

PVPS

annual report 2010

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

P H O T O V O L T A I C P O W E R S Y S T E M S P R O G R A M M E

ANNUAL REPORT 2010

CHAIRMAN'S MESSAGE



The IEA Photovoltaic Power Systems Programme is pleased to present its 2010 annual report. 2010 has been characterized by another year of strong global market dynamics and an ongoing and significant cost reduction which is bringing photovoltaics closer to the so-called grid parity. Going along with this global photovoltaic market expansion is an increasing perception of the future potential role of this emerging energy technology.

From an IEA perspective, a landmark in 2010 has been the publication of the IEA PV Roadmap which estimates an 11 % contribution of photovoltaics to the global electricity supply by 2050 as feasible, corresponding to more than 3 000 GW of installed capacity or more than 4 500 TWh of electricity. Compared to the estimated installed capacity on the order of 35 GW at the end of 2010, this means about a 100-fold increase over the next 40 years. Many PV stakeholders think that more is possible but already these numbers are impressive and challenging at the same time. Another relevant message of the IEA PV Roadmap is the fact that the coming decade will be decisive for the future role of photovoltaics in a sustainable electricity supply.

As a leading international network of expertise, IEA PVPS has the mission to cooperate on a global level in this rapidly evolving technology area. Working on both technical and non-technical issues, IEA PVPS undertakes key collaborative projects related to technology progress, cost reduction and rapid deployment of photovoltaics in various applications. Providing high-quality information about relevant developments in the photovoltaic sector as well as advice to our key stakeholders remain our highest priorities. 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 2010. China joined the PVPS Programme as the 25th member during the year. I welcome China as the most recent IEA PVPS member and look forward to a long and fruitful cooperation. Thailand and the Solar Energy Industries Association (SEIA) from the United States have attended PVPS meetings as observers during the year. Contacts have also been ongoing with Belgium, Chile, Greece, India, New Zealand, Singapore and South Africa.

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

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 25th European Photovoltaic Solar Energy Conference in Valencia (Spain) and Solar Power International in Los Angeles (USA) attracted a large number of visitors and provided an excellent forum for dissemination purposes.

A particular highlight was the 5th IEA PVPS Executive Conference "The Solar Power Utility," which was held in June 2010 in Montreux, Switzerland. This high-level conference attracted participants from various stakeholder groups from all over the world for discussion and debate on the relevant issues of utility scale photovoltaics, such as business models, regulatory issues or financing. Based on the excellent feedback received following the event, the conference was a great success.

2010 was another productive year for PVPS with many new results from the various ongoing projects. The detailed outcomes 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.

A stylized, handwritten signature of Stefan Nowak in black ink.

Stefan Nowak
Chairman

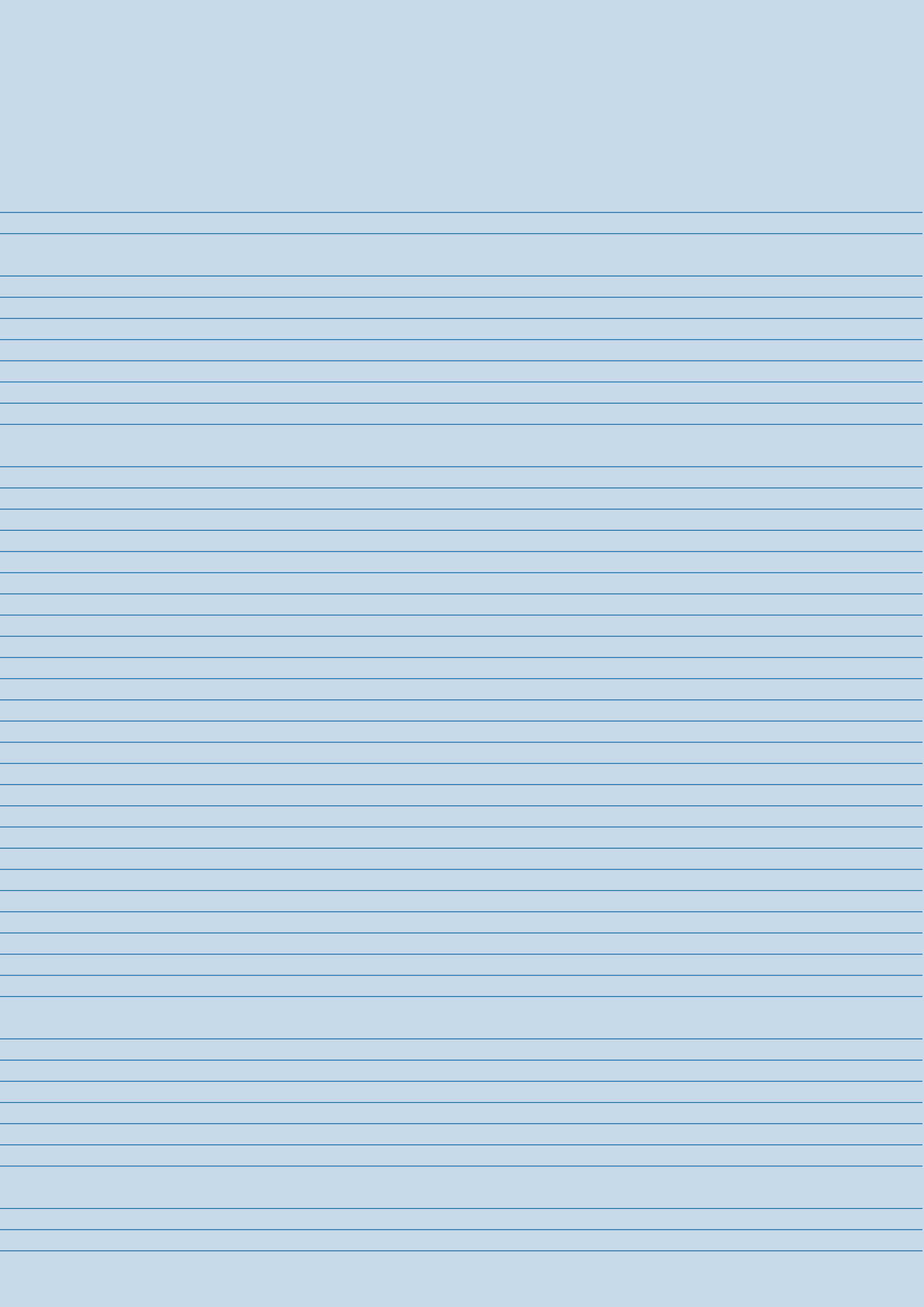


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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



IEA PVPS Executive Committee, Montréal, Canada, October 2010.

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), 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 2010, fourteen Tasks were established within the PVPS programme, of which seven are currently operational.

The twenty-five PVPS members are: Australia, Austria, Canada, China, 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. China joined PVPS in 2010.

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.

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
<p>1 – To stimulate activities that will facilitate a cost reduction of PV power systems applications.</p>	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.
<p>2 – To increase the awareness of their potential and value and thereby provide advice to decision makers from government, utilities and international organisations.</p>	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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;
<p>3 – To foster the removal of technical and non-technical barriers of PV power systems for the emerging applications in OECD countries.</p>	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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; 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;
<p>4 – To enhance co-operation with non-OECD countries and address both technical and non-technical issues of PV applications in those countries.</p>	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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, Technical Tour, Montréal, Canada, October 2010.

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.

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

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

large-scale introduction is hampered by various barriers such as acceptable accessible financing structures, institutional and social barriers, infrastructure issues and sometimes technical problems. PVPS expertise can be instrumental to help overcome some of these barriers.

IEA PVPS TASKS

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

- Task 1. Exchange and Dissemination of Information on PV Power Systems;
- Task 2. Performance, Reliability and Analysis of Photovoltaic Systems (concluded in 2007);
- Task 3. Use of PV Power Systems in Stand-Alone and Island Applications (concluded in 2004);
- Task 4. Modelling of Distributed PV Power Generation for Grid Support (not operational);
- Task 5. Grid Interconnection of Building Integrated and other Dispersed PV Systems (concluded in 2001);
- Task 6. Design and Operation of Modular PV Plants for Large Scale Power Generation (concluded in 1997);
- Task 7. PV Power Systems in the Built Environment (concluded in 2001);
- Task 8. Very Large Scale PV Power Generation Systems;
- Task 9. PV Services for Developing Countries;
- Task 10. Urban Scale PV Applications. Begun in 2004. Follow-up of Task 7 (concluded in 2009).
- Task 11. PV Hybrid Systems within Mini-Grids. Begun in 2006. Follow-up of Task 3. (to be concluded in 2011)
- Task 12. Environmental Health and Safety Issues of PV. Begun in 2007.
- Task 13. Performance and Reliability. Begun in 2010.
- Task 14. High Penetration PV in Electricity Grids. Begun in 2010.

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 - The PVPower Update newsletter continued the familiar PVPower newsletter themes and style in 2010.

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 and organizations 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



Fig. 2 - Workshops are an important method of communicating with stakeholders. Task 1 / Task 14 workshop at EUPVSEC in Valencia, 2010 (photo: Pius Hüsser).

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 2010 fifteen 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 called *PVPower Update*. Task 1 participants provide material of interest to the newsletter editor and ensure that the newsletter reaches its target audience in the respective countries.



Fig. 3 – A combination of the support mechanisms reported on by Task 1 – renewable energy certificates, generous feed-in tariff and utility PV business models – drove the strong market for PV in NSW, Australia during 2010 (photo: Greg Watt).



Fig. 4 – Task 1 Trends work reaches a worldwide audience.

Thirty three issues of the newsletter had been compiled by the end of 2010.

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, Towards a future of large-scale deployment of PV and PV in tomorrow's electricity grids – problem or panacea? 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 2010

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 stakeholders. Also, Task 1 endeavors where possible to be an active contributor to other related workshops / events. Task 1 members made significant contributions to the development and operation of the IEA PVPS Executive Conference held in Montreux, Switzerland in June 2010.

SUBTASK 1.1: Status Survey Reports

Full national survey reports for calendar year 2009 were received from most participating countries during 2010. Most are excellent documents, with most being provided in a timely manner.

The fifteenth *Trends* report was published in October 2010, a little later than planned, and outlined a number of significant developments in both member and non-member countries during calendar year 2009. About 6,2 GW of PV capacity were installed in the IEA PVPS countries during the year (about the same as the previous year) which brought the total installed capacity to over 20 GW. By far the greatest proportion (74 %) was installed in Germany and Italy alone. If Spain's explosive 2008 PV market and almost total collapse in 2009 are removed from the dataset, then the growth rate between the 2008 and 2009 annual markets for the remaining 20 countries becomes an impressive 84 % – a very healthy number during a period of global economic slowdown. Strong growth of the annual market was evident in many countries. The Israeli market took-off with an eighteen-fold increase while the Canadian market experienced a nine-fold boost – both driven by new and successful feed-in tariff (FiT) schemes. Particularly interesting is the number of countries that experienced an annual market increase of the order of two to four-fold – Australia, Austria, Switzerland, Germany, France, Italy, Japan and the Netherlands. Over the previous five years the number of countries offering feed-in tariffs for PV electricity has more than trebled. FiTs have driven grid-connected PV investments in large-scale (multi-MW) plants (for example in Korea, Portugal and Spain), smaller-scale building-integrated applications (for example in Australia, Switzerland, France, Israel and Japan), and combinations of both approaches (for example in Canada, Italy and the US). The FiT can be national-scale, state-based or even operate at the local community level, such as the Swedish scheme announced in 2009. A fairly consistent picture is emerging of the PV industry's future – fewer but larger businesses, global competition for resources and markets, increasing competition and price pressures at all levels of the value chain, and more professional and differentiated business models to address an increasingly sophisticated customer base. It would appear that a large inventory of PV products emerged during



Fig. 5 - The new website provides clearer access to the outputs of the PVPS Programme.



Fig. 6 - A poster highlighting the Task 1 Trends work was prepared for EUPVSEC in Valencia, 2010.

2009 (global demand of 7 GW compared with supply of over 11 GW) which should continue to exert downward pressure on prices in the near-term.

A conference paper and poster were developed for EUPVSEC 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 final issue of the e-newsletter (e-PVPower #32) was produced and disseminated in January 2010. The first issue of the PVPower Update (#33) was produced and disseminated in September 2010. Current and back issues of the newsletter are available on the public website.

SUBTASK 1.3: Special Information Activities

Task 1 (in conjunction with Task 14) developed a workshop for EUPVSEC in Valencia in September 2010, dealing largely with electricity utility issues. With more than 70 participants from industry, the electricity utilities, component manufacturers and the research sector, the workshop – PV in tomorrow's electricity grids – problem or panacea? – was a great success. The programme provided an in-depth insight into the technical challenges associated with the massive deployment of PV in electricity grids, and recent and upcoming demonstration projects from Europe, Japan and the US.

All presentations were made available on the PVPS website.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2011

Task 1 activities will continue to focus on development of quality information products and effective communication mechanisms in support of the IEA PVPS communication strategy. In this context, work will continue on the redesign of the website and changeover to a Content Management System (CMS), plus associated quality control issues and enhancement of the web design into the future.

SUBTASK 1.1: Status Survey Reports

The deadline for receiving the next National Survey Reports (NSRs) is June 2011. These will all be made available via the public website.

The target date for publication of the 16th issue of the *Trends in Photovoltaic Applications* report is August 2011. Electronic versions of the information will be made available progressively on the public website from July 2011 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 *PVPower Update* will be made available twice yearly, with likely months for publication in 2011 being February and August.

SUBTASK 1.3: Special Information Activities

Task 1 (maybe in conjunction with another task) will develop at least one workshop for EUPVSEC in Hamburg, Germany, early September 2011. Another workshop is being developed for PVSEC-21 in Yokohama, Japan, 28 November to 2 December 2011, along the lines of the usual PVSEC workshop model. A national PVPS workshop will be held in Istanbul, Turkey on 16 February 2011 and will feature significant contributions from Task 1 members.

Other specific topics that may receive further attention from the Task 1 group include issues of interest from along the PV industry value chain, the evolution of the global PV market, mapping of electricity utility interests and non-technical issues (policy, regulatory, social and economic) associated with large-scale deployment of PV.

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.

TASK 1 PARTICIPANTS IN 2010 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	Austrian Institute of Technology
Canada	Josef Ayoub	Natural Resources Canada
China	Lv Fang	Electrical Engineering Institute, Chinese Academy of Sciences
Denmark	Peter Ahm	PA Energy A/S
France	Yvonnick Durand	ADEME
European Photovoltaic Industry Association	Gaëtan Masson	EPIA
European Union	Pietro Menna	European Commission, Directorate General for Energy
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer	Ben-Gurion National Solar Energy Centre
Israel	Roxana Dann	Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	ERSE SpA
Japan	Osamu Ikki	RTS Corporation
Japan	Izumi Kaizuka	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
Malaysia	Wei-nee Chen	MBIPV National Project Team
Malaysia	Gladys Mak	MBIPV National Project Team
Mexico	Jaime Agredano Diaz	IIE
Netherlands	Otto Bernsen	NL Agency, Directorate Energy and Climate Change
Norway	Fritjof Salvesen	KanEnergi AS
Norway	Lars Bugge	KanEnergi AS
Portugal	Pedro Paes	EDP
Solar Electric Power Association	Tom Nicholas	SEPA
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Adam Hultqvist	Uppsala University
Switzerland	Pius Hüsler	Nova Energie GmbH
Turkey	Mete Cubukcu	Solar Energy Institute, Ege University
United Kingdom	Greg Seed	IT Power Ltd
United States of America	Carol Anna	NREL

KEY DELIVERABLES (2010 AND PLANNED)

The following were published and also made available on the public website during 2010:

Trends in Photovoltaic Applications in Selected IEA Countries between 1992 and 2009

Report IEA-PVPS T1-19: 2010 (plus paper and poster at the EUPVSEC conference).

PVPower issues 32 and 33.

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

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

During 2011 it is planned to produce the sixteenth issue of the *Trends in Photovoltaic Applications* report, two *PVPower Update* issues, and a range of country and workshop information. The website will be redeveloped in Content Management System (CMS) format during 2011.

MEETING SCHEDULE (2010 AND PLANNED 2011)

The 34th Task 1 meeting was held in Seville, Spain 3-4 June 2010.

The 35th Task 1 meeting will be held in Istanbul, Turkey 16-18 February 2011.

The 36th Task 1 meeting will be held in Amsterdam, The Netherlands, 2-3 September 2011.

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

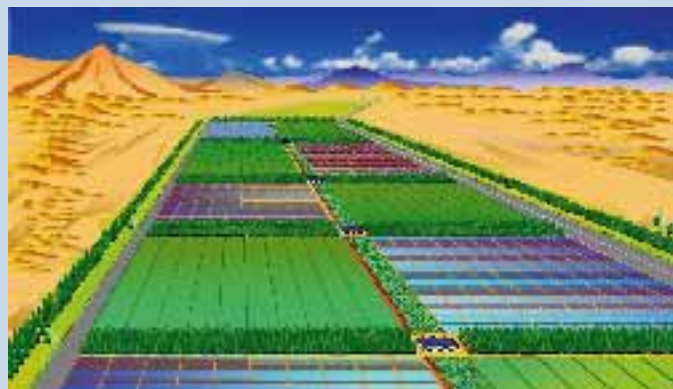


Fig.1 – Image of a VLS-PV System in a Desert Area.

OVERALL OBJECTIVES

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

VLS-PV systems would be promising options for large-scale deployment of PV systems. Installation of MW-scale PV systems has been rising substantially year by year, and a capacity of MW-scale PV systems is expanding as well. The capacity is likely to reach 100 MW soon, and after the stage, GW-scale PV plants consisting of several 100 MW-scale PV systems should be realized within a decade.

The work on VLS-PV first began in 1998, under the umbrella of IEA PVPS Task 6, and was, as Task 8, officially established in 1999. Task 8 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 2010

Task 8 has started its 4th phase activity since 2009, based on a three years Workplan for 2009–2011. During 2010, through two meetings and e-mail communications, Task 8 discussed working items for accomplishment of VLS-PV activity in detail. In parallel, Task 8 performed dissemination activities aggressively.

