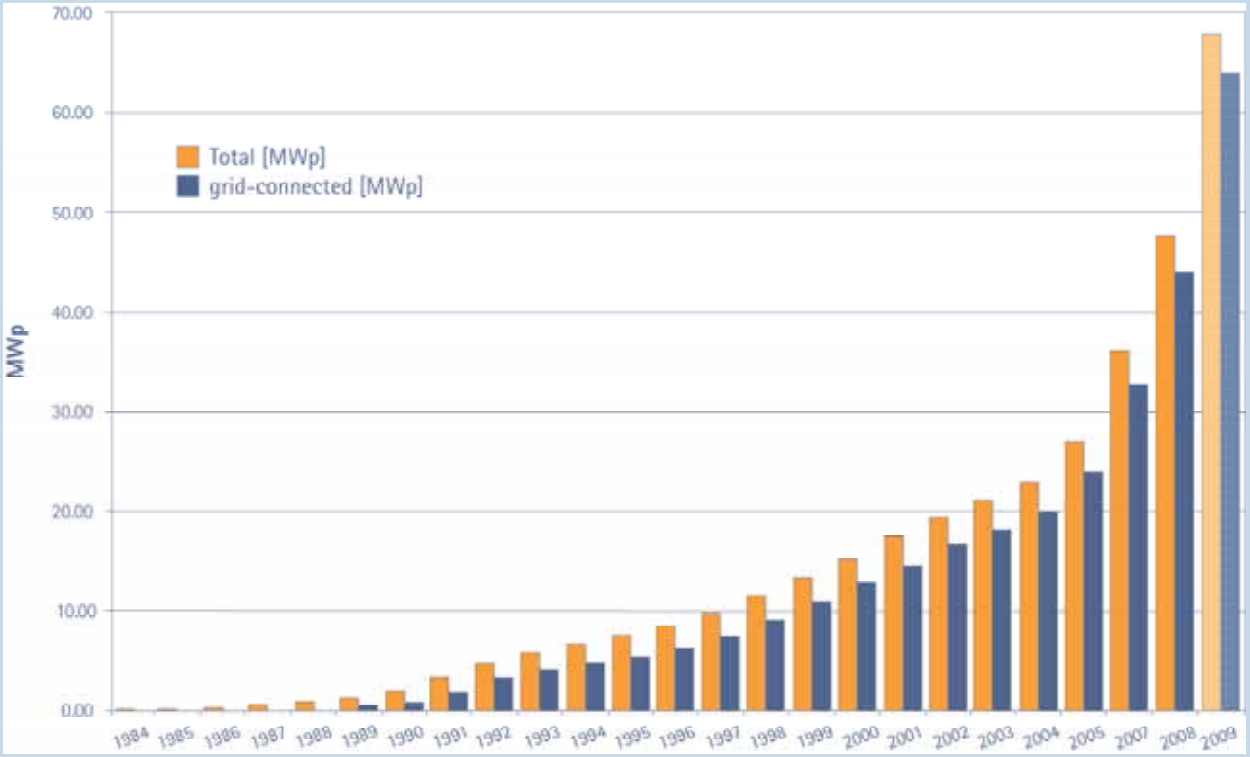

Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between1984 and 2009 (total and grid-connected, estimated values for 2009)

estimated to a value around 20 MWp, substantially higher than the previous year (12 MWp). The total installed capacity has thus risen to more than 65 MWp (Figure 4 and 5), corresponding to more than 9 Wp/capita. The PV energy statistics have been established by tracking the energy produced by grid-connected PV systems and their statistical distribution since 1992 (Table 1). The total energy production of grid-connected photovoltaic systems up to 2008 is thus approaching 34 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue with a focus on innovative research activities, 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.

Based on the experience with the feed-in tariff scheme and as a result of the ongoing policy discussion, 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.

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 – 2008 (GRID-CONNECTED SYSTTEMS)

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
2008	1 200	3 875	44,1	33 400	865

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - Defining the PV Technology Road Map in Turkey (organized by the Turkish PV Technology Platform in 2-3 October 2009).

Fig. 2 - Silicon based wafer production research by the Middle East Technical University and Nurol Corporation.

GENERAL FRAMEWORK

Turkey, with a population of 72 561 312 in 2010 and a surface area of 783 562 km^2, lies in a sunny belt between 36°- 42° north latitudes and is geographically well situated with respect to solar energy potential. However, compared to other energy sources, PV systems don't have sufficient contributions to energy generation in Turkey.

The annual energy consumption and the installed capacity was declared as 193,3 TWh and 44 781,8 MW in 2009 respectively (Non official. Presented by the Turkish Electricity Transmission Co. on February 2010). The share of the total hydro and renewable energy sources which also includes large-scale hydro-electricity generators was 34,4 % of the total capacity and the rest was thermal energy sources. The total installed photovoltaic power system in Turkey is estimated about 5 MW (2010).

At the beginning of 2009, public interest in climate change and photovoltaic technology was quite high. The Turkish Parliamentary General Assembly approved a draft law foreseeing Turkey's adoption of a participation in the Kyoto Protocol on 05 February 2009. After the Republic of Turkey Ministry of Energy and Natural Resources announced the plans of the government for promoting PV power systems, a draft law which defines the feed-in-tariffs for the renewable energy sources by amending the Law on the Utilization of Renewable Energy Resources in the Generation of Electricity ("Renewable Energy Law") was accepted by the Industry, Commerce, Energy, Natural Resources, Information and Technology Commission of the Turkish Parliament on 5 June 2009 and submitted to the Turkish Parliamentary General Assembly. However, the law is still in the discussion phase and needs to be pursued by the governmental side. Following the revision of renewable energy law to support solar electricity, the PV market is expected to grow significantly in near future.