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

Employing the concepts of VLS-PV, 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 discussed. Feasibility



Fig. 2 – Task 8 Workshop in Israel, on 16 February 2010.

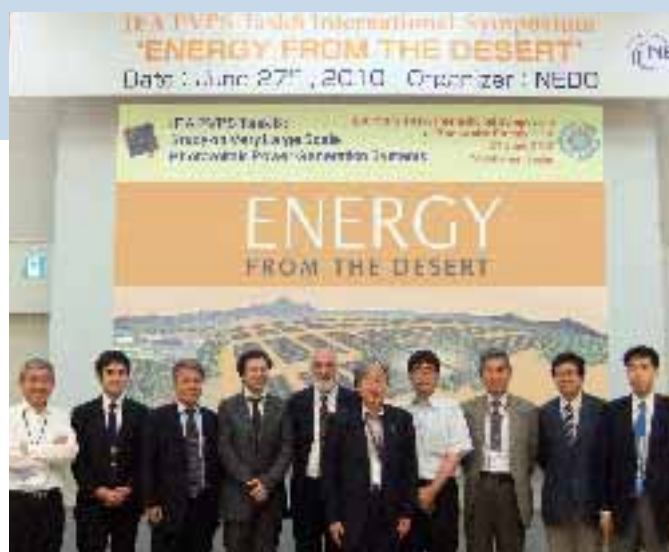


Fig. 3 – Task 8 International Symposium in Yokohama, Japan, on 27 June 2010.

and potential of VLS-PV on deserts will be evaluated from viewpoints of local and global aspect. Japan leads the Subtask 2.

Possible case studies and project proposals of VLS-PV were discussed. A 100 MW PV project in Jordan, called 'Shams Maan Initiative,' would be introduced and a potential project on Gobi Desert would be taken up.

As for the LCA study on VLS-PV systems, Task 8 has started information exchange and collaborative work with Task 12.

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

Detailed practical instructions for implementing VLS-PV projects 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 the Subtask 5.

'Engineering and Financial Guideline for VLS-PV Systems' was discussed and the guideline would be composed of 'Pre-engineering,' 'Technical Engineering Design' and 'Financial Design.' It was proposed that a database of present large scale PV systems in the world should be developed. This would be useful information as a part of the guideline.



Fig. 4 - 23rd Task 8 meeting in Hokuto, Japan, in June 2010.

An idea on estimating 'Possible contributions of VLS-PV systems on global/regional sustainability issues' was proposed and discussed. To estimate such impacts by using existing algorithms would be possible. For simplifying, a comprehensive approach for evaluation would be supposed. Also, a VLS-PV strategy from viewpoints of socio-economic opportunities has been discussed.

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 discussed. 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 discussed. Israel leads the Subtask 6.

The main focus of the present study was how to get VLS-PV into the grid. It was pointed out tentatively that grid matching of intermittent systems would depend on the seasonal and diurnal output profiles of the system, and that properly designed storage and accurate forecasting technologies significantly would increase their grid compatibility.

Also a preliminary survey study on PV and CSP, such as the current status of CSP, IEA Technology roadmaps on PV and CSP, were carried out. The study would be promoted by clearly distinguishing CPV technology, e.g. conventional PV, CPV and CSP.

OTHER ACTIVITIES

Task 8 Workshop in Israel and International Symposium in Japan

An Open Workshop: VLS-PV, Very Large Scale Photovoltaic Power Plant was held on 16th February 2010, as an integrated part of the 16th Sede Boquer Symposium on Solar Electricity Production, in Israel. About 120 people attended the workshop and a fruitful discussion was held.

As a side event of the Renewable Energy 2010 International in June 2010, the Task 8 International Symposium: Energy from the Desert - Potential of Very Large Scale PV Systems (VLS-PV) - was held on 27 June 2010, in Yokohama, Japan. About 100 people attended the symposium. At the symposium, 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," published in 2009, was distributed to all participants.

Contribution to International Conferences

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

- Renewable Energy 2010 International in Yokohama, Japan (June-July 2010)
- ADB: First Asia Solar Energy Forum, in Manila, Philippine (July 2010)
- 25th EU-PVSEC/5th WCPEC in Valencia, Spain (September 2010)

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2010

Task 8 will continue to discuss working items for accomplishment of VLS-PV activity, along with the Workplan. Based on the results, Task 8 will start discussions for the 4th phase technical report and works for drafting manuscripts.

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 (2010 AND PLANNED 2011)

23rd 24-26 June 2010, Hokuto, Japan

24th 4-5 November 2010, Paris, France

25th 5-6 May 2011, Verona, Italy

26th October 2011, Turkey



Fig. 5 - 24th Task 8 meeting in Paris, France, in November 2010.

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
France	Aurelien Bertin	Helios Energie
Germany	Claus Beneking	Aixcell Solar Technology GmbH
Germany	Edwin Cunow	LSPV Consulting
Germany	Joachim Koschikowski	Fraunhofer ISE
Germany	Christof Koerner	Siemens 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
Italy	Roberto Vigotti	Solar Ventures
Japan	Keiichi Komoto	Mizuho Information & Research Institute (MHIR)
Japan	Tomoki Ehara	Mizuho Information & Research Institute (MHIR)
Japan	Kosuke Kurokawa	Tokyo Institute of Technology (Tokyo Tech)
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
The Netherlands	Steven Pleging	Teamsolar BV
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 – DEPLOYING PV SERVICES FOR REGIONAL DEVELOPMENT

RATIONALE AND OBJECTIVES

Progress in 2009: From PV in Developing Countries to Deploying PV Services for Regional Development

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 and related essential services such as lighting, adequate clean water supplies, primary health care, education and other basic services. At the Millennium Assembly of the United Nations in 2000, the international community adopted the eight Millennium Development Goals (MDGs), setting clear and ambitious targets to which renewable energy and solar photovoltaic applications can enormously contribute.

PV technology has matured over the past decade and it is now widely accepted that its viable applications stretch far beyond services to remote communities, and significantly meet needs in the urban environment and in some situations, for the power system. With rising fossil fuel prices and declining PV cells and modules prices, PV applications are competitive in a rising number of situations. Besides the intensive growth of large-scale PV installations in OECD countries, many initiatives in emerging regions are paving the way for broad PV deployment in non-OECD countries. In these regions, recent projects for utility-scale PV power plants (for instance 73 MWp project in Thailand, 22 MWp in Burkina Faso) and implementation of national target plans (such as India's National Solar Mission with more than 5 000 MWp planned for the next 7 years) call for increased sharing of past experience acquired within OECD countries regarding technology, policy framework, financing and implementation models. Hybrid systems in remote locations and island communities are increasingly viable and reliable thanks to rapidly improving electronics.

Hence, after completing a first decade of work, summarized in the brochure *"Photovoltaic Services for Developing Countries, 10 years of Task 9,"* Task 9 is now going forward with a new and broader workplan focussed on the deployment of PV services for regional development, including, but looking beyond rural electrification applications.

The new work program of Task 9 is centered on two parallel approaches:

- 1. Partnerships with carefully chosen relays – regional organizations, national organizations, funding agencies – so called "international megaphones" who formulate a demand for support in deployment of PV solutions – as the best option to meet energy demand in certain circumstances. These partnerships would enable the sharing of PVPS' knowledge in the area of rural electrification and beyond; e.g., highly relevant topics such as penetration of PV in the urban environment, PV hybrids, very large scale PV plants and high penetration in grids. This dissemination process, implemented in cooperation with the "megaphones" consists of participation in conferences, the organization of workshops, awareness and training seminars.



Fig. 1 – A battery bank for a hybrid power plant in Felir, Senegal (photo: IED 2010).



Fig. 2 – PV-Diesel hybrid power plant installed in rural area, Ngar Keur Amadou Yacine, Senegal (photo: IED 2010).

- 2. Substantive work on applications meeting the needs of rural communities such as water pumping, drinking water, health (refrigeration, lighting, etc.), "pico PV services" (highly efficient integrated appliances for lighting and ICT needs), and on relevant business models for deployment. The results of this work will be integrated in the dissemination process.

SUMMARY OF TASK 9 ACTIVITIES

SUBTASK 1: PV for Water Pumping

Water is an increasingly scarce commodity and harnessing and using it efficiently is of central importance. PV offers this possibility, and is often the least cost option on a life cycle basis, albeit burdened with high upfront costs. Building on past experience and capitalizing on the most recent technology developments, Task 9 will produce a position paper and interact with players from the water sector.

- The activity was presented at the Off Grid Power Session of the Intersolar trade fair in Munich in June 2010;
- A draft position paper on *"Policy Recommendations to Improve the Sustainability of Rural Water Supply Systems"* is under discussion with Task 9 experts and will be published in 2011.
- Although international institutions dealing with water access in developing countries generally consider energy for water pumping as a side topic, the Rural Water Supply Network (RWSN) has been



Fig. 3 - PV-Diesel hybrid power plant installed in Kimparana, Mali (photo: IED 2010).



Fig. 4 - PV engineer at the hybrid plant installed in the Vincentian's sisters convent in Mbinga, Tanzania (photo: IED 2010).

identified as an appropriate dissemination channel. Lessons learnt within compilation work shall be presented at a RWSN workshop in 2011 and further partnerships will be developed during the year.

SUBTASK 2: PV and Health Centers

PV technology has been used in the past in a number of health applications both by national and international organizations (WHO, UNICEF, etc.): vaccine refrigeration, health clinic equipment, etc. The goal of this Subtask is to publish a compilation of good practice regarding PV for rural health facilities, and to facilitate the integration of the same into the work program of the relevant international institutions. UNICEF has expressed its interest in cooperation with IEA PVPS.

SUBTASK 3: Pico PV Services

For households without any electricity service or with only limited service, very small amounts of power can meet some essential electricity needs, thanks to efficient devices: basic (portable) telephone charging, radios, even small TVs. Devices of widely varying quality are already flooding the market. This Subtask will discuss the relevance of pico PV devices to meet needs of households with no better alternatives, opportunities and pitfalls to this option.

A comprehensive brochure had been produced by GTZ and a flyer framing the issue will be produced in 2011.

SUBTASK 4: Cooperation with other PVPS Tasks

The activity of this Subtask is twofold:

- PVPS Tasks have produced very relevant results regarding hybrids, PV in the urban environment, large scale PV. Given the trends of the energy sector, these technology solutions are now of rising relevance to meet the needs in a rising number of regional situations. This Subtask is to produce, in close cooperation with experts from the relevant Tasks, dissemination tools adapted to the needs of the target audience: flyers and presentations have been drafted and will be finalized in 2011, serving as an entry point for dialogue with interested megaphones.
- Task 9 is seeking cooperation with international cities' networks to conduct case studies concerning PV deployment in the urban context. Interaction with the International Solar Cities Initiative was started in 2010. Further collaboration opportunities with other networks will be explored in 2011.

SUBTASK 5: Innovative Business Models

Currently a framework is created to assess and categorize various business models in collaboration with universities in the Netherlands, which will be validated in 2011.

SUBTASK 6: Deployment and Outreach

This subtask is the operating arm to establish partnerships with regional organizations, countries, development bodies, etc. During 2010, focus has been placed on Asia, targeting ASEAN Center for Energy (ACE) and Asian Development Bank (ADB). In 2011, partnerships with African Development Bank, Club of African Rural Electrification Agencies (Club ER) – a club of 23 African countries –, ECOWAS centre for Renewable Energy and Energy Efficiency (ECREEE) will be explored.

- Collaboration with the ADB's Solar Energy Initiative (ASEI) was started. ASEI aims at installing 3 000 MW of solar power in Asia within the next 5 years, thus contributing to the ADB's goal of an "Asia free of poverty." The Asia Solar Energy Forum (ASEF), a knowledge management platform will be incorporated in 2011 – and the IEA PVPS will be one of its knowledge partners, contributing the work of the various PVPS Tasks and presenting the solutions developed by industry from the PVPS member countries.
 - In 2010, Task 9 participated in the first and second ASEF conferences in Manila (June) and Tokyo (December).
 - In 2011, participation is scheduled in the Gujarat 500 MW Solar Park conference in India (January 2011), where lessons learnt from the IEA countries on regulatory frameworks will be presented. Task 9 will participate in the next ASEF conference (Bangkok, June 2011) and is to organize a workshop on PV for solutions to meet the needs of rural electrification in partnership with the ADB, mid 2011.
- Collaboration with the Club ER has been initiated, the first theme being PV-diesel hybrid systems.

KEY DELIVERABLES FOR 2011:

- Position Paper on PV Water pumping
- Flyer on Pico PV Services
- Presentation and flyers on Hybrids, PV deployment in the urban environment, large scale PV and PV for rural electrification
- Draft Case studies on PV deployment in the urban environment
- Partnership agreement with a Regional organization in Africa

CONFERENCES AND WORKSHOPS FOR 2011 (ALREADY CONSIDERED)

- Rural Water Supplies Network
- 3rd Meeting of the Asia Solar Energy Initiative
- Workshop on meeting needs for rural electrification through PV services in South Asia
- Discussion Workshop on relevance of PV-diesel mini grids to meet provide electricity services to African communities

TASK 9 MEETING SCHEDULE (2010 AND PLANNED 2011)**2010**

22nd Experts' Meeting, February, Lyon, France.

23rd Experts' Meeting, June, Montreux, Switzerland.

2011

24th Experts' Meeting, February, Copenhagen, Denmark.

25th Experts' Meeting, November, Japan.

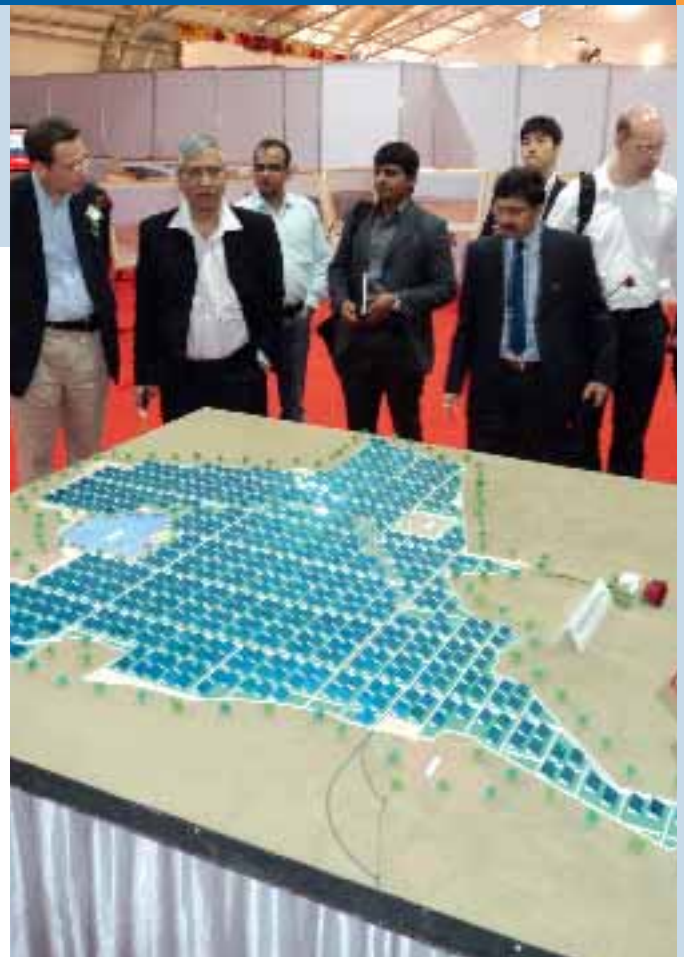


Fig. 5 - Gujarat 500MW Solar Park conference in India (photo: PSA-CIEMAT 2011).

TASK 9 PARTICIPANTS

COUNTRY	NAME	AFFILIATION
France	Anjali Shanker	IED
France	Grégoire Léna	IED
France	Silvia Puddu	IED
Switzerland	Alex Arter	ENTEC
Switzerland	Thomas Meier	ENTEC
Switzerland	Bettina Bühler	ENTEC
Germany	Michaël Blunck	GTZ
Japan	Masanori Ishimura	NEDO
Japan	Takayuki Nakajima	JPEA
Australia	Geoff Stapleton	GSES
Denmark	Peter Ahm	PA Energy Ltd
The Netherlands	Otto Bernsen	Senter Novem
The Netherlands	Johannes Krens	IntroVation
The Netherlands	Pieter Stadhouders	IntroVation
The Netherlands	Rob van der Meulen	IntroVation
United Kingdom	Bernard McNelis	IT Power
ARE	Guido Glania	ARE
EPIA	Eleni Despotou	EPIA

- The Netherlands joined Task 9 in 2010.
- Germany left the Task during the year.
- Sweden is considering joining the Task in 2011.

TASK 11 - HYBRID SYSTEMS WITHIN MINI-GRIDS



Fig. 1 - PV hybrid system on Kapas Island, Terengganu, Malaysia.

INTRODUCTION

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

TASK 11 STRATEGY AND ORGANIZATION

In general, Task 11 has followed a strategy, similar to previous PVPS Tasks, in which the current states of technology and design practice in the participating countries were first assessed and summarized. Further work then focused 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 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.



Fig. 2 - PV-wind hybrid system on Perhentian Island, Terengganu, Malaysia.

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:

- Documentation of field experience and learning 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 2010

In 2010, most Task 11 Activities focused on the writing, review, and editing of deliverable reports. One report from Subtask 10, on evaluation and comparison of software based design tools for PV hybrid systems and mini-grids, was completed and approved for publication by the PVPS Executive Committee in December. Several other reports were in the final stages of editing prior to submission to the Executive Committee.

Task 11 also continued dissemination activities, which included:

- publication and presentation of papers on Task 11 results at the 5th European PV Hybrid and Mini-grid Conference in April,
- presentation of a tutorial on control systems for PV hybrid mini-grids at the Brazilian Congress on Solar Energy in September, and

- organization of a workshop on PV hybrid systems with Malaysian industry and government in September.

PLANS FOR 2011

Task 11 plans to complete its revised Workplan in 2011 and publish the deliverable reports currently in progress. Several on-going IEA PVPS Tasks, in particular Task 9 and Task 14, are working on topics that are similar to those within the scope of Task 11. Thus there is an opportunity to continue and extend some Task 11 activities within these on-going tasks. Task 11 will explore these opportunities with the other PVPS Tasks. Finally, Task 11 will seek further dissemination opportunities, including workshops, special sessions at relevant conferences, and preparation of work summaries targeted to the needs of specific audiences.

PUBLICATIONS AND DELIVERABLE ITEMS

Task 11 deliverable reports are published electronically on the IEA PVPS web-site and on the Task 11 website at <http://www.iea-pvps-task11.org>. Additional conference papers and presentations on Task 11 Activities are also available on the Task 11 Website.

INDUSTRY INVOLVEMENT

Task 11 is fortunate to have significant active participation from equipment manufacturers and system integrators. In addition, personnel from the telecommunications industry, government agencies, electric utilities, and PV system integrators attended Task 11 meetings in 2010 as guests.



Fig. 3 – Task 11 Experts visiting the Kapas Island (Malaysia) PV hybrid system in September 2010.

TASK 11 PARTICIPANTS

As of the end of 2010, the following IEA PVPS countries are participating in Task 11 – PV hybrids in mini-grids: Australia, Austria, Canada, China, France, Germany, Italy, Japan, Malaysia, Spain, 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 listed in Table 1.

MEETING SCHEDULE

(2010 AND 2011 PLANNED)

Task 11 had the following Experts Meetings in 2010:

- 9th Task 11 Experts Meeting, 26-27 April, 2010, Tarragona, Spain
- 10th Task 11 Experts Meeting, 20-23 September, 2010, Terengganu, Malaysia

Task 11 plans to have its final Experts Meeting on 7-8 April, 2011 in Chambéry, France.

TABLE 1 – TASK 11 PARTICIPANTS AND THEIR ORGANIZATION

COUNTRY	NATIONAL CONTACT	E-MAIL
Australia	Wolfgang Meike, Novolta Pty	wolfgang.meike@novolta.com.au
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TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

INTRODUCTION

The growth of the PV market is based on the promise of environmentally friendly energy generation, and is sustained by the support of the environmentally conscious public via market incentives, direct subsidies and R&D support. Without such support the industry cannot grow to levels that would enable the reduction of the price of electricity generated from photovoltaics to the levels of conventional energy generation. Furthermore, continuing diligence on Environmental Health & Safety issues is necessary to safeguard health and 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:

- Quantify the environmental profile of PV in comparison to other energy technologies.
- Define and address EH&S and sustainability technical and perception issues that are important for the market growth.
- 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

Task 12 is subdivided into four Subtasks and 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 Activities in Europe (PV CYCLE)

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/>.

In December 2008, the members of PV CYCLE (currently representing close to 90 % of photovoltaics 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.

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 of PV CYCLE 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 1) were presented at the EU PV Solar Energy Conference in Hamburg in September 2009.

In 2010, 77 new members (including associate members) have joined PV CYCLE. In total, PV CYCLE has 110 full members, representing close to 90 % of the European market and 16 associate members. PV CYCLE has identified a number of collection points in Germany, Italy, France, Spain, the UK, the Netherlands, Czech Republic, Switzerland, Greece, Austria, Slovenia, Belgium and Portugal. In total, 88 of these collection points have been certified. Hellmann Worldwide Logistics has been appointed as the logistics service provider for Germany. The company will report on CO₂ emissions of its transportation activities regarding end-of-life PV modules in Germany.

By the end of 2010, PV CYCLE's Environmental Agreement has been signed by almost 85 % of its members and has become operational during the year 2010. So far, almost 80 tonnes of end-of-life PV modules have been collected in appropriate containers.

Activities in the USA

A recycling scoping workshop was organized and chaired by Vasilis Fthenakis, Brookhaven National Laboratory (BNL) during the 34th IEEE Photovoltaic Specialists Conference (PVSC) in Philadelphia, in June 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 was developed by BNL, to define a "cost optimisation model" for the collection and recycling of PV modules. The model was demonstrated with BNL's best available data derived from recent publications.

Activities in Japan

In Japan, research on PV recycling is ongoing. NEDO has designated the research activities on PV recycling to the Kitakyushu Foundation for the Advancement of Industry, Science and Technology (FAIS).

LCA for recycling of the Chevetogne modules

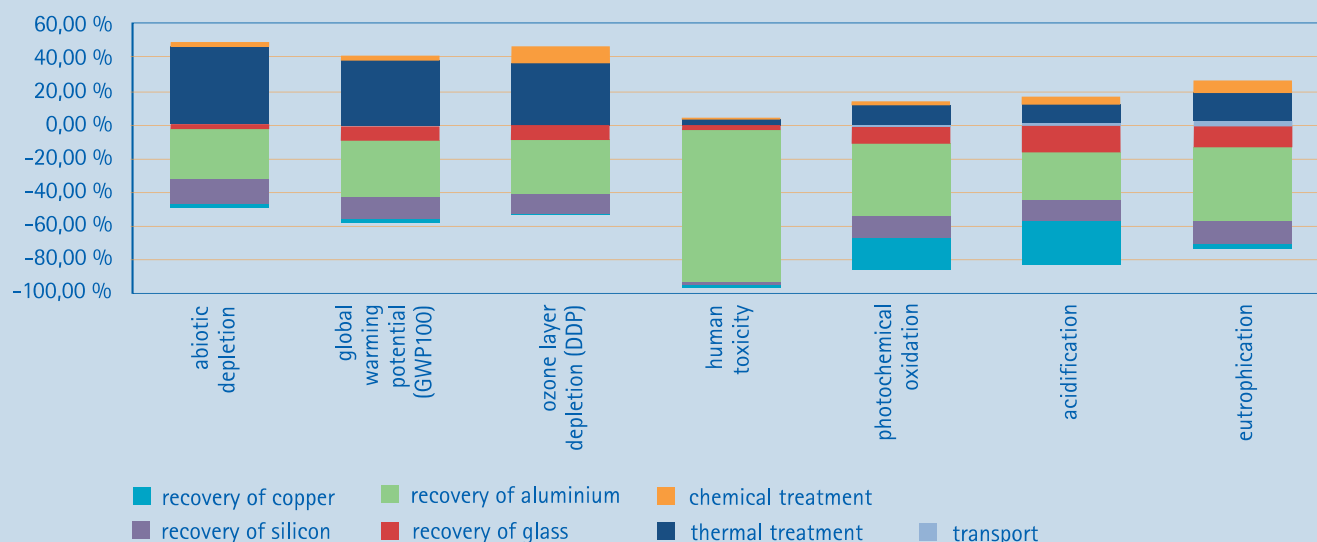


Fig. 1 - Life Cycle Analysis for recycling the Chevetogne modules in the Sunicon (SolarWorld) pilot plant. Negative values represent environmental bonus from recycling. The positive values represent the total environmental impacts with recycling. Source: K. Wambach et al., PV CYCLE - The voluntary Take-Back System and Industrial Recycling of PV Modules, Photovoltaics Recycling Workshop, 34th PV Specialists Conference, Philadelphia, June 11, 2009.

The Kitakyushi FAIS is coordinating the work of the technical committee, in which representatives from the PV Industry (Showa Shell and Shinryo Corporation), from the academic world (University of Kitakyushu, Mizuho Information and Research Institute), from administration (the city of Kitakyushu) are involved. Also METI, JPEA, glass manufacturers and non-iron refinement companies, the building sector, installation companies are involved in the work. This activity focus on establishing a low cost recycling technology by 2015 at which time a recycling infrastructure system will start on a local scale. Subsequently, it will be investigated how the system can be expanded to a national level.

International Activities

In the framework of the international collaboration IEA-PVPS Task 12, EPIA and PV CYCLE hosted 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). The event presented the state-of-the-art PV module recycling and provided a platform for discussion between the PV industry and experienced players in recycling from other related sectors.

The event attracted more than 200 participants. Presentations are available at www.epia.org. A second International Conference will take place Madrid, Spain, in January 2011 in (see section Plans for 2011). During the Task 12 meetings, regular updates regarding the recycling activities from PV CYCLE and NEDO are being presented. As such, Task 12 serves as an excellent platform for the worldwide dissemination of best practices related to the recycling of end-of-life PV modules.

SUBTASK 2: Life Cycle Assessment

Task 12 participants are engaged in ongoing projects on LCA of PV module technologies. 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>

- Columbia University: <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 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. New and updated data has been incorporated during 2010, such as LCI data on chemicals used in PV, materials for mounting structures, efficiencies and electricity consumption for the production of CdTe PV modules as well as updated national PV mixes for all countries. A Life Cycle Inventories (LCI) report is in preparation and will be available in 2011.

SUBTASK 3: Safety in Facilities

EPIA has launched in 2009 a Sustainability Working Group chaired by Karsten Wambach, Sunicon and Marietta Grammenou, Heliosphera. The WG works on environmental, health and safety (EH&S) issues by combining the expertise from the different industry participants.

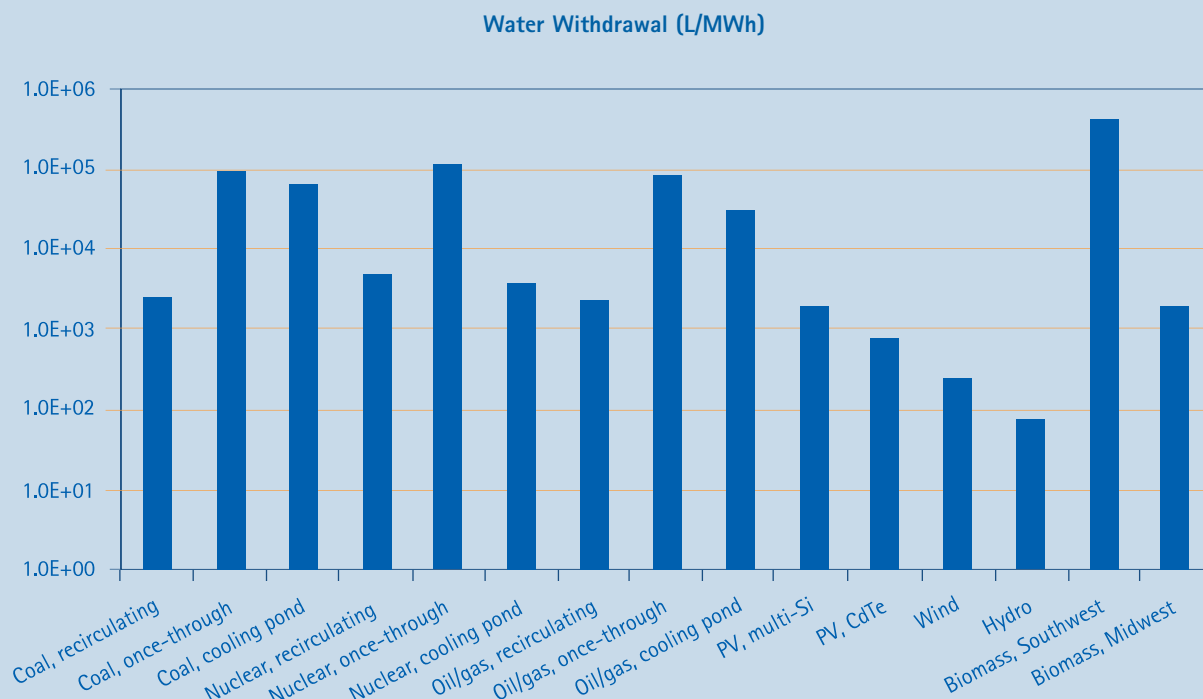


Fig. 2 – Photovoltaic life cycles use three orders of magnitude less water than thermoelectric power plants. Fthenakis V. & Kim HC. Life-cycle uses of water in U.S. electricity generation, *Renewable and Sustainable Energy Reviews*, 14(7), 2039–2048, 2010.

With respect to EHS, the WG has been working during 2010 on the use and handling of hazardous substances and materials during PV production as well as on the topic of fire safety with respect to PV installations. This working group is 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.

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 2011

The 2nd International Conference on PV Module Recycling will take place on the 25th of January in Madrid, Spain. The conference will examine logistics and financial solutions for the collection and recycling of PV modules and technologies that have potential applications in recycling CIGS PV modules. The conference will also include sessions dedicated to presenting experiences from other sectors and other geographical regions; e.g. the Spanish battery take-back and recycling program, the Dutch voluntary flat glass recycling scheme, and PV recycling activities in India and Japan. The PV Life Cycle Inventory Report will be available in 2011. It will include an overview of studies on Life Cycle Assessment (LCA) and will include the LCI data such studies are based on. It is expected that publishing the LCI data will enable additional studies and enhanced information dissemination.

The Task 12 members are examining performance data from new PV installations; based on the results of data compilation, the need of updating the "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" will be evaluated.

A new release of the EcolInvent database (v3.0) is scheduled for late 2011. New datasets will be included; a new modelling approach and data format will be available. The 2010 data should then be implemented in this version. Topics here are the recycling of PV cells, a-Si and other thin film technologies.

Research on the environmental impacts of large PV penetration will be conducted based on specific case studies in different areas worldwide.

PUBLICATIONS

The Task 12 report, "Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity," was updated by Task 12 experts during 2010 and can be downloaded under the Task 12 heading at: www.iea-pvps.org.

Further articles, book chapters and presentations at international conferences can be downloaded at: <http://www.iea-pvps-task12.org/45.0.html>.



Fig. 3 - Task 12 Expert meeting in Madrid, Spain, 25th January 2011.

TABLE 1 – TASK 12 PARTICIPANTS

COUNTRY	ORGANISATION	PARTICIPANT
Austria	Umweltbundesamt	Mr. Werner Polz
Belgium	EPIA	Ms. Eleni Despotou
Belgium	EPIA	Mr. Daniel Fraile
Belgium	EPIA	Mr. Pieterjan Vanbuggenhout
Belgium	PV CYCLE	Mr. Jan Clyncke
Belgium	PV CYCLE	Ms. Virginia Gomez
Canada	5N Plus Inc.	Mr. Maxime Cossette
Canada	5N Plus Inc.	Mr. Marc Suys
Canada	5N Plus Inc.	Ms. Valérie Gravan
France	Centre Energétique et Procédés, MINES ParisTech	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 (Escuela Superior de Comerç Internacional)	Mr. Marco Rauei
Switzerland	ESU-Services	Mr. Rolf Frischknecht
Switzerland	ESU-Services	Mr. Matthias Stucki
The Netherlands	ECN	Mr. Ton Veltkamp (replaced Ms. Mariska de Wild-Scholten)
The Netherlands	Raboud University Nijmegen	Ms. Nellesmieke Mohr
USA	Brookhaven National Laboratory	Prof. Vasilis Fthenakis
USA	Brookhaven National Laboratory	Mr. Hyung-Chul Kim
USA	First Solar	Ms. Lisa Krueger

TASK 13 – PERFORMANCE AND RELIABILITY OF PV SYSTEMS



Fig. 1 – Data acquisition systems at a large one-axis tracking PV installation Germany (photo: Fraunhofer ISE).

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.

The 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 as well as 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 and was 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 started its activities in May 2010.

OVERALL OBJECTIVE

The overall objective of Task 13 is to help market actors to improve the operation, the reliability and the quality of 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 lifetime 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 modules, 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 aim at meeting this challenge by involving these companies



Fig. 2 - Task 13 Expert Meeting at INES, Le Bourget du Lac, France, 25-26 October 2010 (photo: Thomas Nordmann).

at an early stage of the project development. This gives the industry's representatives the opportunity to introduce cooperative and tailor-made activities into the current work. In order to guarantee anonymous processing of the data provided by the industry, standardised reporting forms are being developed and agreements will be established with the project partner in charge of the respective subtasks.

Various branches of the PV industry are being 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 Asia, Europe and the USA.

Two approaches to data collection and analysis of PV system performance are being applied:

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

Task 13 activities are organised 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 standardised format on a monthly basis. The information gathered will be accessible for interested market actors via an online Performance Database. Especially in conjunction with the existing PVPS Task 2 database, the development of typical PV system yields and other performance indicators may be depicted over the last two decades. As well, the database will also be useful as a benchmark for new PV installations.

In cooperation with the industry and national programmes, participants will collect facts on the long-term reliability of PV systems. This comprises information on failure rates and failure modes of the main components, module and inverter, as well as a documentation of

existing PV system faults. As mentioned above, this action will require intense discussions with the related companies and a complete anonymisation of the data. The results 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 great detail. As a first step, a set of standardised graphical representations was developed and introduced to the participants. This will allow for a consistent comparison of different correlations between measured quantities among PV systems in different countries and climatic regions of the world.

In a second step, loss mechanisms will be determined and evaluated by simulation of the system's behaviour. 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 Reliability Assessment

Subtask 3 addresses testing and characterisation methods for performance and reliability assessment of PV modules. Participants review national and regional studies on how to measure the power of thin-film modules and evaluate these from an international perspective. This activity will leverage existing studies to identify ways of reducing the uncertainty of thin-film module measurement and attempt to develop an international consensus for the basis of a recommendation of best practices.

Participants establish a common methodology for analysing field data for PV modules and apply this methodology to modules deployed in a variety of locations around the world. This activity will evaluate

outdoor performance data to identify patterns with the hope of creating ways to better predict performance as a function of changing conditions, instantaneous, daily, and seasonal.

Information on PV module performance and failures in the laboratory and in the field will be collected. Participants review the failure modes findings and classify them in categories regarding their impact on the module performance. Furthermore, measuring methods for the detection of module failures will be reviewed. Information on the state-of-the-art of PV module degradation, identification of main problems due to material properties and failure risk estimations will be collected and provided.

Research results of the degradation behaviour of PV modules, of the comparison of degradation under accelerated stress conditions in the laboratory versus realtime outdoor testing as well as of the climatic parameters influencing the lifetime of the PV modules will be compiled.

SUBTASK 4: Dissemination

This Subtask is focussed on the information dissemination of all deliverables produced in Task 13. The range of activities in this Task includes workshops, presentations, databases and reports. Task 13 discusses the concept of introducing 'active supporters,' i.e. industry partners, funding the project. In return they will receive newsletters, flyers and will be invited to Task Workshops. The objective is to create a "project brand" indicating the supporting of the project as a marketing instrument, of cooperating with industry and preparing real 'industry workshops.'