In 2009, the grid electricity cost has continued to increase. The average electricity price per kWh has reached to 0,13 EUR/kWh for households and 0,08-0,12 EUR/kWh for industry at the beginning of 2010 (ref. Turkey Electricity Distribution Co. [TEDAS]). The grid parity for PV power systems in Turkey is expected to be carried in the next five years.

NATIONAL PROGRAMME

Turkey's dependence on natural gas and, accordingly, on foreign energy sources is still the main difficulty of the energy policy. The official development plans aims to ensure sufficient, reliable supply of electricity at low cost, diversify energy sources, and secure energy supplies in order to maintain economic and social development of Turkey.

Turkey has an official goal of 30 percent renewable energy use by 2023. The share of wind and geothermal energy is aimed as 20 GW (20 % of the total capacity) and 600 MW respectively in 2023. However, there is no specific official goal for the solar electricity generation. It is only defined that the huge solar energy potential is planned to be used in the next years (Ref. The Strategic Document of Electricity Energy Market and Security of Supply). Turkish PV Technology Platform (UFTP), among whose members are public bodies, universities, local authorities, trade and professional chambers and industrial companies, defined a vision road map for PV Sector in Turkey. UFTP has collected the related public bodies and industrial companies on several meetings (Figure 1) and defined the moderate PV installed capacity with a moderate scenario and a policy driven scenario as 6 GW and 10 GW respectively (http://www.trpvplatform.org/).

Fig. 3 – 15,6 kWp dual-axis solar tracker PV power system in Mugla, by Mugla University.

Fig. 4 - PV power system application by Airfel Corp. in Istanbul.

The Energy Market Regulatory Authority (EPDK) is the responsible authority for evaluating the license applications on over 500 kW plants for renewable energy sources. Although the utilization of the utility grid as an energy reserve up to 500 kW power for renewable energy sources does not require any permission, the new legislation requires the approved project by an authorized institution and the new regulations are planned to be valid in 2010 to require some extra rules during the grid connection. The purchasing price of renewable energy sources is the average of the Turkish wholesale price announced in the previous year. In practice, all renewable energy producers are currently selling their electrical energy to the Market Financial Reconciliation Centre, which currently offers the highest price in Turkey due to a recent supply gap. For all renewables, a purchasing guarantee of at least 5 EUR Cent/kWh is currently given for 10 years. (A proposal for significantly higher purchasing price for PV is under consideration in the Turkish Parliament).

R&D

Photovoltaic research and development activities are still mainly undertaken across a range of universities, 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).

The Solar Energy Institute of Ege University (http://eusolar.ege.edu.tr/) continues researching the development of organic dye-sensitized solar cells and the characterization of PV systems on grid connected and off-grid applications. The Middle East Technical University has maintained the silicon based wafer production researches with Nurol Corporation (Figure 2). Mugla University has installed a 15,6 kWp dual-axis solar tracker in 2009 and the total PV power capacity of the university campus has reached 110 kWp (Figure 3). The Institute of Materials Science and Nanotechnology (UNAM) of Bilkent University, Gazi University, Istanbul Technical University, Hacettepe University, Kocaeli University, Pamukkale University, TUBITAK-UME and TUBITAK-Marmara Research Center Energy Institute are other important research institutes which have increased their PV researches and development activities in 2009. The university members in the Turkish PV Technology Platform (UFTP) increased continually in 2009. One of UFTP's main goals is to enable the cooperation between the universities on PV technology related research.

Fig. 5 - PV power system application by Girasolar Ltd. in Manisa.

IMPLEMENTATION

About 1 MW of PV is estimated to have been installed in 2009, with the annual market increasingly slightly from the stable level of the previous four years. Off-grid applications account for around 90 % of cumulative installed PV capacity of about 5 MW. The PV systems especially are used as the autonomous systems in the mobile base stations, the solar lighting systems and the remote areas where there isn't any connection to the utility grid. There are also some sample grid-connected photovoltaic power systems at the some research institutes/universities. Some attractive PV applications which were installed in 2009 are shown in Figures 4 to 7.

Fig. 6 - PV power system application by Anel Corp. in Istanbul.

Fig. 7 - PV power system application by GEO Ltd. in Izmir.

INDUSTRY STATUS

The photovoltaic sector in Turkey is still fairly small, providing work for only a small number of employees. The main business types are importer, wholesale supplier, system integrator and retail sales. The companies serve in the installation, engineering and project development parts. There are a few domestic battery manufacturers whose products can be used for off-grid PV applications. Currently there is no notable production of feedstocks, ingots and wafers in Turkey. There are three PV module manufacturers in Turkey: Aneles Co. (http://www.aneles.com.tr), DATATSP Co. (http://www.datatsp.com) and Terasolar Co. (www.tera-solar.com). The module prices in these local manufacturers were 2-2,5 EUR/Wp in 2009.

MARKET DEVELOPMENT

Two important activities which were aimed at developing the PV market in Turkey were the 2nd and 3rd Solar & PV Technologies Exhibitions, organized on 26 February-1 March 2009 and 11-14 March 2010 respectively (http://www.solarfuari.com/). Turkish and foreign PV companies came together at the fair. UFTP organized a symposium at the exhibition during the 3rd Solar & PV Technologies Exhibition (Figure 8). The aim of the exhibition and conference was also to stimulate increased collaboration within and outside Turkey.