Task 13 (probably in conjunction with Task 1) will develop a workshop for the 26th EUPVSEC in Hamburg, Germany, first week of September 2011, dealing with PV deployment and PV system performance issues.

MEETING SCHEDULE (2010 AND PLANNED 2011)

The Kick-off Meeting of Task 13 was held in Cologne, Germany, 17-19 May 2010.

The 2nd Task 13 Meeting was held in Chambéry, France, 25-27 October 2010.

The 3rd Task 13 Meeting will be held in Madrid, Spain, 23 - 25 March 2011.

TASK 13 PARTICIPANTS IN 2010 AND THEIR ORGANISATIONS

COUNTRY	ORGANISATION
Austria	Austrian Institute of Technology (AIT)
Austria	Institute of Polymeric Materials and Testing (IPMT), Johannes Kepler Universität Linz
Austria	Polymer Competence Center Leoben (PCCL)
EPIA	European Photovoltaic Industry Association (EPIA)
France	Electricité de France (EDF R&D)
France	Commissariat à l'Énergie Atomique et Énergies Alternatives/ Institut National de l'Énergie Solaire (CEA/INES)
Germany	Fraunhofer-Institut für Solare Energiesysteme ISE
Germany	Institute for Solar Energy Research Hamelin (ISFH)
Germany	TÜV Rheinland Energie und Umwelt GmbH
Israel	Arava Power Company
Israel	Unirom Electronics Ltd.
Italy	European Academy Bozen/Bolzano (EURAC)
Italy	Gestore dei Servizi Energetici - GSE S.p.A.
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Malaysia	Universiti Teknologi Malaysia (UTM)
Malaysia	Universiti Teknologi MARA (UiTM)
Norway	University of Agder
Spain	Universidad Carlos III de Madrid
Switzerland	Scuola Universitaria Professionale della Svizzera Italiana (SUPSI)
Switzerland	TNC Consulting AG
Turkey	ANELES AS
USA	National Renewable Energy Laboratory (NREL)
USA	Sandia National Laboratories

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

TASK 14 - HIGH PENETRATION PV IN ELECTRICITY GRIDS

INTRODUCTION

As PV continues to expand its share of the global electricity generation mix, it becomes increasingly important to understand the key technical challenges facing high penetrations of PV within power systems. Key issues include the variable and somewhat unpredictable nature of PV generation, the power electronics interconnection to the grid and its location within an electricity network typically designed only for supplying loads. Power system protection, quality of supply, reliability and security may all be impacted.

Due to the different characteristics of PV compared to other renewable generation in all of these respects only limited lessons can be learned from more established intermittent renewable technologies such as wind generation.

Overcoming the technical challenges will be critical in placing PV on an even playing field with other energy sources in an integrated power system operation and augmentation planning process and will allow PV to be fully integrated into power system, from serving local loads to serving as grid resources for the interconnected transmission and generation system.

Recognizing that a limited number of high-penetration PV installations currently exist, their effects on the reliability of grid operations are the subject of research programmes in a number of countries around the globe. Even though there are not many representative case studies, it is important to discuss these in a collaborative manner. With further growth of distributed, as well as centralized PV capacities, the need for international R&D collaboration to address this evolving field and to collect and disseminate international knowledge of PV systems at high penetration levels is becoming critical for the further large-scale deployment of PV.

OVERALL OBJECTIVES

Against this background, Task 14 addresses the role of PV in electricity grid configurations with a high penetration of Renewable Energy Sources (RES), where PV constitutes the main RES. Although up to now, no common definition of "high-penetration PV scenarios" exists, there is common consensus 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 Distributed Generators (not only from RES), Task 14 will analyze 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. By international collaboration, issues relating to the role of PV in the future electricity supply system will be investigated; particularly facing future high-penetration scenarios, which are now becoming reality in a number of locations around the globe.



Fig. 1 - IEA PVPS Task 14 Organisation.

The main goal of Task 14 is to facilitate the use of grid connected PV as an important source in electric power systems on a high penetration level where additional effort is necessary to integrate the dispersed generators in an optimal manner. The aim of these efforts is to reduce the technical barriers to achieving high penetration levels of distributed renewable systems in 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.

SUBTASKS AND ACTIVITIES

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

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

Work in pursuit of the foregoing objectives will be performed by photovoltaic system specialists, engineers and researchers working in the fields of planning, as well as installation and research in the Task 14 Participants' countries.

The work programme is organized into four main subtasks and one cross-cutting subtask, which will be the link between the main 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 as collating information for the general public. The objective is to review and



Fig. 2 – Joint Task 1/Task 14 Workshop, "PV in Tomorrow's Electricity Grids: Problem or Panacea?" 26th EUPVSEC, Valencia, Spain, September 2010 (photo: Pius Huesser).



Fig. 3 – 2 MW PV system at U.S. Army Fort Carson, NREL Photographic Information Exchange (photo: NREL).

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*
This work will put together an exchange platform that will allow all members to input information and modeling files. This platform will be accessible to Task 14 members as well as to key researchers they have designated in their respective countries.
- *Collect state of the art information about existing high penetration PV installation including:*
To establish the base case of high penetration scenarios and have the necessary information for subtasks to start working, this activity will lead a data collection phase, which will include a review of the current literature as well as information on existing systems in the various countries. In order to carry this work in a pertinent manner, Subtasks 1–4 will provide the Cross-Cutting subtask with a list of the parameters necessary for their work. An assessment of the current state of the art will be performed and a report on the state of the art and a collection of cases will be prepared.
- *Gather a collection of existing modeling cases for existing installations*
In order to facilitate and ensure repeatability of their modeling work, Task 14 members will have to share their experience and follow consistent approaches for their development work. While it is well admitted that each group may use different platforms for various reasons, the mathematics and physical reasons governing the model should be transposable from one platform to the other. The work of this activity is to collect existing knowledge in an ordered manner and deduct commonalities and differences.
- *Using the knowledge developed in the various Subtasks*
Task 14 work will involve the refinement of numerous models to reach a better integration of PV to the grid. This activity endeavors to merge the findings and advanced control techniques developed in the various subtasks and come up with a set of pertinent cases/scenarios that can be useful to the industry and utilities worldwide in solving PV integration issues.

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, an optimized local energy management and a better understanding of how temporal fluctuation PV penetration level can be improved in grid. The case study will be oriented to demonstrate the feasibility of local high PV penetration in grid (different penetration scenarios and different urban scale in case studies).

This Subtask has the following activities:

- *Review monitoring tools and adapt prediction tools to anticipate the shift in local grid*
This activity will review monitoring and adapt prediction tools to anticipate the shift in local grid to answer to the prediction need of utilities (interaction on solar resource prediction with IEA SHC Task 3).
- *Review and analyze local storage and energy management system to improve the penetration of PV in local grid (Network driven demand side management from a house to a city level).*
A review of Demand Side Management (DSM) – PV approaches in different countries, including profiling (annual, etc.) will be made. The necessity of storage (options) will be investigated in order to achieve an optimum scale for micro smart grids.
- *Characterize temporal fluctuations in relation to local weather conditions, according to the topology of the PV plants (small urban plants with different orientations, MW PV plants) to improve short terms predictions.*

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; concluding with recommendations on grid codes, incentives and regulation. It has the following four main activities:

- *Review of State-of-the-Art of actual and future Distribution Grids with High PV Penetration:*
Information provided by distribution system operators will be used to review the current state of distribution grids with high PV penetration in a number of case studies. The grid operator's

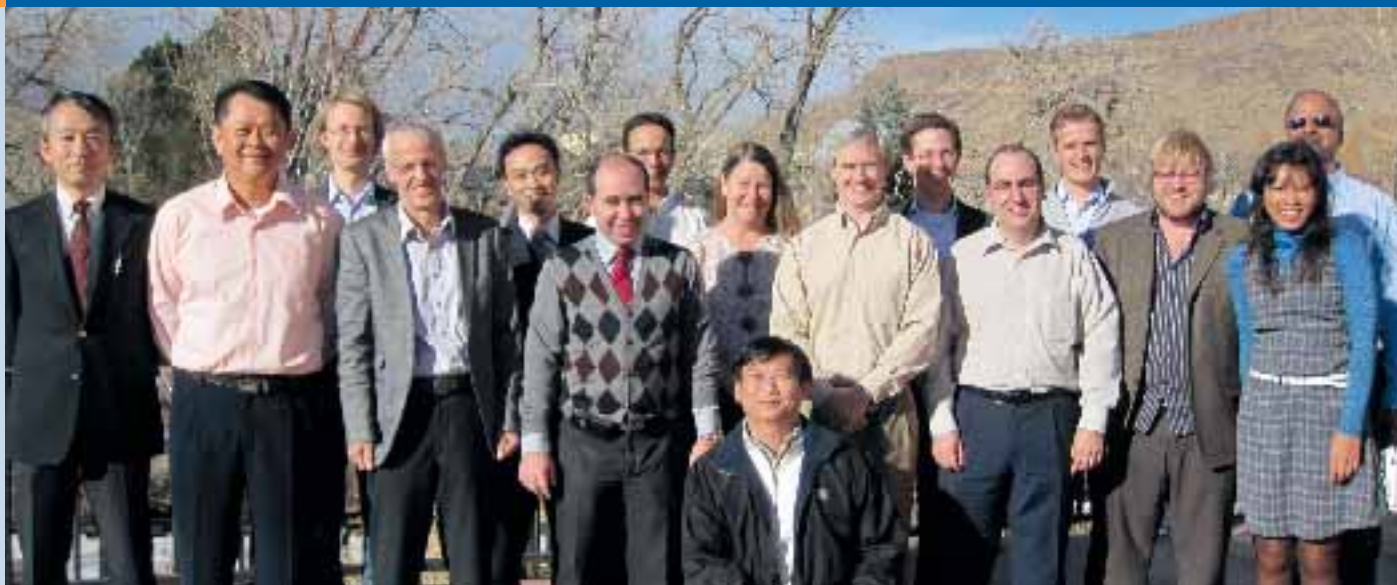


Fig. 4 - Task 14 Experts Meeting in Golden, CO, U.S.A., December 2010.

expectation of the required future grid expansion can be used to identify the future challenges. Following these evaluations, gaps between state-of-the-art and future high PV penetration grids will be identified. This will be compared with information from different countries to identify best practice examples that may be a reference for challenges and solutions.

- *Optimized Reactive Power Balancing in distribution grids: Review of optimization approaches and comparison of impacts on country-specific grids*

Possible optimization approaches for reactive power control, such as central coordinated control and local unit parameterization, will be reviewed. Leading experts (e.g. in Austria, Germany, US, Australia and Japan) already have developed approaches that will be analyzed with regard to their applicability in other participating countries. On the basis of grid simulations, the different impacts on country-specific grids with high PV penetration will be analysed. Aspects to be regarded are voltage stability, losses, component heating and economical impacts. These parameters provide measures to assess the technical effectiveness and economic efficiency of the analyzed approaches of reactive power balancing for country-specific distribution grids in an international benchmark.

- *Optimized Active Power Control Strategies in distribution grids: Review of optimization approaches and comparison of impacts on country-specific grids*

Possible optimization approaches for active power control, such as energy management and curtailment strategies, will be reviewed. Leading experts (e.g. in Austria, Germany, US, Australia and Japan) already have developed approaches that will be analyzed with regard to their applicability in other participating countries. Grid simulations and cost-benefit analyses are used for the investigations and comparisons.

- *Change from Distribution to Supply Grids and Dynamic Studies*
Case studies of distribution grids in different countries with high PV penetration that have changed to supply grids (at least at certain periods of time reverse power flows) are analysed. Dynamic simulation studies assess the challenges and impacts for grid operators. Possible solutions for improving the security of supply and efficiency will be investigated. Steadystate, dynamic simulations and transient simulations will be used and complemented with cost-benefit-analyses.

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. In order to realize high PV penetration to a power system, it is crucial to evaluate the impact and envision the future power system. The focus will be laid on grid interaction and penetration related aspects. Gaps in current PV system technology and electric power system operation practices will be identified. Furthermore, detailed analyses, how large numbers of PV installations can be successfully integrated total power systems including the technology of smart grids will be made.

- *System-wide PV generation analysis and forecast:*
This activity will survey and review the existing methodologies to analyze and forecast the system-wide PV Generation including smoothing effects. Methodologies considering the applicability to different structures of power markets for different forecast-range and accuracy will be evaluated, in order to conduct simulation case studies for selected regions.
- *Power system operation planning with PV integration*
Existing methodologies for long-term power system operation planning including PV integration and Demand Side Management/ Demand Response technologies for DSM/DR will be reviewed, in order to develop criteria and scenarios for case studies including applicability of new technologies such as power storage, generation load dispatch, and DSM/DR. Based on the outcome, simulation case studies of long-term power system operation planning for selected regions will be conducted.
- *Power system augmentation planning with PV integration*
This activity will evaluate and select one or more methodologies and technologies for long-term power system augmentation planning, including PV integration. Criteria and scenarios including new generation technologies, fossil fuel availability and price, power system demand, and energy policy will be developed and simulation case studies will be made for selected regions in order to distill the generic scenarios of PV integration.



Fig. 5 – Task 14 Utility Workshop, Golden, Co, U.S.A., December 2010.

SUBTASK 4: Smart Inverter Technology for High Penetration of PV

PV inverters play a key role as interface between PV generation and the electricity grid and integrate grid protection, system monitoring and control functions and also act as interface to storage. Subtask 4 addresses the inverter technology, technical requirements and standards, and system integration aspects for successful smart integration of a high penetration of PV by effectively applying the opportunities offered by modern power electronics. The activities include:

- *Outline of opportunities for smart PV inverters in high-penetration scenarios*
Current functional, protection, control, safety and other requirements for inverters will be reviewed and the impact of different applications (residential vs. utility scale), connection levels (Low Voltage, Medium Voltage, etc.) and network topologies (feeder length, etc.) will be investigated in order to define performance, operating ranges and utility compatibility with high penetration PV.
- *Analysis of technical capabilities and Inverter Topologies including simulation modeling of devices*
A collection and review of the suitability of different hardware and control topologies for the application in High PV Penetration scenarios will be made. The impact of additional functionalities on the design, dimensioning and performance of PV inverters will be investigated, aiming at the improvement of available inverter simulation models.
- *Review and Analysis of remote control and communication for Smart Inverters*
This activity will include a review of remote control practices (interfaces, communication technologies, protocols, etc.) and currently available communication standards suitable for Smart Inverters. The aim is to assess the suitability of current standards/practices for high PV penetration scenarios.

PROGRESS AND ACHIEVEMENTS 2010

In September 2010, Task 14 together with Task 1 organized a Joint Task1/14 work-shop at the European PVSEC/ WCPEC in Valencia,

discussing high penetration issues under the headline "PV in Tomorrow's Electricity Grids: Problem or Panacea?" With more than 70 participants from industry, utilities, manufacturers and research, the Task 1/14 workshop was a great success and attracted broad interest from all stakeholders. The workshop program included seven presentations in two sessions. The first session was provided by Task 14 experts and gave an in depth insight into technical challenges associated with the massive deployment of PV into the electricity grids. The second session presented recent and upcoming demonstration projects from Europe, Japan and the U.S., where the efficient integration of PV is demonstrated in a realworld environment. Two panel discussions following each session's presentations concluded the workshop agenda.

A second workshop targeting utilities as one of the main stakeholder groups was held in early December 2010 in Golden, Colorado, USA. Hosted by the U.S. Department of Energy, the National Renewable Energy Laboratory, and the Solar Electric Power Association the "IEA PVPS Task 14 – High Penetration PV Workshop" brought together representatives from U.S. utilities and IEA-PVPS Task 14 experts. Following the presentations of case studies, successful examples of high penetration photovoltaic projects and the associated challenges from the United States, Europe and Japan were discussed.

Task 14 Workshop presentations from both workshops held in 2010 are publicly available for download at the IEA PVPS website Workshops section: <http://www.iea-pvps.org/workshops/>

SUMMARY OF TASK 14 ACTIVITIES PLANNED FOR 2011

Task 14 activities in 2011 will focus on the collection of case studies of high penetration PV scenarios in the participating countries. The cases include PV penetration scenarios in local distribution grids, as well as from the overall power system wide perspective. The objective of this activity is to provide recommendations for managing grid with high penetration of PV.

In addition, another focus for 2011 will be the investigation of the suitability of Forecast Tools with respect to high penetration PV; linking together weather forecasts, prediction and monitoring tools.

INDUSTRY INVOLVEMENT

Since Task 14's beginning, industry has been directly involved in the development of Task 14's concept and Workplan. In addition, a number of PV industry and utility representatives also participate in the Task 14 group. The main goal is to provide access to more transparent technical analyses in order for industry, network operators, energy planners as well as authorities in the energy business to decide on steps to be taken and strategies to be developed on a sound basis. During 2010, Task 14 actively integrated industry by organizing special workshops for knowledge exchange between experts from utilities and the Task 14 group.

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.

During 2010, Task 14 work was presented at some of the key events, including the paper "Bringing Together International Research of High Penetration PV in Electricity Grids - The New Task 14 of the IEA-PVPS Programme," which was presented at the 26th European PVSEC/ WCPEC in Valencia, September 2010.

In addition, Task 14 was presented at the 4th International Conference on Integration of Distributed Energy Resources in Albuquerque, New Mexico, USA, in December 2010.

For the upcoming periods, the publication plans of the joint activity will include:

- A first data collection which shall 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 and 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.

MEETING SCHEDULE (2010 AND 2011 PLANNED)

2010:

- Kick-Off Meeting, April 12-14, 2010, hosted by AIT, Vienna, Austria
- 2nd Experts Meeting and Utility Workshop, December 2-4, 2010, 2nd Experts, hosted by NREL, Golden, CO, U.S.A.

2011:

- 3rd Experts Meeting, May 11-13, 2011, hosted by EDP, Lisbon, Portugal
- 4th Experts Meeting, November 2011, location to be defined

TABLE 1 - LIST OF TASK 14 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
AUS	Ian McGill	University of NSW
AUS	Glenn Platt	CSIRO Energy Technology, Australia
AUT	Roland Bründlinger	AIT - ÖFPZ Arsenal GmbH
AUT	Christoph Mayr	AIT - ÖFPZ Arsenal GmbH
CAN	Ravi Seethapathy	Hydro One, Ontario
CAN	Andrew Swingler	Schneider Electric
CAN	Dave Turcotte	Natural Resources Canada
CHE	Lionel Perret	Planair SA, Switzerland
CHE	Jan Remund	Meteotest
CHE	Pierre Renaud	Planair SA, Switzerland
CHN	Wang Yibo	Chinese Academy of Science
DEU	Gunter Arnold	Fraunhofer IWES
DEU	Martin Braun	Fraunhofer IWES
DEU	Olivier Führer	SMA Solar Technology
DNK	Kenn H. B. Frederiksen	EnergiMidt A/S
ESP	Vicente Salas	Universidad Carlos III de Madrid
ISR	Moshe Ohayon	Israel Electrical Company
ITA	Daniel Bacchiocchi	GSE, Gestore dei Servizi Energetici
JPN	Yukihiko Maede	NEDO
JPN	Kazuhiko Ogimoto	The University of Tokyo
JPN	Hiroshi Takemoto	New Energy and Industrial Technology Development Organization (NEDO)
PRT	Rui Andres	EDP Inovação, S.A.
PRT	Joao Maciel	EDP - Energias de Portugal
SWE	Muhamad Reza	ABB Corporate Research
USA	Christy Herig	SEPA
USA	Benjamin Kroposki	National Renewable Energy Laboratory

AUSTRALIA

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

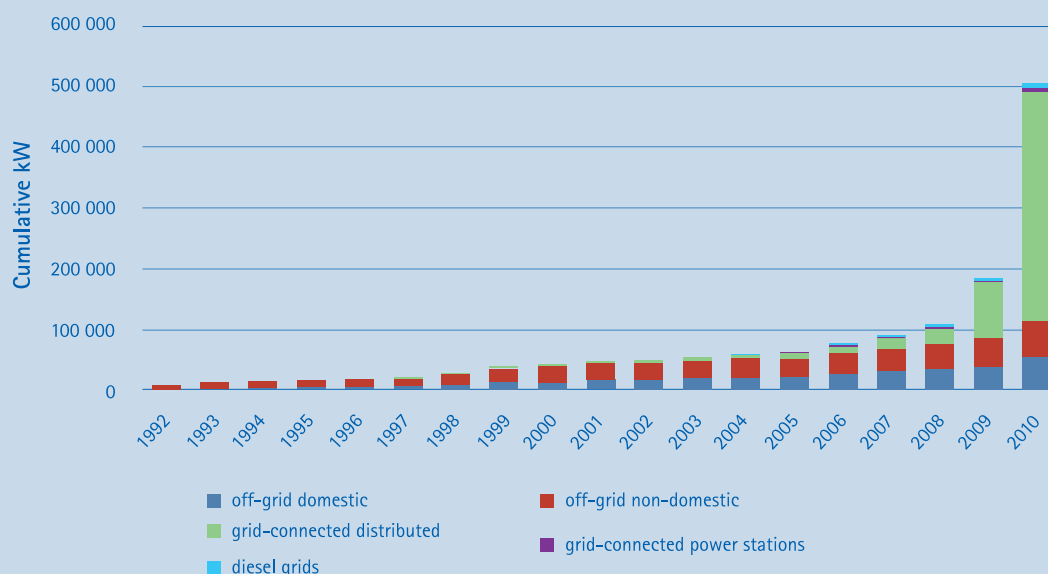


Fig. 1 - Cumulative PV Power Capacity Installed in Australia (1992-2010).

GENERAL FRAMEWORK

The Australian grid-connected PV market grew significantly in 2010, due to the support available through the Renewable Energy Target, State based feed-in tariffs, schools programs and a high Australian dollar.

PV is now well recognized across Australia, and has high public support. Electricity prices are rising rapidly in all jurisdictions and, if PV prices continue to fall in line with international trends, it will become increasingly attractive over this decade, even without government subsidies.

Rapid market growth has been accompanied by significant industry growth and demand for accredited installers. Governments and industry associations are committed to ensuring PV products and installations are of high quality, so more rigorous inspection regimes and training have been implemented. High levels of uptake are also shifting the technical and regulatory focus onto changed grid management techniques, new tariff structures and targeted deployment strategies.

NATIONAL PROGRAMME

Australian Government support programs impacted significantly on the PV market in 2010, especially the Renewable Energy Target, which aims to increase renewable electricity from 8 % to 20 % by 2020. The target uses a 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. For off-grid systems, the multiplier is available for systems up to 20 kWp. The multiplier reduces each year.

Other Australian Government support includes the National Solar School Program, 7 Solar Cities, Solar Flagships (2 large-scale PV systems) and R&D support.

R & D, D

Research Institutes and Funding

The Australian Solar Institute was established in 2009 to drive collaborative, focused R&D which improves the efficiency and cost effectiveness of PV and solar thermal electric technologies. It commenced funding of PV research and development projects in 2010 with core funding to the University of NSW, the Australian

TABLE 1 - SOLAR CREDIT SCHEDULE

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



Fig. 2 - 65 kWp PV System on a heritage listed building at Cockatoo Island, NSW, generating 100 MWh/yr (photo: Solgen Energy Pty Ltd).

National University and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) as well as project specific research at a range of other research centres and industries. Research funding is also provided through the Australian Research Council. The Australian Centre for Renewable Energy was formed in 2010 and will provide funding for development and commercialization of renewable technologies.

Public funding for PV R,D&D in 2009 was dominated by the 499,5 MAUD in market support provided through the Solar Homes and Communities Plan. A further 26,8 MAUD was provided from Commonwealth, State and Local governments for PV research, development and demonstration. Funding from the Australian Solar Institute began in 2010, with over 50 MAUD allocated.

The CSIRO operates the National Solar Energy Centre and works with government, universities and industry on a range of projects including organic solar cells, smart grids and evaluation of PV technologies.

University Research

At the Centre for Sustainable Energy Systems, Australian National University, research covers defect detection and surface passivation in silicon wafers; high performance silicon solar cells, including SLIVER solar cells; modelling; plasmons and nano PV technology; PV modules, hybrid PV/thermal parabolic trough concentrator systems; and solar cooling.



Fig. 3 - 9,8 kWp Silex Solar PV System on a barn in Sutton Forest, NSW (photo: Todae Solar Pty Ltd).

Murdoch University research covers silicon nanowires, quantum dots and amorphous silicon. PV systems research encompasses BOS components (e.g. fuses and circuit breakers for overcurrent protection in PV systems) and issues associated with transformerless inverters in grid connected PV systems.

The University of NSW undertakes research into improving efficiencies and reducing costs of 'first generation' crystalline silicon cells and modules; development of 'second generation' thin silicon layers on glass; 'third generation' high efficiency thin film cells; and silicon photonics. The University provided the key contribution to a multi-cell combination that set a new outright record of 43 % efficiency for converting sunlight into electricity by any means, irrespective of complexity or cost.

Specific areas of solar energy research undertaken at the University of Queensland include organic and hybrid solar cells, nano-structured photoanodes, adaptive and smart grids, frequency and voltage stability, new inverter technologies, and modelling the effect of distributed and utility-scale solar energy deployment on the National Electricity Market. The University has implanted a new "Micro-Grid" strategy which seeks to deploy major renewable energy infrastructure across multiple campuses.

Queensland University of Technology undertakes research in the areas of dye-sensitized solar cells, polymer solar cells, direct coupled PV applications for chemical and electrolytic processes, PV powered nanosensors for wireless technology, performance evaluation and economic analysis of PV systems, BIPV, and high penetration PV.

Demonstration and Field Test Programs

The Alice Springs Desert Knowledge Solar Centre monitors many different and innovative PV technologies, including refractive concentrators using Fresnel lenses, hybrid solar cells which combine crystalline and amorphous silicon layers and large scale tracking systems suitable for commercial power generation. By end 2010, 22 systems were installed at the Solar Centre.

TABLE 2 – STATE BASED FEED-IN TARIFFS

STATE	START DATE	SIZE LIMITS	RATE AUD C/KWH	DURATION YEARS	TYPE	CAP	ELIGIBILITY
Victoria	2009	5 kW	60	15	Net	100 MW	Residential, community, small business
South Australia	2008	10 kVA 1Ø 30 kVA 3Ø	44	20	Net	Review at 10 MW	< 160 MWh/yr electricity use
Australian Capital Territory	2009	< 30 kW	45,7	20	Gross	15 MW residential 15 MW commercial / industrial	Residential, business, industry
Northern Territory	2008	AUD 5 per day cap	51,28 Domestic: 19,23	To 30 June 2013	Gross	AUD 5 / day	Alice Springs Solar City only (fully subscribed)
	2008	< 30 kVa	Commercial: 22,37	On-going	Gross	n/a	Residential / commercial. If > 30 kVa, rate is negotiated with PWC
Queensland	2008	10 kVA 1Ø 30 kVA 3Ø	44	20	Net	Review at 8 MW	< 100 MWh/yr electricity use
New South Wales	2010	10 kW	60 20	7	Gross	50 MW 300 MW	Fully subscribed
Western Australia	2010	5 kW (city) 10 kW (country)	40	10	Net		Residential

IMPLEMENTATION

In addition to the National PV Programmes described above, a range of State based feed-in tariffs apply across Australia, as shown in Table 2.

INDUSTRY STATUS

Silex Solar began cell and module production in early 2010 and will gradually increase production from 13 MW to 20 MW in 2011, and to 35 MW in 2012, if demand remains strong. The company expects to increase product efficiency from 17 % to 20 % by 2012. Silex also owns PV concentrator company Solar Systems and plans to build a 100 MW plant in Victoria.

Australian company BT Imaging commercialised its luminescence imaging technology. The first product, the LIS-R1™ is a flexible offline R&D tool that allows fast and highly spatially resolved characterisation of silicon bricks prior to wafering, silicon wafers at any processing stage or fully processed silicon solar cells. It is also developing a range of inline characterisation tools.

The Dyesol group is a world leader in development and commercialisation of dye solar cells (DSC). Dyesol continues to work towards higher performance with single cells and with tandems; long

term stability over 20+ years in the field; and development of lower cost materials and processes to achieve grid parity.

XeroCoat is a start-up company commercialising a new solar anti-reflection coating based upon a novel liquid sol gel coating process which produces nanoporous silica thin films of the correct refractive index for anti-reflection coating glass and plastics in the visible solar window. The technology can increase the power output from a solar PV panel by 3 %. The company is now based in Silicon Valley, CA and maintains its research and development in Brisbane.

MARKET DEVELOPMENT

PV installations in 2010 are estimated to be around 320 MW, up from 79 MW in 2009. The most significant change is the high uptake of grid-connected, distributed systems, with installations increasing from 14,8 MW in 2008 to 67,4 MW in 2009 and to an estimated 280 MW in 2010, due to the generous Renewable Energy Credits and Feed-in Tariffs available. Total installed capacity in Australia is now over 500 MW, producing over 900 GWh per year.



Fig. 4 - Residential PV system (photo: Silex Solar).

FUTURE OUTLOOK

Solar Flagships

In May 2009 the Australian Government announced a call for 1 GW of solar generation via 4 solar power stations (including solar thermal and PV). A total of AUD 1,5 Billion has been allocated towards the Solar Flagships program. The Australian Government has indicated that it expects to contribute one dollar of Commonwealth funding for every two dollars of private and state/territory government funding.

The Solar Flagships program is split over two funding rounds with the first round to target 400 MW of electricity generation. Announcement of the successful PV and solar thermal projects for Round 1 is expected to be made in the first half of 2011. The call for Round 2 applications, targeting the remaining 600 MW of solar generation is expected in 2013-14. All projects must include a research infrastructure component.

Proposed Changes to the Renewable Energy Target Legislation

With small-scale solar installations taking up an increasing portion of the Renewable Energy Target, the scheme has been separated into two parts: a Large-scale Renewable Energy Target (LRET), with a target of 41 000 GWh by 2020 and a Small-scale Renewable Energy Scheme (SRES) for which the Solar Credits mechanism described earlier applies. Liable parties will be required to purchase RECs from both markets, with a limit of 14,8 % in 2011 from small generators. A government clearing house has been established for SRES, and provides a fixed REC price of AUD 40. Buyers and sellers of small-scale RECs can use the clearing house, trade directly with each other or via independent REC traders.



Fig. 5 - Solar System concentrating PV dish (photo: Silex Solar).

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - Blue Chip Energy's the "Energy Efficient Greenhouse" (photo: © Blue Chip Energy).

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

The Austrian Photovoltaic Industry is composed of mainly internationally acting production companies which could perform also in 2010 quite well; Traditional export rates of the individual production companies are frequently 90 % or even more, because the home market is still small, even though the on-going increase since 2009 might be a step to a larger home-market.

The public support schemes are more or less continuously under discussion and experience a yearly change which allows private users and investors only short time planning.

The total available budget for supporting PV Systems generally addresses only a small amount of the huge number of prospective buyers of PV systems in Austria. However, with the decreasing cost of PV systems, the support scheme allowed many more systems to be co-financed by public money in 2010. The PV Association anticipated more than 50 MW as the installation rate in 2010, which would more than double the 2009 numbers.

Austria has mainly three levels of supporting PV systems. Different from other countries, the feed-in-tariff system will only be responsible for the minor part of the supported PV systems in Austria:

- Feed-in Tariff is provided via the national green-electricity act (GEA), firstly issued in 2002, and meanwhile revised several times. Even though the "new RES" are supported by this act, mainly via up to 13 years guaranteed feed-in tariffs, the financial cap (current regulation: new PV-installations leading to another expenses of 2,1 MEUR per year) is low. 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. At the end of 2010, the Ministry published to increase this amount, however, not backed by concrete numbers. A significant change of the 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.

- Systems up to 5kW are supported by the also limited sources of the governmental Austrian Climate and Energy Fund. This public 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. In 2009, the budget was doubled leading to about 7-8 MW of PV installations. In 2010, 35 MEUR might have led to an estimated 20 MW of installations since the support per kW installation was reduced significantly according to the lower PV prices. This support scheme provides additional financial benefits to building integrated systems (BIPV).
- Besides that, some regions provide PV support budgets as well. Especially the province of Lower Austria provided significant means in 2009 and 2010, but has more or less stopped this support at the end of 2010.

However, these various initiatives, leading to some ten Megawatts per year are, by many PV stakeholders, not seen as appropriate basis to seriously and continuously introduce PV as a significant source of electricity into the energy system. The Austrian Photovoltaic

Association announced 8 % of total electricity by PV to be realistic until 2020, if the support system will become more reliable and some framework conditions will be changed accordingly. At the end of 2010, about 0,1 % of the total electricity was provided by photovoltaics.

The Federal Ministry of Economy, Family and Youth, as well as the Federal Ministry of Agriculture, Forestry, Environment and Water Management, managed an energy strategy process involving more than 100 experts in order to derive a strategy in compliance with the European 20-20-20 targets; to achieve the 34 % renewable target for Austria until 2020. Currently Austria stays with 30 % in 2009, making 34 % in 2020 a quite easy target.

RESEARCH AND DEVELOPMENT

The National PV Technology platform, founded in September 2008 along with the 6th Austrian PV conference, experienced a very good development in 2010. Through support from the Ministry of Transport, Innovation and Technology, a financial basis now provides more backing in order to achieve the following targets: The PV Technology Platform brings together about 25 leading Austrian PV-Industries, Universities and Research Institutes in order to discuss their needs for a long term strategy towards an international competitive positioning on the growing world market. At the end of 2009, about 2 800 employees were working in the PV industry in Austria. This initiative is coordinated by the University of Applied Sciences Technikum Vienna. Public awareness for the achieved performance and the further outstanding opportunities for the Austrian photovoltaic industry, aim at further improving the frame conditions for manufacturing and innovation in Austria, as well as innovation workshops, in order to boost research and innovation as the main goals of the Austrian PV technology platform.

For many years, the Austrian PV research activities have mostly been 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 and, concerning grid interconnection of renewables, in the IEA ENARD Implementing Agreement. The RTD development and approach is widespread located and decentralised orientated.

Two national programmes, "New Energy 2020" by the Austrian Climate and Energy Fund, as well as "Buildings of Tomorrow Plus," again by the Ministry of Transport, Innovation and Technology, were launched already in 2008 and cover quite broad research items on energy technologies including a specific PVfocus.

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

The electricity companies have more and more focus on the development of new renewable. Sometimes specific 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 frequently invest in other European countries.

Austria's currently largest (1 MWp) PV system near Eberstalzell, by the Upper Austrian utility "Energie AG", went into operation in 2010. Other very relevant PV activities were implemented by Verbund - Austrian Renewable Power and many other utilities. PV and the high penetration in some parts of the low voltage network become more and more drivers for the comprehensive and internationally orientated "Smart Grid" activities in Austria, which are coordinated and supported by the Ministry of Transport, Innovation and Technology.

Research Highlights of Photovoltaics in Austria are:

- The AIT Energy Department focuses on the strategic research fields "Electrical Infrastructure" and "Energy for the Built Environment." The integration of PV into Smart Electricity Networks is in the centre of research efforts in the field of distributed energy resources (DER). Low and high voltage technology, power quality, safety and reliability analysis are investigated. In 2011, an extensive laboratory infrastructure for high power testing of DER will be developed. Since 2003, AIT Energy runs a fully fledged Photovoltaic Module Test Laboratory, accredited according to EN 17025, for R&D on crystalline and thin-film modules. With this background, research focuses on new PV technologies, advanced experimental investigation, characterisation and modelling of PV modules, cells and systems. Regarding PV performance, the simulation of system output and life-cycle testing as well as building-integrated PV systems (BIPV) are addressed. On a European level, AIT Energy is participating in the DERlab Network of Excellence, in projects like METAPV and EcoGRID as well as in the EU infrastructure projects DERri and SOPHIA; offering access to its research infrastructures in the areas PV, inverter and power technologies. On an international level AIT Energy is engaged in national and international standardisation for distributed generation and PV systems. It takes part in several IEA PVPS activities, such as Task 13 (Performance and Reliability of Photovoltaic Systems), and holds the lead in Task 14 (High Penetration of PV Systems in Electricity Grids).
- 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.
- In the Christian Doppler Laboratory for Nanocomposite Solar Cells scientists of **Graz University of Technology** and NanoTecCenter Weiz Forschungsgesellschaft are working in cooperation with the industry partner ISOVOLTAIC AG on new nanostructured materials for flexible organic based photovoltaic modules which can be fabricated with roll-to-roll processing technologies.
- 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.