The other important development is that the Solar Energy Industry and Tradespersons Association (GENSED), Turkey's largest industry association, devoted to the solar photovoltaic (PV) electricity market was founded in 2009 (http://www.gensed.org/). GENSED aims to form a healthy PV sector development with the strong UFTP support.

FUTURE OUTLOOK

Turkey's energy policy objectives aim to reduce Turkey's dependence on fossil fuels by undertaking renewable options. Since the wind sector is quickly growing in Turkey, the learning curve of the generation of electricity by renewable resources rises day by day. The target of 30 % from renewable energy sources and 20 GW from wind power by 2023 is a good guideline for development and deployment of PV in Turkey. If the Turkish Grand National Assembly approves the amendments which enable the feed-in-tariffs for PV power systems on the draft law, a highly competitive market is expected to be emerged for the entire PVPS value chain in Turkey.

Fig. 8 – The 3rd Solar & PV Technologies Exhibition, organized in Istanbul on 11-14 March 2010 (http://www.solarfuari.com/).

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UNITED KINGDOM

PV TECHNOLOGY AND PROSPECTS
PAUL COWLEY, SENIOR CONSULTANT, IT POWER

Fig. 1 - Finalising a 18,4 kWp at St. Francis of Assisi Church in Rochester (photo: Solstice Energy Ltd).

GENERAL FRAMEWORK

The UK government is taking a prominent international stance on climate change issues, and under the Climate Change Act 2008 the UK set itself a demanding legally binding objective to reduce greenhouse gas (GHG) emissions by 80 % by 2050. An interim target seeks total GHG emissions reductions of 34 % by 2020, including a 26 % reduction in CO_2 compared to the 1990 baseline. One feature of the Act is a carbon budgeting system which caps emissions over five year periods, commencing with the period 2008-2012. Three budgets are set at a time, to establish a trajectory to 2050. In May 2009, the levels of the first three carbon budgets were approved by Parliament and are now set in law as follows under Statutory Instrument 2009 No. 1259, The Carbon Budgets Order :

TABLE 1: UK CARBON BUDGETS FOR 2008 TO 2022

	BUDGET 1 (2008-12)	BUDGET 2 (2013-17)	BUDGET 3 (2018-22)
Carbon Budgets ($MtCO_2e$)	3 018	2 782	2 544
Reduction below 1990 Levels (%)	22	28	34

Alongside the Climate Change Act, the Energy Act 2008 establishes the legislative framework for the UK to meet its future energy challenges. The key policy goals are:

- to establish a path to cutting CO_2 emissions by some 60 % by 2050;
- to maintain the reliability of energy supplies;
- to promote competitive markets in the UK and beyond;
- to ensure that every home is adequately and affordably heated.

Key provisions of the Act in respect of renewable energy include:

- Strengthening the Renewables Obligation 'to drive greater and more rapid deployment of renewables in the UK. This will increase the diversity of the UK's electricity mix, thereby improving the reliability of our energy supplies and help lower the carbon emissions from the electricity sector';
- Paving the way for the introduction of Feed-in Tariffs 'to enable the Government to introduce a tailor-made scheme to financially support low carbon generation of electricity in projects up to 5 MW. The aim is that generators will receive a guaranteed payment for generating low carbon electricity'.

The UK's medium-term renewable energy policies are also framed by the policies of the European Union; the Directive on Renewable Energy targets 20 % of total energy (including electricity, heat and transport) from renewable energy sources (RES) by 2020, with an objective for a 22 % contribution from RES to electricity supply. The obligation on the UK is to meet 15 % of total energy and 20 % of electricity from renewables in the same timeframe.

Fig 2 - 4 kWp on a garage slate roof in West Cornwall (photo: Plug into the Sun).

Fig. 3 - 70 kWp Ground Mounted PV system near Cheltenham (photo: Apollo Renewables).

The UK's blueprint for measures to satisfy and even exceed these obligations is established under the Renewable Energy Strategy, published in 2009 following a period of public consultation. Alongside positive climate and supply security outcomes, the strategy also acknowledges the economic opportunity for the UK, including the potential to create up to half a million more jobs in the UK renewable energy sector resulting from around 100 billion GBP of new investment. The lead scenario suggests more than 30 % of electricity (coupled to 12 % of heat and 10 % of transport energy) could be met from renewables. Underpinning this are new financial mechanisms - the Feed-in Tariff and a new renewable heat incentive (RHI) - alongside an enhanced Renewables Obligation (RO), new investment for emerging technologies and the intent to assist individuals, communities and businesses to invest in small-scale generation technologies.
The Government's proposed design for the Feed-in Tariff or 'Clean Energy Cashback' scheme was released for public consultation during Q3 2009. The proposal outlined differentiated incentives for gross generation dependent on technology and scale of generator. An additional bonus for electricity exported to the network was also proposed. The finalised design incorporating amendments such as index-linking and generally increased tariff levels was put before parliament in February 2010. The mechanism applies to all microgeneration technologies (up to 50 kW). Generators greater than 50 kW up to 5 MW can opt to access either the FIT or register under the RO. Tariffs for PV are fixed (linked to inflation) for 25 years. The rates for 2010/11 are presented in Table 2.

TABLE 2: TARIFF LEVELS FOR PV FINANCIAL INCENTIVES UNDER UK FIT

SCALE	TARIFF LEVEL FOR NEW INSTALLATIONS IN PERIOD (GBP/KWH)
4 kW (new build)	0,361
4 kW (retrofit)	0,413
>4 - 10 kW	0,361
>10 - 100 kW	0,314
>100 kW - 5 MW	0,293
Standalone system	0,293

Many local planning policies require new developments or significant refurbishments to include on-site renewables such as solar PV. This may be determined based on a targeted Carbon Dioxide abatement or a specific requirement for a certain proportion of the onsite energy to be achieved through renewable energy generation. Typically the policies specify a requirement between 10-30 %.