Fig. 2 – HEI Solar Light GmbH's stand-alone solar LED lighting systems: The hei solar light™ (photo: HEI Solar Light GmbH).

- **Ofi** – Austrian Research Institute for Chemistry and Technology – started research activities in the field of the (accelerated) aging behaviour of PV-modules and materials in 2009. Ofi will focus their PV research in the following years on aging tests including the influence of air pollutants on PV modules and on polymeric materials/ composites used for module production. With innovative and highly sensitive analytical methods, material incompatibilities and their influence on module performance will be investigated in line with the aims of the IEA PVPS TASK 13.
- **Vienna University of Technology**, Energy Economics Group (EEG), are covering 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 as well as medium and long term diffusion scenarios of PV.
- At the Energybase, the largest passive Solar office building in Austria, the **University of Applied Sciences Technikum Vienna** offers Bachelor and Master Programmes with a strong focus on PV and other solar technologies. Research at the University Institute is focused on PV strategies as well as on system and building integration.
- 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 where also the 17 kWp PV system – 5 different module types, 5 different inverter types, 2 monitoring/data logging systems, meteorological station – are used for practice.

- The **Institute of Polymeric Materials and Testing (IPMT)** at the Johannes Kepler University Linz (JKU) was established in 09/2009 and has now completed its first phase of laboratory investments, thus achieving full operation capability. Key individuals of the IPMT have a broad experience in the field of plastics for solar applications and expertise and know-how related to coordination and management of large research projects. In 2010, the JKU with the IPMT started a Project entitled "Solar-electrical Systems based on Polymeric Materials: Novel Polymeric Encapsulation Materials for PV Modules."
- The **Polymer Competence Center Leoben (PCCL)** is working in the field of polymeric encapsulation materials for solar cell and PV module encapsulation. Since 2003 the main focus of the research was set on durability testing, lifetime modelling and aging characterization of polymeric materials and components as well as the evaluation and qualification of new materials for PV encapsulation. A newly installed research focus is the establishment of correlations between material properties, processing parameters and PV module failure.

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 52 MW of PV power had been installed in Austria by the end of 2009. No figures for 2010 are available yet, but it is expected that about 100 MW were totally installed in Austria at the end of 2010.

The annual growth rate in 2009 was, with a total of 20,2 MW, almost five times the rate of 2008, and by far the largest rate ever. 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 much more than 95 % of the total capacity. Grid-connected centralised systems in form of PV power plants play a minor role, even though the before mentioned largest system is a centralised one. Building integration is an important issue and a cornerstone of the public implementation strategy; some more quite remarkable installations were realised in 2010.

The governmental **Austrian Climate and Energy Fund** issued a new funding initiative for building integrated PV in prefabricated single-family houses, which was quite well accepted by this specific industry.

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

The Austrian PV industry could still expand their activities during 2010, focussing on the export of their products predominately to the booming European and non-European markets. In Austria, about 2 800 employees in the PV business seem to be a success, but this is dependent very much on the development outside the borders of the country.

AT&S used their knowledge as European market leader and one of the world's strongest performing PCB manufacturers and transferred it into the PV segment. The outcome is, that AT&S installed a 40 MW automated manufacturing line for conductive backsheet foils which will be the base for every backcontact technology module manufacturer. In addition, AT&S offers specific solutions of PV modules for all types of applications (ex.: triangles; colorized; semitransparent; personalized, etc.).

Blue Chip Energy produces high efficient monocrystalline solar cells with a yearly capacity of 87 MWp. Currently, approximately 140 employees are working in the company. Besides cell production, Blue Chip Energy offers complete solutions in the field of photovoltaics and photovoltaics integrated solutions; e.g., the "Energy Efficient Greenhouse."

Crystalsol is developing a new type of flexible photovoltaic module with a significant versatility and cost advantage, compared to currently known photovoltaic technologies. Crystalsol's first product will be a low cost semi-finished photovoltaic film for the building integration market. 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.

Since 2004, **Energetica** has been producing high quality PV modules with sophisticated technology and attractive design at its own production facility. The core competences are clearly defined as producer of PV-modules, system provider and project contractor.

Since the beginning of 2010, the **Ertex Solartechnik GmbH** is an independent company with the main investor ERTL Glas. Their main product is the laminated safety glass module (VSG) which can be also easily assembled to insulating glass. In 2010, **ertex solar** realized projects mainly in Austria, Germany and France, and also in overseas countries such as Singapore or Mexico. Beside the VSG, **ertex solar** also implemented their INTEVO, a roof system which provides energy and water tightness.

Falconcell Productions GmbH is the first manufacturer of high quality multicrystalline silicon solar cells in Austria. Founded in 2006, Falconcell began operations in 2007 with a production capacity of 30 MWp.

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 among the top 3 inverter manufacturers in the world. The company has sales subsidiaries in 13 countries such as Australia, Germany, Italy, France, Turkey and USA.

HEI Solar Light GmbH is the leading Austrian Energy Technology Company specialised in developing and manufacturing, stand-alone solar LED lighting systems. **hei solar light™** shapes a minimalist design together with innovative technology into a uniform and integrated whole. The company started production in 2007 and is rapidly expanding fabrication facilities. At present, their main achievement is the installation of decorative and efficient solar lights for the outdoor lighting of Masdar City, located in the United Arab Emirates.

ISOVOLTAIC AG is the global market and technology leader in the development and production of backsheets for photovoltaic modules. It has 25 years of experience in the production of high-quality composite protective sheets for solar cells – the well-established ICOSOLAR® backsheets.

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

Lisec Maschinenbau GmbH provides fully automatic production lines for any kind of PV modules based on the Lisec encapsulation technology, which benefits from 50 years of experience in the production of insulating glass. The tempered thin glass used for the glass-glass modules guarantees more robust, absolutely diffusion-proof and highly efficient PV-modules.

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

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

PVT Austria Photovoltaik Technik GmbH, is the first manufacturer of PV modules in Austria, since 2001. PVT produces standard and tailored modules from mono and multicrystalline silicon solar cells. The company successfully ramps up their production capacity to 50 MWp per year, trend increasing.

HILBER SOLAR GmbH: Based on 20 years' experience in the development, production and implementation of solar technology and with more than 180 MW in total installations, HILBER SOLAR is currently launching its new product family "SOLWING." After starting with SOLWING T, a new, multi-axis tracking system which for the first time is designed for private, commercial and industrial customers, further cutting-edge solutions will follow.

RESolution is a division of **EBNER Industrieofenbau**, a worldwide leading supplier of thermal equipment. RES offers heat treatment equipment for thin film PV applications such as CIGS, CdTe or other functional materials.

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, such as batteries, inverters, cell-wiring or mounting systems.

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

Welser Profile is a manufacturer of cold-roll formed, customised and bespoke special sections, tubes, components and complete profile systems made from steel and non-ferrous metals. Welser Profile use their professional know-how to create optimized and long lasting system solutions for the global production of solar energy; e.g., mounting posts, carriers and longitudinal carriers, as well as a wide range of profiles required for base constructions.

MARKET DEVELOPMENT

The Federal Association Photovoltaic Austria is very active in public relations, in creating a national network to distribute information on PV and in initiating various workshops, press conferences and other awareness raising activities. By fostering the political contacts, intensive political lobbying work and a broad series of articles in newspapers for PV, the association is aiming at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives preferably based on feed in tariffs. At the end of 2010, much more than 150 companies and persons involved in the PV business were members of the Association.

The 8th Annual National Photovoltaic Conference (a two day event in 2010, organised by the University of Applied Sciences Technikum Vienna and supported by the Ministry of Transport, Innovation and Technology), is THE established annual "get together" of the Austrian PV community, bringing together about 250 PV stakeholders in industry, research and administration. The "PV Congress," a further annual event, organised by the Austrian Climate and Energy Fund, was introduced in 2010. It aims at addressing mainly the installation companies, as well as the end users.

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 150 participants in 2010.

FUTURE OUTLOOK

The situation of the steadily growing export oriented Austrian PV industry is expected to be further improved, mainly due to the further booming global PV market.

In general, the situation of the local PV market is improving but would benefit from more stability in the support system.

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

PV research and development will be further concentrated on international projects and networks, following the dynamic know-how and learning process of the worldwide PV development progress. Mainly within IEA PVPS, Task 14 on "High Penetration Photovoltaic in Electricity Grids," commenced in 2010 and lead by Austria, might become a focal point of the international research activities. However, the national energy research programmes are also more and more dedicated to PV issues, with many projects now in operation.

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 also to be mentioned; where PV plays a more and more 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, some new courses are currently under development. All of them include PV as an essential part of the future energy strategy. The importance of proper education for 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 their education.

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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([HTTP:// WWW.CANMETENERGY.NRCAN.GC.CA](http://www.canmetenergy.nrcan.gc.ca))



Fig. 1 – Enbridge and First Solar 80 MW Sarnia Solar Project, the largest operating photovoltaic facility in the world in 2010 (photo: Enbridge Inc.).

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], the ecoENERGY Technology Initiative [3], and the Clean Energy Fund [4].

The Province of Ontario, Canada's second largest province, leads the country in photovoltaic (PV) investment. In 2010, the Ontario Ministry of Energy reaffirmed, in its Long Term Energy Plan [5], its commitment to "maintaining a clean, modern and reliable electricity system." Renewable energy sources, such as solar and wind, are slated to play a prominent role in new generation, assisted through continuation of the successful Feed-in Tariff (FIT and micro-FIT) programs [6] administered by the Ontario Power Authority (OPA) [7]. As of the third quarter of 2010, the OPA had 3098 MW of in-service generation capacity from renewable energy, 170 MW of which was PV. Another 1144 MW of PV capacity is under development [8]. In 2010, the world's largest solar-PV facility was in operation in Ontario by the Enbridge and First Solar 80 megawatt Sarnia Solar Project (Fig. 1) [9].

NATIONAL PROGRAMME

RESEARCH AND DEMONSTRATION

NRCan's CanmetENERGY is responsible for conducting PV R&D activities in Canada that facilitate the deployment of PV energy technologies throughout the country. The PV program coordinates national research projects, contributes to international committees on the establishment of PV standards, produces information that will support domestic capacity-building, organizes technical meetings and workshops to 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.

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: whereas in the past electrical power was generated in large power plants, sent to the consumption areas through transmission lines, and delivered to consumers through a passive distribution infrastructure, the electrical grid is now moving to a distributed and dynamic power generation and Smart Grid infrastructure. This has significant implications for PV development and investment, as it lends itself to integration across the electricity distribution systems. CanmetENERGY is responsible for delivering on the R&D mandate of the Grid Integration of Renewable and Distributed Energy Resources (DER) – 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 support, NRCan addresses the technical, institutional and regulatory barriers, with the aim of promoting the grid integration of clean power including photovoltaic.

The new PV Innovation Research Network [10], funded by the Natural Sciences and Engineering Research Council of Canada (NSERC), brings 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. 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, there is 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.

In 2010, the Canadian Solar Buildings Research Network (SBRN) completed its five-year work program [11]. It had been the centre of Canada's R&D into solar buildings, innovating solar energy production and efficiency of use in commercial, institutional and residential buildings in Canada. The network pooled 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 research network was the development of the solar-optimized buildings an integrated advanced technological system that approached net-zero annual total energy consumption. CanmetENERGY also contributed to this research effort and is leveraging its activities through its leadership of a large international collaboration for the IEA-SHC/ECBS Task 40/Annex 52, entitled "Towards Net Zero Energy Solar Buildings". Its objective is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding of a harmonized international definitions framework, tools, innovative solutions and industry guidelines. To achieve this objective, Task/Annex experts from 18 countries, including Canada, will document research results and promote practical demonstration projects that can be replicated worldwide.

Finally, Sustainable Development Technology Canada (SDTC) [12], an arms-length foundation that operates as a not-for-profit corporation that was established by the Government of Canada in 2001, provides support for the development and demonstration of innovative technological solutions 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 principle federally-funded body that leverages private sector resources to demonstrate market-ready technologies, including solar photovoltaic product development.

Standards and Codes

The Standards Council of Canada, an agency of the Federal Department of Industry Canada, is responsible for the National Standards System. It is responsible for standards accreditation of organizations and test laboratories. Standards Council of Canada is Canada's representative at the International Electrotechnical Commission (IEC), a global organization that works towards the harmonization of standards in a broad range of electrical product safety and quality. The Canadian sub-committee to the IEC TC 82 actively participates in the development of PV standards. It collaborates with the Canadian Standards Association to make recommendations on international standards adoption. To date Canada has adopted the international IEC61215 and IEC61646 standards that define the test and qualification requirements for crystalline and thin-film solar PV modules. It has initiated a process for the joint adoption of the IEC 61730 for PV module safety, in collaboration with Underwriter's Laboratory (UL) and the Canadian Standard Association (CSA), that would replace the current ULC-1703 PV module safety standard.

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 grid interconnection requirements across the country. This included the development of two harmonized national interconnection standards, CSAC22.2 no.257 and the CSA C22.3 no.9. The CanmetENERGY Laboratory conducts research and field-testing addressing concerns raised by electricity distributors to update and improve the electrical code. Distributed generation installations of PV systems must be installed in accordance with all applicable general rules of the Canadian Electrical Code: to Part I and II 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. 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 was a key issue to ensure that systems were inter-operable with utility networks, with the first edition of the IEC 61850-7-420 Ed.1 standard for basic communication structure, including photovoltaic device and system logical nodes.

IMPLEMENTATION

Ontario's Feed-In Tariff Program

Ontario's Feed-In-Tariff program [6], managed by the OPA, is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar-PV, bioenergy, waterpower and wind. The incentive program is divided into two streams, one targets the small, medium and large renewable energy projects generating more than 10 kW of electricity (referred as the "FIT Program"), 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 enters into a 20 year contract to receive a fixed price of up to 0,802 CAD per kWh for the electricity they generate (Table 1).

**TABLE 1 - ONTARIO POWER AUTHORITY
FEED-IN TARIFF RATES FOR SOLAR PV (CAD)**

APPLICATION TYPE	SIZE	CONTRACT PRICE (¢/KWH)	
Rooftop Ground-mounted	≤ 10 kW	80,2	microFIT
	≤ 10 kW	64,2	
Rooftop	10 - 250 kW	71,3	FIT
Rooftop	250 - 500 kW	63,5	
Rooftop	> 500 kW	53,9	
Ground-mounted	10 kW - 10 MW	44,3	

As of December 2010, the OPA received, under the FIT program, 3 656 applications representing about 4 886 MW of PV generating capacity (Table 2). Under the microFIT program, the OPA received 18 176 applications representing 166 MW of generating capacity (99 % of which was for PV, Table 3) [13]. Given limited transmission capacity and an extremely large number of applications, a transmission planning process, known as the Economic Connection Test (ECT), was created to facilitate generator investment in new transmission "enabler" lines (Fig. 2). A comprehensive regulatory evaluation of these new electricity network investments proposals would be conducted by the Ontario Energy Board (OEB) [14], the province's regulator authority. A map tool showing the locations of PV projects which have been offered contracts by the OPA under the FIT Program, or are awaiting ECT, is also available from the OPA [15].

Normally required to pass a series of connection tests before being offered a contract (or capacity to connect), the OEB created exemptions for small projects connected within the distribution system. Known as "capacity allocation exempt," these projects have "no more than 250 kilowatts of rated generating capacity where the facility is connected to a less than 15 kV line" and "500 kW or less of rated generating capacity where the facility is connected to a 15 kV or greater line" [16].

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

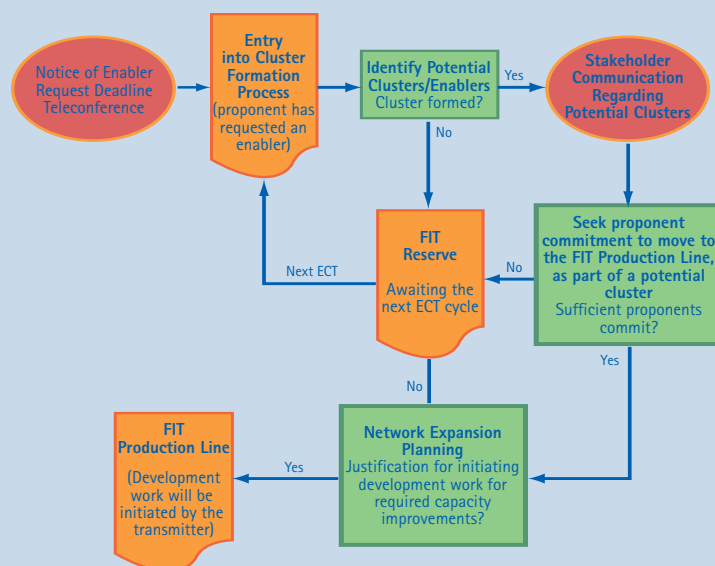


Fig. 2 - Process for identifying FIT project "clusters" that are awaiting connection and new "enabler" transmission network infrastructure projects (Ontario Power Authority).

**TABLE 2 - SUMMARY OF PROGRESS IN THE FIT
PROGRAM IN THE PROVINCE OF ONTARIO [13]**

FIT	APPLI- CATIONS	AWAITING ECT	OFFERED CONTRACTS	EXECUTED CONTRACTS
Number	3656	72	1376	1119
Capacity (MW)	4886	592	911	856

**TABLE 3 - SUMMARY OF PROGRESS IN THE
"MICROFIT" PROGRAM IN THE PROVINCE
OF ONTARIO [13]**

MICROFIT	APPROVED	EXECUTED
Number	18176	2619
Capacity (MW)	166	21

company's requirements. Net metering regulations have been put in place in all provinces that establish rules for the flow of electricity between utilities and distributed PV systems. The implementation of these regulations requires 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 (for example, BC Hydro and Hydro Quebec).