As reported in last year's Annual Report, the Code for Sustainable Homes 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.

Other measures that have some bearing on the implementation of renewable energy technologies include:

- CERT 2008-2011, which obliges energy suppliers to achieve reductions in carbon emissions in the household sector through the promotion of energy efficiency improvements and renewable energy generation.
- Permitted development rights for microgeneration installations which have little or no impact beyond the host property. This removes the need for specific planning consent, reducing the cost and speeding up the process of a PV system installation in a residential setting.

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. National and many local grant programmes as well as the forthcoming Feed-in Tariff will only be accessible to applicants using installers registered with the scheme.

Fig. 4 - 1 kWp PV facade on an Office block in Central London (photo: Bright Green Energy Ltd).

Fig. 5 - 9,7 kWp PV installation - Hamworthy Library, Poole (photo: Sustainable Energy Installations Ltd).

IMPLEMENTATION

The major ongoing 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. The Scheme will run until 2037.

Renewable Obligation Certificates (ROCs) are issued to registered generators of eligible renewable electricity. Suppliers can meet their obligation by either presenting ROCs, paying a buyout price (37,19GBP per ROC for 2009-10 obligation period) or a combination of the two. At the end of an obligation period the buyout funds received are distributed on a pro rata basis amongst the suppliers who presented ROCs.

Up until 31 March 2009, 1 ROC represented 1 MWh of eligible supply. As of 1 April 2009, the RO scheme was modified to allow variation in the number of ROCs that could be created dependent on the generation technology, size of generator and various other factors. The changes are intended to encourage a larger contribution from emerging renewable technologies. They necessitated a change in the obligation on suppliers from meeting a percentage of generation to one demonstrating they had secured the requisite number of ROCs. For 2009/10 the requirement was 0,097 ROCs per MWh of supply in England and Wales & Scotland, and 0,035 ROCs per MWh in Northern Ireland.

Eligible PV generation will receive two ROCs per MWh regardless of scale. 'Microgenerators' - considered to be systems under 50 kW of rated capacity - are generally eligible to create 2 ROCs per MWh of electricity generated, although from April 2010 new microgeneration installations will be able to access the Feed-in Tariff.

In addition to the Renewables Obligation, a number of funding options have been available to both homeowners and community groups.

The Low Carbon Building Programme (LCBP) launched in 2006 provides grants for the installation of microgeneration technologies (both electricity and heat). To qualify for a grant, both the major hardware and the installers of the system must be accredited under the Microgeneration Certification Scheme (MCS).

The programme is split into two streams:

- Phase 1 Householders: Householders could apply for grants of up to 2 500 GBP per property towards the cost of installing microgeneration technologies. For PV, the allocation was up to 2 000 GBP/kW of installed capacity, subject to an overall maximum of 2 500 GBP/kW. Almost 14 MGBP has been committed to over 4,500 PV projects under the scheme.
- Phase 2 Public Sector and Charitable bodies: Up to 50 % funding to a maximum of 50 kW or 200 000 GBP per site was available for new PV projects. Funding was subject to meeting benchmark targets for the cost per tonne of carbon dioxide abated. Almost 42 MGBP has been committed to 2450 solar PV projects; this accounts for 57 % of the funding committed to all microgeneration technologies.

Phase 2 had been scheduled to end in June 2009, however additional funding of 35 million GBP was committed to an extension of the programme - LCBP2e - in the government's April 2009 budget with a further 10 million GBP added to Phase 1. The intent was that this should bridge the gap until the introduction of the Feed-in Tariff in April 2010. 9 million GBP was earmarked for Solar PV. The additional funding under Phase 2e was fully committed by end November 2009 and the scheme was then closed to further applications.

With the advent of the Feed-in Tariff, both Phases of LCBP in England, Wales and Northern Ireland were closed to grant applications for electricity generation irrespective of technology as of February 2010.

Homeowners based in Scotland can still apply for grants through Energy Savings Scotland's home renewable grants scheme, while local community groups are catered for by the Community and Renewable Energy Scheme (CARES). Both initiatives were established in 2009 as an evolution (rebranding) of the Scottish Community and Householder and Renewables Initiative (SCHRI).

Fig.6 - 4,3 kWp retrofit domestic roof installation, County Durham (photo: Cleaner Air Solutions Ltd).

The household stream provides grants of up to 30 % of the installed costs to a maximum of 4 000 GBP. CARES provides funding on a case-by-case basis to non-profit community organisations such as charities, local authorities, schools and housing associations. Capital grants of up to 150 000 GBP are available. Funds are also available for non-capital aspects including feasibility studies, community consultation and capacity building.

The Community Sustainable Energy Programme launched in 2008, provides 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 a significant proportion of the costs of microgeneration installation.

Several energy companies - predominately the electricity and gas suppiers - award grants for community-oriented renewable energy projects. There are also local initiatives supporting PV installations in some parts of the country.

MARKET DEVELOPMENTS

Figures for the PV capacity installed during 2009 are not yet available but early indications - particularly funding committed under the low Carbon Buildings Program (both Phases) suggest similar growth to that experienced in 2008 with around 5 MW being installed during the year. This would imply cumulative total installed capacity of approximately 26 MW. The changes to the RO and introduction in April 2010 of the FIT are expected to drive rapid expansion of the renewable energy sector which is essential if the UK is 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), Department for Business, Innovation and Skills (BIS) and the Carbon Trust. The UK Energy Research Centre (UKERC) Research Register provided by the Science and Technology Facilities Council details publicly funded research activities in the solar sector, available at http://ukerc.rl.ac.uk UK RD&D funding encompasses a broad array of measures from fundamental research through to industry development such as installer training programmes.

Currently considerable attention is focused on developing technologies and processes for rapid, cost-effective solar cell fabrication, particularly organic and nanostructured materials suitable for roll-to-roll production. An example is the Excitonic Solar Cell (ESC) Research being undertaken as part of The SUPERGEN (Sustainable Power Generation and Supply) Initiative. ESCs include dye-sensitized nanocrystalline cells, organic cells and hybrid organic-inorganic cells, and in all cases cell fabrication can be achieved using low cost, large area deposition methods on both rigid and flexible substrates.

The Advanced PV Research Accelerator funded by the Carbon Trust has an ongoing project to develop commercially competitive organic solar cells with an efficiency of 8 %. The aim for these plastic solar cells to be delivering 1 GW of power (equivalent to carbon dioxide savings of more than 1 million tonnes per year) within ten years.

INDUSTRY

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 2009 was anticipated to amount to 230-235 MW equivalent per annum, up marginally on the 2008 figure of 225 MW.

Sharp's plant in Wrexham manufactures a broad range of monocrystalline and polycrystalline modules for supply to UK and Europe. Production volume is 220 MW per annum, or some 4 000 modules per day. The factory, which also assembles microwave devices, employs over 500 people.

Romag in Consett is an established specialist glass company serving a number of sectors including solar PV. These are marketed under the 'PowerGlaz' brand and encompass glass/glass laminates, louvres, roof-integrated tiles, solar charging canopies as well as standard modules from 165 W to 235 W.

GB-SOL based in South Wales manufactures custom PV panels, including glass/glass laminates for architectural applications. The company also manufactures standard modules from 5 W to 200 W and a range of 'flexi' panels on anodised aluminium sheet.

The Microgeneration Certification Scheme register of installers identifies almost 180 MCS approved installation companies for solar PV systems throughout the UK.

FUTURE OUTLOOK

Changes to the support mechanisms for renewable energy technologies - the Renewables Obligation and in particular the introduction of the Feed-in Tariff- are expected to stimulate significantly increased demand for solar PV generation in 2010 and beyond. For the foreseeable future, while interest rates remain relatively low, many individuals with savings may consider the Returns on investment expected under the FIT as an attractive proposition. For more widespread uptake, finance packages and new delivery models may be required. The government anticipates that such features will be developed by the commercial finance sector.

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND FUTURE OUTLOOK
CAROL ANNA, NATIONAL RENEWABLE ENERGY LABORATORY
KATHLEEN C. BOLCAR, U. S. DEPARTMENT OF ENERGY

Fig.1 - The 25 MW DeSoto Next Generation Solar Energy Center, the largest photovoltaic generation plant in North America, was built ahead of schedule and under budget for Florida Power and Light in 2009.

GENERAL FRAMEWORK

The infusion of significant public funds in 2009 contributed to photovoltaic (PV) manufacturing, deployment, and research in the United States. The American Recovery and Reinvestment Act of 2009 (known as the Recovery Act or Economic Stimulus Act) became law in February 2009. Under this legislation, the US Department of Energy (DOE) was allocated 36,7 BUSD to spend on initiatives to create jobs and transform energy use. Other Federal agencies, such as the US Department of the Interior and the US Department of Defense, chose to fund PV projects with some of their Recovery Act money.

Grants to states have also been used to support efforts in PV deployment. Photovoltaic manufacturing received a boost with the Recovery Act provision of a new 30 % investment tax credit for projects that establish, re-equip, or expand manufacturing facilities. Because fewer businesses were seeking tax credits during the economic downturn, the U.S. Treasury and DOE announced that companies could choose to receive direct payments for renewable energy production projects instead of tax credits.

This influx of government funds, coupled with falling prices for PV components, caused the additions to PV capacity in 2009 to be slightly higher than those in 2008, despite the unfavorable economic and financial climate.

Meanwhile, the DOE partnered with Federal, state, and local government agencies, national laboratories, universities, and private industry to advance PV technology and increase markets. Specifically, the DOE increased support to programmes aimed at developing pilot production of innovative cell technologies, bringing cross-cutting PV products to market, and promoting approaches to grid integration to accommodate high capacities of PV generation.

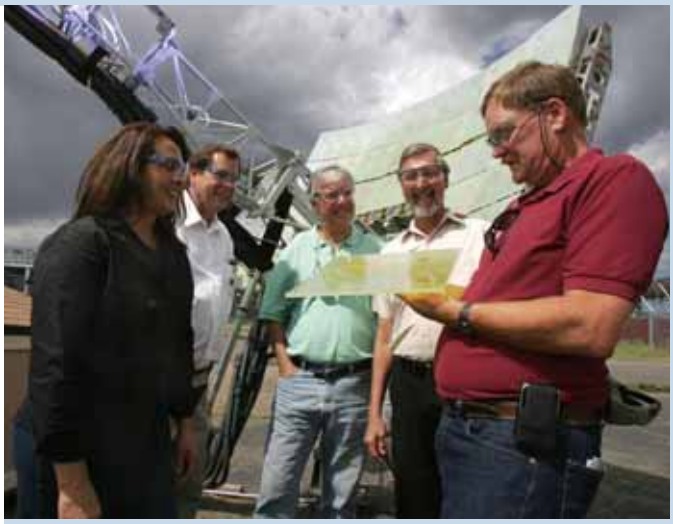

Fig. 2 - The National Renewable Energy Laboratory's Ultra-Accelerated Weathering System tests products for outdoor durability and can replicate years of sun damage in just a few weeks.