INDUSTRY STATUS

There are over 440 solar photovoltaic companies operating in Canada, many of which are members of the Canadian Solar Industries Association [17] and Énergie Solaire Québec [18]. The majority of these companies are participants in Ontario's FIT Program, since developers must show that the equipment and labour for system installations consist of 40 % 'Ontario' content for projects less than 10 kW in size, and 60 % for larger installations.

In 2010, several companies announced major investments in Ontario that would lead to new "green jobs" in Ontario; they included Siemens [19], Fronius [20], ATS Photowatt Ontario [21], Canadian Solar Inc. [22] and a Korea-based Samsung C&T Corporation-led consortium [23]. The Province's Green Energy and Economy Act [24], released in 2009, is continuing to create the conditions necessary to attract investments in the solar industry in Ontario. In addition, Canada has three companies that are suppliers of feedstock materials for solar PV markets: Bécancour Québec produced approximately 182 tonnes of silicon last year; 5N Plus had a significant increase in Cadmium Telluride production that is exported for the fabrication of thin-film CdTe modules; and Calisolar, who acquired 6N Silicon, has an estimated production capacity of 2 000 T/yr.

MARKET

Growth in the PV Canadian sector has been consistent over the past 18 years, with capacity growing by more than 22 % percent annually between 1993 and 2009. The Ontario feed-in-tariff program is paving the way for a steep uptake for grid-connected PV. Provincial and Territorial government policies are now all supporting "net-metering" of PV power and have encouraged a number of building integrated PV applications. The market uptake has been low for net-metering applications due of the low price of electricity in most regions of Canada. A sustainable market for remote and off-grid applications has developed over the last 18 years in Canada and accounted for 75 % of total PV installed in 2009, however this is expected to be only 50 % in 2010 due to the large growth of grid-connected applications in the province of Ontario.

Employment in PV-related areas in Canada grew by about 30 % in 2009 to 2 700 jobs. These positions included those in manufacturing, sales and installation, R&D, and other positions in the PV-value chain including company R&D, as well as utility PV dedicated labour (IEA-PVPS NSR 2009: R&D 100; Manufacturing 1 975; Other 625). The main increase was in the manufacturing sector as new companies have set up manufacturing bases in Ontario to enable them to satisfy the FIT Program Ontario content requirements.

The national survey completed in 2010 showed a significant decrease in PV module prices (weighted average) to 3,31 CAD per watt. Compared to 11,09 CAD in 1999, this represents an average annual price reduction of slightly over 10 % over an 11-year period. The Canadian total PV power installed capacity is expected to double, reaching an estimated capacity of 200 MW in 2010, compared to 94 MW that was in operation in 2010. As expected, a large fraction of this growth is in the grid-connected market segment in the province of Ontario.

FUTURE OUTLOOK

The Feed-In Tariff Program in the province of Ontario is viewed by the Canadian PV industry as a major step towards developing a competitive, strong Canadian solar industry. The FIT program addressed many of the concerns regarding the delays and interconnection obstacles identified by the industry during the review process. The tremendous initial response to the microFIT program signals a strong support for residential solar rooftop applications in Ontario.

The federal government is also leading the efforts of a technical study group to better understand the technical interconnection issues for high penetration levels of PV systems in electricity grids. This work will be undertaken in collaboration with the International Energy Agency PVPS Task 14 and Canadian stakeholders to better address the emerging field of PV integration enabled through smart grid infrastructure in Canada.

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CHINA

PV TECHNOLOGY AND PROSPECTS

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GENERAL FRAMEWORK

PV industry in China has grown rapidly in recent years and has become the largest producer of PV modules in the world since 2007. About 8 GW solar cells were produced in 2010, which is nearly the double of PV production in 2009. Chinese PV products are mainly shipped to other countries in the past years and more than 90 % of PV modules are exported to the international market. The RE Law was approved in 2006 and sought to speed up market development of RE in China. It is expected that at least 400 MW of PV were installed domestically in 2010 and the PV market in China will increase steadily in the following years.

NATIONAL PROGRAM

In 2007, the National Development and Reform Commission (NDRC) issued the "National RE Medium and Long Term Development Program (2015, 2020)." The PV target in the program is relatively too low: cumulative PV installation by 2015 will be 250 MW and 1 600 MW by 2020. Along with the cost reduction and industry development, the target can be re-set to a much higher level.

As estimated by the China RE Society (CRES) and the China RE Industry Association (CREIA), great progress will be reached in the following 5-15 years:

TABLE 1 - CHINA PV TARGET TO 2030

TARGETS		2009	2015	2020	2030
Technical Targets					
C-Si	Efficiency (%)	16-19	18-20	20-22	> 25
	Thickness (μm)	180-200	160-180	120-150	100
	Si Consumption g/Wp	7,0 - 9,0	6,0 - 8,0	4,0 - 6,0	4
Thin Film	Amorphous (%)	5%-8%	8%-10%	10%-12%	15%
	CdTe (%)	9%-11%	11%-13%	13%-15%	18%
	CIGS (%)	10%-12%	13%-15%	16%-18%	20%
HCPV (%)		25%-35%	30%-40%	Industrialization, Eff.: 40%	
Next Generation		Technology breakthrough		Industrialization	
Annual Production(GW)		4	10	20	100
Cumulative Installation(GW)		0,3	5	50	500
Price Targets					
PV Module	Poly-Si (USD/kg)	50-60	30-40	20-30	£ 20
	C-Si Module (CNY/Wp)	12,0-15,0	8,0-10,0	6,0-8,0	£ 6,0
	TF Module (CNY/Wp)	8,0-10,0	6,0-8,0	4,0-6,0	£ 4,0
System Price (CNY/Wp)		1,8-2,0	1,2-1,5	0,8-1,0	£ 0,8
FIT (CNY/kWh)*		1,5	1	0,7	0,6



Fig. 1 - Zhejiang Yiwu Trade Building 1,295 MWp BAPV was installed by Beijing Corona Company in 2008.

RESEARCH AND DEVELOPMENT

During last 30 years (1981-2010), progress on R&D of PV technologies (both PV cells and utilization technologies) have been received. The efficiency of PV cells in research and commercial levels are shown in Table 2 and Table 3.

TABLE 2 - THE CHINESE HIGHEST PV CELL EFFICIENCY IN LABORATORY

TYPE OF SOLAR CELL	HIGHEST EFFICIENCY (%)	RESEARCH INSTITUTION	AREA (CM2)
Mono-C Si	20,40	Tianjin Power Supply Institute	2x2
Poly-C Si	18,00	Wuxi Suntech Power	12,5x12,5
Amorphous	9,20	NANKAI university	20x20
GaAs cell	29,25	Tianjin Power Supply Institute	1x1
CIGS	14,30	NANKAI university	0,87
CdTe	13,38	Sichuan University	0,502
DSSC	7,40	Plasma Physics Institute, CAS	10,2
u-Si/a-Si	11,80	NANKAI university	0,253
HIT	17,27	Graduate School of Chinese Academy of Sciences	1,2

TABLE 3 - PV CELL EFFICIENCY AT THE COMMERCIAL LEVEL

TYPE OF SOLAR CELL	CELL EFFICIENCY (%)	MODULE EFFICIENCY (%)
Mono-C Si	≥ 1	14-15
Poly-C Si	≥ 1	14-15
Amorphous	-	6-10



Fig. 2a and Fig. 2b – 10 MW LSPV was installed by the end of 2010 in Tibet YangBaJing by the Institute of Electrical Engineering, Chinese Academy of Science.

IMPLEMENTATION

The China Renewable Energy Law was approved by the National People's Congress (NPC) Standing Committee on 28 February 2005 and has been valid since 1 January 2006. Since November 2009, RMB 0,004 CNY per kilowatt-hour was charged to the power retail price. In 2010, the collected RE fund was about 13,5 billion CNY in total for the RE development subsidy.

The "Solar Building Project" has been implemented in two phases since 2009. The first phase of the project covers 111 projects with 91 MW in total capacity. The second phase of the project was started from 12 April 2010 and the total approved capacity of the second phase is about 100 MW. The government gives subsidy to the capital investment of the project: 20 CNY/W subsidy to BIPV projects and 17 CNY/W to the BAPV projects.

With the "China Golden Sun Demonstration Program," the government will provide 50 % subsidy to the capital cost of grid-connected PV projects and 70 % to the off-grid PV projects. The first 120 projects were approved by the end of 2009 and the total capacity is about 200 MW. The second phase of the program was started from September 2010 and the program approved 50 PV projects with about 300 MW in capacity. From 2012, at least 1GW will be installed domestically in China, annually, by the Gold Sun Program.

The National Energy Administration (NEA) started the first concession bidding for a 10MW LS-PV at Dunhuang, Gansu Province in 2009. 1,09 CNY/kWh of Feed-in Tariff was set for the project through bidding process. In June 2010, NEA started the second cycle of concession bidding for LS-PV power plants in western Gobi-desert. The project covers 13 PV plants in the 6 western provinces with a total capacity of 280 MW. The Feed-in Tariff (FIT) of the 13 PV plants was confirmed through bidding and the results were from 0,728 CNY/kWh – 0,99 CNY/kWh.

The Chinese government gives full financed support to the off-grid PV projects every year and the average annual installed capacity is about 10 MW.

INDUSTRY

PV Cell and Module Production

Driven by the international PV market, the PV industry has developed rapidly since 2004. More than a 50 % annual increase of PV production has been achieved in last 6 years and China has become the largest PV producer in the world since 2007. In 2010, PV production in China shared about 50 % of the total world PV shipment.

TABLE 4 – PV CELL PRODUCTION AND Y/Y INCREASE

YEAR	2007	2008	2009	2010 (E)
China PV Shipment (MW)	1 088	2 600	4 011	8 000
Y/Y (%)	172,0	139,0	54,3	99,5



Fig 3. - The SDDX Program (China Rural Township Electrification Program) is the first large scale rural electrification project using renewable energy such as stand alone PV power systems, PV/wind hybrid systems and small hydro systems. In 2002 and 2003, the total 721 PV or PV/Wind hybrid systems with capacities of 15 384,14 kW were installed.

Today there are 12 PV producers in China which are overseas stock-holding companies and another 13 PV manufacturers which are domestic stock-holding companies. The PV cell production of the top 13 PV companies is listed below:

TABLE 5 - PV CELL PRODUCTION IN CHINA (2009, 2010)

NO.	COMPANY	2009 CELL	2010 CELL (E)
1	JA Solar	509	1 500
2	Suntech Power	739	1 200
3	Yingli Green Energy	525	1 000
4	Trina Solar China	399	930
5	Canadian Solar China	326	700
6	Solarfun	220	450
7	Jinko Solar China	120	400
8	China Sunergy	194	300
9	Ningbo Solar	140	200
10	Changzhou Yijing	135	150
11	Zhejiang Sunflower	120	150
12	LDK Solar China -	0	120
13	Jetion Solar	80	100
14	Others	504	800
15	Total Production	4 011	8 000

High Pure Poly-Silicon Feedstock

In 2010, the total production capacity of poly-Si in China was about 60 000 Tons and the real production was about 40 000 Tons. More than 45 % of poly-Si was imported from abroad in 2010. It is estimated that the output of poly-silicon will meet the needs of national solar cell production within 2-3 years.

TABLE 6 - POLY-SILICON SHORTAGE ISSUE IN CHINA

YEAR	2006	2007	2008	2009	2010 (E)
Production (Ton)	300,0	1 100,0	4 729,0	20 357,0	42 890,0
Demand (Ton)	4 000,0	10 000,0	25 000,0	40 000,0	80 000,0
Shortage (Ton)	3 700,0	8 900,0	20 271,0	19 643,0	26 310,0
Share of Import (%)	92,5	89,0	81,1	49,1	46,4

MARKET DEVELOPMENT

By the end of 2009, the cumulative PV installation in China was 300 MW and by the end of 2010, the cumulative installed PV was expected to reach at least 700 MW.

In China, PV is used mainly in the following areas: rural electrification, communication & industries, PV products, such as PV street lights, lawn lamps, PV traffic lights, PV battery chargers, solar boats & solar cars, solar torch, etc.; and grid-connected PV applications, such as BIPV and LS-PV.

TABLE 7 - PV INSTALLATION IN CHINA SINCE 1990 (MW)

YEAR	1990	1995	2000	2002	2004	2006	2007	2008	2009	2010
Annual Ins.	0,5	1,55	3	18,5	10	10	20	40	160	500
Cumulative	1,78	6,63	19	42	62	80	100	140	300	800

TABLE 8 - PV MARKET SHARE BY SECTORS IN THE LAST 10 YEARS

YEAR	RURAL ELEC. (MW)	COM.& IND. (MW)	PV PROD. (MW)	BIPV (MW)	LS-PV (MW)	ANNUAL (MW)	CUM. (MW)
2000	2,00	0,80	0,20	0,00	0,00	3,00	19,00
2001	2,50	1,50	0,50	0,005	0,00	4,50	23,50
2002	15,00	2,00	1,50	0,01	0,00	18,50	42,00
2003	6,00	3,00	1,00	0,07	0,00	10,00	52,00
2004	4,00	2,80	2,00	1,20	0,00	10,00	62,00
2005	2,00	2,90	1,50	1,30	0,20	8,00	70,00
2006	3,00	2,00	4,00	1,00	0,00	10,00	80,00
2007	8,50	3,30	6,00	2,00	0,20	20,00	100,00
2008	4,00	5,00	20,50	10,00	0,50	40,00	140,00
2009	9,80	2,00	6,00	34,20	108,00	160,00	300,00
2010 E	15,00	6,00	6,00	188,00	285,00	500,00	800,00

TABLE 9 - SHARE OF EXPORT AND DOMESTIC INSTALLATION OF PV MODULES (2007-2010)

YEAR	2006	2007	2008	2009	2010 (E)
PV Production (MW)	400,0	1 088,0	2 600,0	4 011,0	8 000,0
Export (MW)	390,0	1 068,0	2 560,0	3 851,0	7 500,0
Installation (MW)	10,0	20,0	40,0	160,0	500,0
Share of Export (%)	97,5	98,2	98,5	96,0	93,8

Chinese PV production is in the top level in the world, but the market is relying on foreign countries. Since 2006, the exported PV modules share was more than 95 % and the domestic PV installation share was only less than 5 %.

FUTURE OUTLOOK

On 25 November 2009, the State Council of China announced that 40-45 % of GHG Emission for unit GDP will be reduced by the year of 2020; comparing with the level of 2005 and non-fossil energy, it will share 15 % of total energy consumption by 2020. PV will play an important role in GHG reduction and the improvement of the energy structure.

China is now the biggest producer of C-Si modules with the lowest cost in the world. However, China is weak in thin-film technology,

high-efficiency C-Si technology and CPV. The high level manufacturing facilities and many materials need to be imported from abroad. Further R&D efforts and investment need to be put into PV to upgrade technology and balance the manufacture chain.

The domestic PV market needs to be expanded urgently to balance the PV manufacturing capacity and to make PV play a more important role in energy supply and GHG reduction. More efficient incentives are required to push market development forward; for example, the standard FIT for PV should be like wind power. Today, wind power generation projects have standard FIT, which is from 0,51 CNY/kWh to 0,61 CNY/kWh, according to the resources.

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS

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Fig. 1 - New office building at EnergiMidt, Silkeborg, is supplied with 55,5 kWp PV systems. A part of the PV system is constructed as a moveable sunshade with transparent thin film panels. The panels can be controlled individually or automatically. The building is designed as energy class 1 with an estimated total consumption of 27 kWh/m²/year.

GENERAL FRAMEWORK

The Danish government proposed in early 2007 a new energy plan called Energy Vision 2025. This plan was in principle adopted by a majority of the Parliament early 2008 in terms of a national energy plan. This energy plan focuses on a fully liberalised energy market supported by a framework, which underpins high consumer and environment protection, energy efficiency, subdued development in energy prices and high security of supply both in the short and long term. The energy plan further focuses on the ongoing development of efficient energy technologies both nationally and in the EU, and the government wishes to strengthen the research community and the development of new and promising energy solutions. With regard to renewable energy (RE) the plan sets quantifiable targets for the overall contribution from RE following or surpassing the national targets as defined in the EU RE Directive, but 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 the base year 1990. The market for CO₂ certificates is seen as the most cost-effective way to reach this target.

Renewable energy is not only a future option, but very much a present and considerable element in the energy supply: By end 2009, more than 27 % of the national electricity consumption was generated by

renewable energy sources including waste incineration. 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 consumers.

In September 2010 the so called Climate Commission appointed by the Government reported on the possibilities to reach the Government vision of a fossil fuel free energy system by 2050; the report is regarded as a tool box from which the politicians can select instruments. Renewable energy technologies, in particular wind, play an important role, but PV is just seen as one among other emerging renewable energy technologies to be prioritized when found viable.

Photovoltaic technology (PV) is not specifically mentioned in the government's energy plan, but in early 2004, the Danish Energy Authority (EA) in collaboration with the electricity sector, the industry and other key stakeholders finalized a national strategy on PV after a public hearing. This PV strategy includes the fields of research, development and demonstration. Deployment activities in support of the PV strategy are envisaged to be developed in the coming years and an overall framework for the coordination of PV development and deployment in Denmark is thus envisaged to be in place inside a few years. The PV strategy was updated mid 2006 by way of an annex outlining the need for long term operational targets and support mechanisms for demonstration. A full update has been completed in 2009 including the need for large scale demonstration or deployment instruments, but so far, no political decision on supporting instruments are in place.

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.

Regions and municipalities are playing an increasingly more active role in the deployment of PV as an integral element in their respective climate and energy plans.

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), 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. This has been followed by the PV Island Bornholm (PVI) project now implementing 2-3 MW in the regional municipality of Bornholm and targeting 5 MW. This activity is contributing to the ECO-GRID project; establishing a real life laboratory for smart grid solutions.