NATIONAL PROGRAMME

The DOE national research programme works to make PV cost competitive with conventional electricity generation, which results in significant PV electricity use in the United States. The DOE Solar Energy Technologies Program supports the entire development pipeline through its PV Technology, Systems Integration, and Market Transformation subprogrammes. The annual appropriations process, separate from the one-time injection of funds provided by the Recovery Act, included a base budget of 145 MUSD for the PV Technologies subprogramme. In addition, the Recovery Act included 16,8 BUSD for the DOE Office of Energy Efficiency and Renewable Energy's programmes and initiatives. About 12 BUSD were awarded

Fig. 3 - Sandia researchers hold samples containing arrays of microsolar cells. Such cells demonstrated 14,9 % efficiency and hold promise for low-cost manufacturing.

by the close of 2009. The DOE invested about 44,5 MUSD in PV activities in 2009, and 128,5 MUSD was allocated for 2010 from annual appropriations.

Photovoltaic cell technologies under development include wafer silicon; amorphous and single-crystal, thin-film silicon; high-efficiency (III-V) semiconductors; cadmium telluride and copper indium gallium diselenide (also known as "CIGS") thin films; and advanced organic and dye-sensitized thin-film cells. The Next Generation PV Devices and Processes project supports exploratory research and development to bring innovative concepts to the prototype stage. To bridge the gap between verification of these concepts and commercialization, the PV Technology Pre-Incubator project helps small businesses develop commercially viable prototypes. Once a prototype looks promising, the PV Technology Incubators project explores the commercial potential of new manufacturing processes and products produced in pilot-scale operations. Prototypes must demonstrate cost, reliability, and performance advantages.

To advance PV component and system designs that are ready for mass production, the Technology Pathway Partnerships select designs that can reduce the cost of PV-generated electricity to grid parity by 2015. Industry-led teams developing new PV technologies for commercialization work in the University Photovoltaic Product and Process Development effort, which targets materials science research and process engineering. Manufacturing and product costs are reduced under the PV Supply Chain and Cross-Cutting Technologies effort by improving common PV manufacturing processes and materials with potential to impact the PV industry within two to six years. System integration and market transformation activities help remove technical and institutional obstacles to the wider use of PV to generate electricity for the nation.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION

DOE awarded Recovery Act funds in 2009 for research and development of PV technologies to six national laboratories - Argonne National Laboratory, Los Alamos National Laboratory, the National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory, the Pacific Northwest National Laboratory, and Sandia National Laboratories (SNL). Through partnerships with industry and universities, these laboratories worked to carry out the national programme.

Research

One key to advancing PV technology is to make DOE research and test facilities available to industry. In 2009, NREL installed an Atmospheric Processing Platform to work with industry to test novel thin-film cells produced from inks and other solutions. The PV manufacturing industry can also work with NREL using the Rutherford Backscattering System, which came online in 2009. The Rutherford measurement system rapidly identifies any trace impurities - introduced during manufacturing processes-that can limit the yield and conversion efficiencies of PV cells. Upgrades are planned for the Distributed Energy Technologies Lab at SNL that will support the evaluation of smart inverters and control products developed by industry under the Solar Energy Grid Integration Systems project.

Designing PV products for long life is facilitated by the new Ultra-Accelerated Weathering System at NREL. This solar concentrator provides test results 12 times faster than other accelerated weathering systems and can replicate years of sun damage in just a few weeks.

Another channel of Recovery Act funds to PV research and development was the Advanced Research Projects Agency-Energy (ARPA-E), which supports high-risk, high-reward research. PV projects funded under ARPA-E include work on direct wafer technology to form high-efficiency "monocrystalline-equivalent" silicon wafers directly from molten silicon; a new class of high-efficiency thermoelectric devices and materials powered by waste heat from power plants, industrial processes, and vehicles; and a novel thermoelectric waste heat harvesting device based on large-area arrays of 1-D concentric silicon nanotubes.

Development

Based on the results of the DOE Renewable Systems Interconnection study published in 2008, 12 activities were initiated to develop advanced PV inverters, controllers for components and systems, and energy management systems for distributed PV systems. In 2009, five Solar Energy Grid Integration Systems contractors were selected for additional funding (11,8 MUSD) to develop advanced hardware

Fig. 4 - U.S. Department of Energy Solar Decathlon 2009 all-team photo on the National Mall in Washington, D.C. (Photo by Stefano Paltera/U.S. Department of Energy Solar Decathlon).

with communications and intelligence to the prototype stage. Additional system integration work will include up to 37,5 MUSD for seven projects that will model, test, and evaluate the impact of large amounts of PV power on the reliability and stability of the grid.

Research supported by DOE helped SunPower Corporation to develop a full-size prototype solar panel with minimum cell efficiency of 23 % and a total area efficiency of 20,4 % (confirmed by NREL). Another technology developed at NREL, the inverted metamorphic multijunction, or IMM, solar cell, is being commercialized by Emcore Photovoltaics and Spectrolab. The cell's efficiency was demonstrated in 2008 to be 40,8 % under concentrated sunlight.

Demonstration

Strategies for increasing solar energy use are being explored through DOE's Solar America Cities partnership with 25 U.S. cities. Solar experts work with decision makers such as city councils, tax boards, and planning commissions to develop innovative solar financing options, streamline permitting processes, update building codes, and educate residents and businesses about solar energy. In 2009, DOE announced Recovery Act funding for 16 cities to implement 40 promising new projects. Another activity, the Solar America Board for Codes and Standards, is ensuring the responsiveness, effectiveness, and accessibility of PV codes and standards.

Having a sufficient number of trained installation contractors, system designers, engineers, technical salespeople, and code officials is important to the successful expansion of PV generating capacity; however, qualified instructors are in short supply. In 2009, DOE awarded nearly 10 MUSD in Recovery Act funds to nine regional solar training centers, starting a five-year programme to increase the quality and availability of instruction in solar heating and PV.

The U.S. Department of Energy Solar Decathlon 2009 challenged 20 university teams from four countries to design and exhibit energy-efficient houses powered by the sun. Conducted on the National Mall in Washington, D.C., the competition demonstrated innovative clean-energy technologies, showed consumers the potential of solar-powered living, and helped cultivate a well-trained workforce of future engineers, architects, and entrepreneurs uniquely prepared for green jobs.

IMPLEMENTATION

Although the U.S. economy was in turmoil and state legislatures faced severe budget crises in 2009, Federal and state leaders adopted policies to develop cleaner and more diverse energy sources as tools for economic revitalization.

Federal Initiatives

With its emphasis on clean energy as a way to stimulate the economy, the Recovery Act prompted initiatives in nearly every agency of the Federal government. In 2009, the U.S. Department of the Interior and DOE collaborated on a study to identify 24 tracts of land administered by the Bureau of Land Management that are most suitable for large-scale solar energy development. The lands are located in Arizona, California, Colorado, Nevada, New Mexico, and Utah. The Bureau of Land Management has applications for about 470 renewable energy projects representing a combined power capacity of up to 97 GW.

State and Local Initiatives

Between September 2008 and September 2009, approximately 40 new solar incentive programmes were created in 19 states, according to the Database of State Incentives for Renewables and Efficiency (DSIRE), which is maintained with support from DOE. Programme incentive levels in 10 states were reduced.

The number of *performance-based incentives* offered by states and utilities increased in 2009. The DSIRE database tallied 39 production incentives in 28 states, with 14 production incentives for solar (excluding feed-in tariffs), 11 feed-in tariffs, and 14 renewable energy credit (REC)-purchase programmes (through which RECs are purchased separately from electricity). California established a law, effective in 2011, that qualifies utilities purchasing electricity through the state's feed-in tariff as eligible for credits under the state's renewable portfolio standards.

Tradable renewable energy credits (TRECs) were tentatively authorized in December 2009 by the California Public Utilities Commission to help utilities comply with the state's renewable portfolio standards. Utilities would be allowed to meet up to 40 percent of their annual RPS compliance through TRECs. Unbundled REC contracts were also allowed. The TRECs will give California's utilities added flexibility to meet the state's RPS and stimulate the development and installation of renewable energy projects in California. Allowing TRECs will also stimulate development outside of California because the RECs do not have to be generated by systems located in the state.

At the close of 2009, *renewable portfolio standards* in 29 states and the District of Columbia required utilities to procure increasing amounts of renewable electricity and/or RECs. Sixteen of those states (and Washington, D.C.) have specified the amount of solar electricity and/or distributed generation that must be provided.

Net metering policies were in place in 42 states at the close of 2009. These policies, which vary widely among states, are an important incentive promoting customer-sited PV and other renewables.

Fig. 5 - A new 2 MW solar garden powers the Mars candy factory, PSEG Solar Source's first project.

Financing options evolved rapidly at the city and county level. Through property-assessed clean energy (PACE) programmes, several local governments offered loans to property owners to help pay for PV systems. These loans are usually repaid via a special assessment on the property, which becomes a lien on the property until the amount is paid in full, usually over many years. Local governments issue bonds or tap existing accounts to fund the loans. Several such programmes sprang from DOE's Solar America Cities efforts. At the close of 2009, 18 states and 30 municipalities had authorized or established PACE programmes.

As of December 2009, 20 U.S. states offered *manufacturing incentives* (mostly in the form of tax credits) to attract the construction of PV manufacturing facilities to their areas.

New Utility and Industry Programmes

About 100 MW of utility-driven projects were operating at the end of 2009, but U.S. utilities have announced more than 4,9 GW of large projects for the near future, according to a study from Emerging Energy Research. By December 2009, the U.S. had roughly 2,4 GW in power purchase agreements for PV, according to an article in Public Utilities Fortnightly. Two California utilities, Pacific Gas and Electric Company (PG&E) and Southern California Edison, each announced plans to build, own, and operate about 250 MW of distributed PV plants over the next five years. The utilities will also each purchase the output from an additional 250 MW of third-party owned projects.

Yet to be demonstrated, space-based PV gained its first customer when PG&E agreed to buy 200 MW of power over 15 years. The energy from orbiting solar panels would be converted to radio-frequency energy and transmitted to a receiving station in California, where it would be converted to electricity and added to the power grid.

In 2009, the Interstate Renewable Energy Council released updates for its influential rules and procedures for interconnecting and net metering distributed generation. The council's updates incorporate evolved best practices and compile them into a template regulators and utilities can use as a starting point when drafting local rules.

PV gardens, parks, and plants sized at 1 MW and larger were installed at a variety of sites - including universities, beverage plants, a candy factory, department stores, grocery stores, movie theaters, office towers, and pharmaceuticals plants. Executive Order 13423 mandates that Federal agencies use a certain amount of renewable energy, which encouraged some Federal building managers to install PV systems in 2009. PV demand at schools and government facilities was also supported by a Recovery Act allocation of 1,6 BUSD for Clean Renewable Energy Bonds (CREBs), which provide low-cost financing for public sector renewable energy projects.

INDUSTRY STATUS

According to the Solar Electric Power Association (SEPA), by the end of 2009 there were more than 90 000 distributed, grid-connected solar electric systems installed in the United States. Makers of solar panels and their suppliers had to slash prices as scarce credit quickly reduced demand. The cost of PV modules fell by up to 50 %, according to industry analysts.

Production

More new PV manufacturing plants for the United States were announced in the first half of 2009 than in the previous three years combined, according to GTM Research. Companies based in Europe and Asia showed increasing interest in U.S.-based PV manufacturing. Few equipment manufacturers received Recovery Act funds in 2009. An exception is Solyndra, based in Fremont, California, which received a DOE loan guarantee of 535 MUSD to construct a manufacturing facility for its innovative, cylindrical PV systems. The company also received a cash grant in lieu of tax credits that equates to 30 % of the installed cost of the factory.

On the other hand, a number of companies announced lower profits, layoffs, and delayed plans for expansion. Recession forced some companies to reevaluate their business plans. Innovalight, based in Sunnyvale, California, decided to license its technology and is selling its silicon ink to solar cell makers rather than manufacturing its own cells. The company 1366 Technologies in Lexington, Massachusetts, put its factory plan on hold and opted to sell factory equipment to solar cell makers. In another response to a contracting market, some manufacturers decided to buy unfinished solar farm projects and complete them with their own products, thereby creating demand for the product.

New Products

Microgrids, self-contained small grids, could be a potential way for utilities to integrate energy storage systems and renewable power sources like PV at manageable scales. Minigrid self-contained electricity generation and distribution systems can remain stable even when the grid is not. Such virtual power plants combine PV generation with smart inverters, battery storage, home networked energy-saving devices, and smart meters. In one example, the U.S. Department of Defense contracted with GE Corporation to build a microgrid at the Marine Corps base in Twentynine Palms, California.

Micro inverters are not new but are gaining ground as part of AC PV panels (DC modules that each include a small integrated inverter). These AC PV modules are even being sold for the do-it-yourself market through hardware stores.

Smart inverters can serve a crucial role in adding intelligence to the rooftop, whether by adapting to disturbances on the grid or adjusting for power factor.

Building-integrated PV is being developed by larger companies. Dow Chemical announced plans to sell solar shingles in 2010. One of the largest roofing companies, Johns Manville of Denver, Colorado, arranged to buy flexible solar thin films from United Solar Ovonic and created a new company to market eco-friendly products for the commercial rooftop market.

Utility-Scale PV Projects

The biggest utility-scale project that came on line in 2009 was a 25 MW PV installation known as the DeSoto Next Generation Solar Energy Center in Arcadia, Florida. Commissioned by Florida Power and Light, it is the largest PV facility in North America (90 000 PV modules) and was constructed ahead of schedule and under budget. The DeSoto plant uses SunPower Corporation PV modules and SunPower's proprietary tracking system to increase energy production.

Utility investments were also stimulated in 2009 by the Federal Investment Tax Credit, which became available to investor-owned utilities in October 2008. This enabled utilities to consider direct ownership of PV systems. According to SEPA, innovative utility-scale business models are emerging that include leasing rooftops from customers and mounting PV systems on poles in parking lots.

MARKET DEVELOPMENT

State and local government initiatives and policies, combined with the Federal ITC, have encouraged the installation of more than 400 MW of new, grid-tied PV generation capacity in 2009. California accounted for between 215 MW and 240 MW, depending on the estimates, and more than 43 MW of that was for residential grid-connected systems. Although companies announced plans for many large solar projects, including utility-owned and third-party owned projects, only a few of them were completed in 2009. Most will come on line in 2010 and beyond.

Researchers are still counting market numbers for 2009, but preliminary estimates indicate that the United States accounted for 6 % of the 5,5 GW of worldwide PV module shipments for the year. About 69 % of U.S. shipments were thin-film modules. On the demand side, the United States consumed an estimated 8 % of the global demand for modules in 2009.

FUTURE OUTLOOK

Manufacturers of PV modules and components claimed about 40 % of the 2,3 BUSD of tax credits announced at the end of 2009. The investment tax credits are worth up to 30 % of each planned project, including more than 400 MUSD for materials and component manufacturers. While projects selected for this tax credit generally must be placed in service by 2014, some of the selected projects were completed in 2009, and about one third will be completed in 2010.

Acknowledgments:
The following people reviewed and contributed to this report: Katie Bolcar, Jennifer Decesaro, and Hannah Muller, DOE; Carol Anna, Selya Price, and Bethany Speer, National Renewable Energy Laboratory; Ward Bower, Sandia National Laboratories; Mark Frickel, Sentech; Christy Herig, Solar Electric Power Association; Paula Mints, Navigant Consulting; Rusty Haynes, North Carolina Solar Center, North Carolina State University; Larry Sherwood, Sherwood Associates; Shayle Kann, GTM Research, and Patricia Weis-Taylor, PWT Communications.

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.

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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

For information, contact the former Task 5 Chairman or visit the PVPS website:

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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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PARTICIPANTS

In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

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Task 7 deliverables: www.iea-pvps.org
Task 7 website: www.task7.org
Task 7 demosite: www.demosite.ch
PV Projects database: www.pvdatabase.com

ANNEX A

IEA – PVPS EXECUTIVE COMMITTEE

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