By the end of 2010, about 6,5 MW is estimated to have been cumulatively installed. 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 1 000, more than 3 000 house owners had registered their interest. However, uncertainty about the programme due to change of government and increased demand for end-user payment 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 in mid 1998 for a pilot-period of four years. In late 2002, the net-metering scheme was extended another four years up to end of 2006. Net-metering has proved to be a cheap, easy to administrate and effective way of stimulating the deployment of PV in Denmark. However, the relative short time window of the arrangement has so far prevented it from reaching its full potential. During the political negotiations in the fall of 2005, the net-metering for privately owned PV systems was made permanent, and net-metering – beginning in 2011 at a level of approx. EUR 0,30/kWh, primarily because of various taxes – appears now to be able to stimulate PV deployment as the installed capacity during 2010 is estimated to exhibit a growth rate of 40-50 %.

RESEARCH & DEVELOPMENT, DEMONSTRATION

During 2003, the government announced additional financial support to the new R&D programme started in 2002. Over a 5 year period,



Fig. 2 - Copenhagen Towers are supplied with a 270 kWp integrated PV system delivered by Gaia Solar. The building fulfills the requirement of EU's "Green Building Code."

more than 150 MDKK was allocated to renewable. However, as the focus of the programme is on university research activities, it is so far only to a limited extent that PVs have benefitted from the programme. In 2004, the government increased the PSO allocation for R&D into environmentally benign electricity generating technologies from 100 MDKK per year to 130 MDKK per year. This R&D facility, called ForskEI, 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; 1,139 MDKK has been allocated for 2011. In 2010, a few R&D PV projects have indeed benefitted from support during 2010 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." The previously mentioned PV projects in Skive and on Bornholm have benefitted significantly from this facility.

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 has been supported by Energinet.dk since 2002. 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.

In 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 Horsens. The group in Copenhagen is 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, which had been run by the utility EnergiMidt, as mentioned above, intended to demonstrate low cost and architectural acceptable integration of PV technology primarily on existing single family houses. By end of project ultimo 2006, it had implemented a bit more than 700 kW in total. There was a focus on the gradual increase of end-user payment and this paved 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 250 Wp, 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 system cost considerably.

In Copenhagen, the so called Valby Initiative has progressed. Valby is region of Copenhagen undergoing extension changes and refurbishment, and a PV initiative targeting about 300 MW has long been in preparation. The initiative has been integrated into actions in the EU Concerto Programme.

The Skive project has by end of 2010 implemented about 800 kW and is expected to implement more capacity than the targeted 1 MW – this due to decreasing prices. By end 2010, the new PVIB project has implemented around 50 kW ahead of schedule.

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 in late 2008. With initially some 40 members, the association is expected to provide the emerging PV industry with a single voice.

R&D efforts are beginning to exhibit commercial results in terms of export.

Inverter technologies have been R&D'd for some years for both fuel cell and PV applications. For the latter, a commercial breakthrough was also announced in 2003 by the Danfoss related company Powerlynx, which reports in 2010 to have reached production close to 1 GW. Powerlynx, which now employs more than 250 people, was fully acquired by Danfoss during 2007, and is now called Danfoss Solar Inverters.

PV Si cell production stopped in Denmark in 1996. A single Danish module manufacturer (Gaia Solar) with an annual capacity of about 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 for Si mono-X cells and modules in 2010. The pilot production line is expected to ramp up to 100 MW annual capacity in 2011, but there has since been no news available on this new initiative.

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.

Danish investors have entered the PV scene acting as holding companies, e.g. for cell/module manufacturing in China.

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

MARKET DEVELOPMENT

The total PV business volume in 2010 is very difficult to estimate with any degree of accuracy primo 2011, due to the commercial secrecy surrounding the above mentioned new business developments in the fields of investments and production of Si cell/modules, feed stock and inverters. However, an increase from 80 MEUR in 2009 to +100 MEUR in 2010 is a "best guess," mostly due to exports.

The cumulative installed PV capacity in Denmark (including Greenland) is by end of 2010 estimated to about 6,5 MW; an increase of about 2,2 MW or about 50 % during 2010.

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 update a national PV strategy and consequent deployment schemes may succeed in creating a more coordinated and unified approach to PV in Denmark. 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 Skive project targeting 1 MW on municipal buildings, is expected to exhibit a high replication potential stimulating other municipalities to similar initiatives. The PVIB project targeting 5 MW has in 2010 started implementation, initially with funding to reach about 2 MW.

The present net-metering scheme – by beginning of 2011 at around EUR 0,30/kWh – appears to have reached a level stimulating PV deployment within the limits of the scheme. For private households and other entities entitled to the net-metering scheme, grid-parity can be expected to be reached during 2011 or 2012.

The trend towards commercial sustainability for PVs is seen as ongoing with steady improvements of the price/yield relation. Projections and scenarios completed during 2010 indicates, that with the continued global technical and economic development of the PV technology, with now a permanent net-metering scheme in Denmark and with unchanged development of the Danish end-users increasing willingness to invest in PVs, a market for PV roof-tops in Denmark without any investment subsidy may emerge already in 2012; given that the necessary demonstration activities can be continued.

EUROPEAN COMMISSION

RESEARCH DEVELOPMENT AND DEMONSTRATION ACTIVITIES ON PHOTOVOLTAICS SUPPORTED BY THE EUROPEAN COMMISSION
 PIETRO MENNA, EUROPEAN COMMISSION, DG ENERGY
 FABIO BELLONI, EUROPEAN COMMISSION, DG RESEARCH

POLICY

European legislation has proven to be an important driver for the development of renewables, including photovoltaics (PV). The new renewable energy directive had to be transposed by December 2010. However, before that milestone there had already been another important measure, the adoption and notification to the Commission of the National Renewable Energy Action Plans (NREAPS) by the 27 Member States.

The NREAPS contain elements which are relevant for future PV development, such as the sectorial targets for electricity, the planned measures for authorisation procedures, support schemes and grid connection, and the estimates of the contribution provided by the different renewable energy technologies. The estimates indicate that by 2020 PV electricity will cover a share larger than 7 % of their renewable electricity consumption, i.e. about 18 % of the capacity of their renewable electricity plants.

However, there are significant differences among the roles of PV in the different Member States. While some countries are not counting on this technology at all (Finland, Ireland, Sweden), others estimate to produce with PV about 10 % of their renewable electricity (Greece, Italy, Luxembourg, Malta and Spain). The PV contribution reaches about 20 % for Germany and more than 26 % for Cyprus. In absolute terms, Germany is the leading country for both PV installed capacity and overall electricity generation. Considerable further investments could be expected by 2020 not only in Italy and Spain, but also in Portugal, and the UK.

Another important element of the national strategies is the suite of measures to be undertaken to reach the sectorial targets. The objective of the regulatory framework set up by the directive and of the detailed strategies described in the NREAPS is to ensure a stable and attractive investment environment for the different renewable technologies. Well designed, foreseeable and easy-to-adjust schemes are vital for the further growth of the sector, while the lessons learned show that frequently changed and stop-and-go kind of schemes should be avoided.

The growing amount of variable energy installations in the national electricity systems poses certain challenges to the electricity grid and raises new requirements for the electricity infrastructures. It is necessary to envisage new lines, reinforcements, intelligent solutions as well as storage, in order to increase the overall flexibility of the system.

The Energy Infrastructure Package recently adopted by the Commission is proposing a new strategy and toolbox to develop an integrated European energy network fit for the challenges of today and tomorrow [1].

DEPLOYMENT

From the market demand point of view, Europe is definitely the world leader. According to the estimates reported in a recent publication, the cumulated installed PV capacity in Europe was larger than 15,800 MW at the end of 2009 [2]. During 2009, about 5 500 MW of new PV

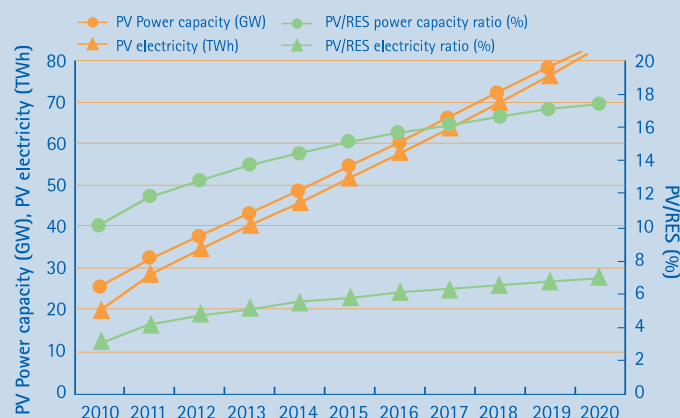


Fig. 1 - PV sectorial targets estimates based on NREAPS notified to the European Commission by the 27 Member States.

installations were deployed in Europe. This is more than 78 % of the world's newly installed PV power. However, the European market remains very heterogeneous. Most of the PV power capacity newly installed in 2009 is located in Germany (3,800 MW); Italy (600 MW), Czech Republic (400 MW), Belgium (300 MW) and France (200 MW), which have also had a record year in terms of installations, but are still far from the German volumes.

Despite the reduction of the feed-in tariff, Germany's PV sector is expected to keep growing at a steady rate, with rooftop systems continuing to dominate the market. Italy, currently representing the second largest market in Europe, has decided to cut its incentive scheme (*Conto energia*) by 18 %, as of 2011. The reduction will continue in 2012 and 2013 by 6 % per year. However, despite these incentive reductions, the demand for the future years should be assured. In fact, the decrease in the average selling price of the modules, which mostly reflects reduction in cost, should allow a sufficient margin for system integrators.

From the market supply point of view, Europe is a net importer of PV devices, and the trend will likely continue due to the recent, rapid growth of the production capacity in Asia. However, Europe (mostly Germany) maintains its predominant role as a manufacturing equipment supplier. In addition, European know-how in the current wafer-based silicon technology remains competitive.

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 (EII) 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. The first four EIs on solar, wind, carbon capture and storage, and electricity grids have officially been launched at the SET-Plan conference in Madrid, on 3 June 2010. The launch was marked by a joint statement by Member States, the European Commission and industry representatives and by the endorsement of the Implementation Plans for the Initiatives (2010 – 2012).

The Implementation Plan 2010–2012 of the Solar European Industrial Initiative (SEII) announces that during the coming three-year period, up to 1,2 BEUR on RD&D are to be invested in new production technology and in integration of PV into the grid as well as into the built environment; aiming at achieving cost reduction and enabling large-scale deployment. These are the first steps in the path to reach, within this decade, competitiveness with electricity prices for residential and commercial sectors and even with conventional fossil fuels for industrial applications, in locations with high irradiation. Almost 60% of the investment will need to be provided by the private sector whereas the remaining amount should be balanced between the EC and EU MS.

Presently, the main challenge with the SEII is to step up from a general mobilisation and endorsement, to the effective implementation phase. There are several financial instruments available at EU and Member States level to carry out the SEII activities. For instance, the EU Framework Programme for Research will continue to focus the topics of the yearly work programme on the priorities of the solar implementation plan. Similarly, the national programmes finance projects that are coherent with the plan. To further the scale of the action, joint or coordinated calls between EU Member States and/or Member States and the Commission could become a key instrument for the whole process.

To put this process in motion in a coordinated and consistent way, it is necessary to preliminarily identify the activities where Member States could work together, avoiding duplication and exploiting potential synergies. This could provide a single SET-Plan entry point to drive future activities and projects to their successful accomplishment.

RTD & DEMONSTRATION

The 7th Framework Programme for Research, FP7 (2007–2013) has a significantly increased budget compared to the previous programme, and runs for seven years. Calls for proposals based on topics identified in the *work programme* are being launched on an annual basis. FP7 has begun with less emphasis on the development of traditional wafer-based silicon PV, which is the focus of increasing R&D investment by companies and national programmes. Development of materials for longer-term applications, concentration PV and manufacturing process improvement have attracted relevant European funding. Furthermore, significant funding has been made available for thin-film technology.

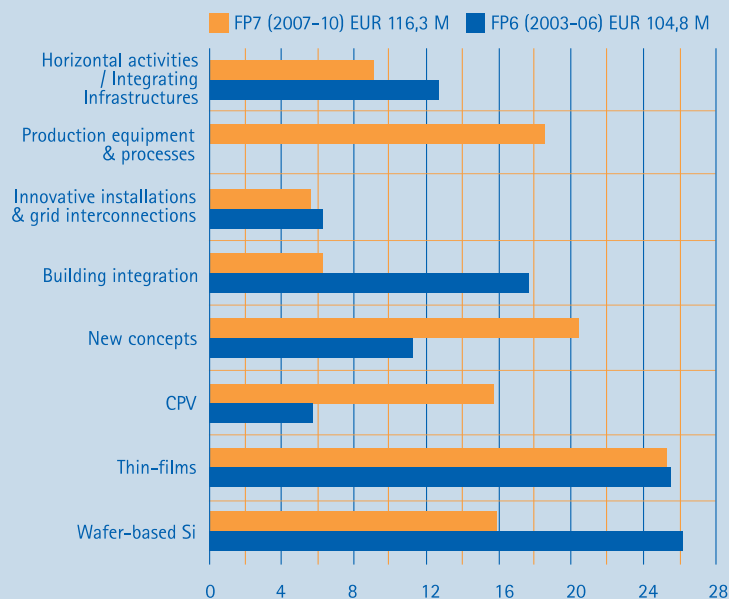


Fig. 2 – Investment in PV, 2003–2010 (in Million EURO).

Five calls for proposals have been already launched for the years 2007, 2008, 2009, 2010 and 2011. The PV projects granted and/or selected following the 2007, 2008, 2009 and 2010 calls have been described elsewhere [4].

CONCLUSIONS

It is difficult to predict the evolution of the global PV sector in the coming years. On the one hand, it is worth recalling that the EU PV market is mostly driven by support schemes which are being revised, almost everywhere in Europe. On the other hand, the most cost-effective producers are planning significant increases of their production capacity, although this obviously carries a risk of over-supplying of the market. Those companies which are not able to achieve competitive cost/price reductions are at risk of disappearing, either through mergers or through acquisitions by stronger partners.

The SEII offers a timely opportunity for European companies to accelerate their PV development and demonstration activities, to increase their innovation base, and to improve their competitiveness.

The Commission maintains long-term support for research, development and demonstration in the solar PV sector, providing a framework within which researchers and industrialists can work together to develop technology and applications. With the first four calls launched under the 7th Framework Programme for Research, more than 116 MEUR has already been invested in innovative projects on PV.

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S ACTIVITIES AND ROADMAP

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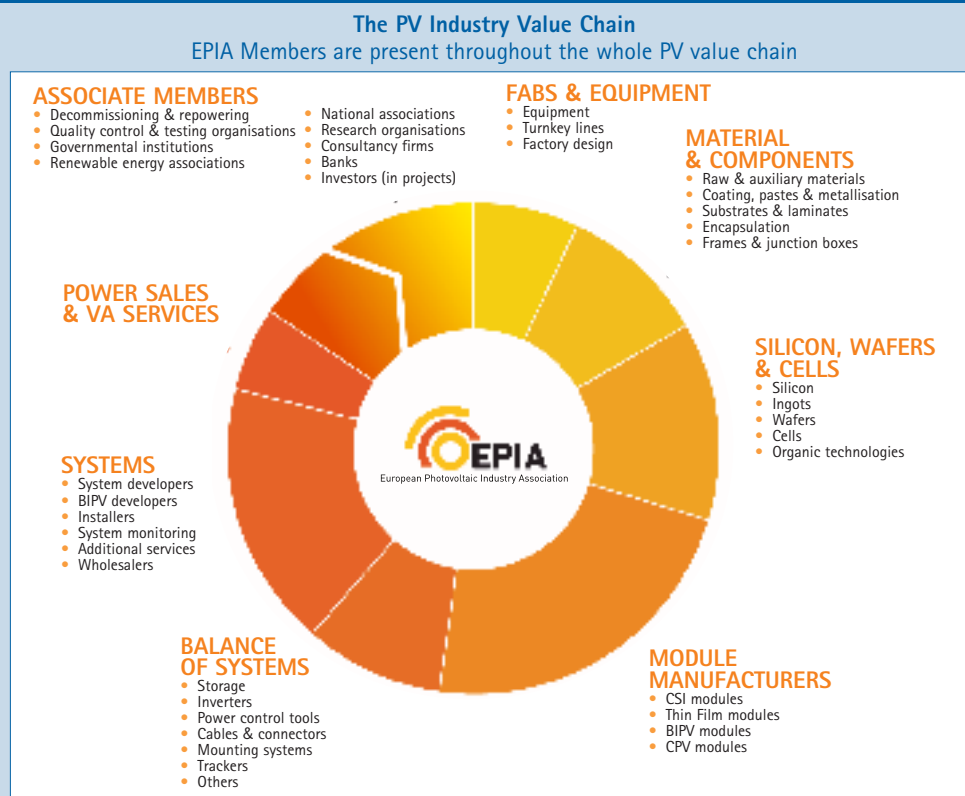


Fig. 1 - EPIA Members are present throughout the whole PV value chain.

With over 240 members active along the whole value chain, from silicon producers, cells and module manufacturers to systems providers, EPIA is the world's largest photovoltaic (PV) industry association. It represents over 95 % of the European photovoltaic industry and 80 % on a global scale.

EPIA's mission is to support the development of the PV industry and markets, driven from the strength of its unique and strong voice at European and international levels.

EFFORTS FROM LOCAL TO GLOBAL SCALE

Throughout 2010, EPIA has made great efforts in supporting a sustainable development of existing European PV markets as well as in setting the conditions to open new global markets with a huge PV potential. These efforts go from local and regional to global scale. At the local level, EPIA supports PV actors by disseminating best practices in terms of administrative and legal procedures, based on the outcomes of the European co-funded project "PV Legal." At the national level, EPIA has supported its national association members by providing sound recommendations on how governments should make the best use of photovoltaics in achieving their Renewable Energy Targets; targets set by the European Directive on Renewable Energy Sources. EPIA, through its "PV Observatory" project launched in 2010, identifies beneficial conditions for market development and best practices for sustainable deployment of PV. The recommendations of the PV Observatory are structured as follows: sustainable support schemes, streamlined administrative procedures and efficient grid connection processes.

EPIA does not only look into the existing PV markets but it also aims to unlock the PV potential of many countries which, while presenting excellent conditions for the use of PV (high irradiance, high electricity prices, dependence on energy imports, etc.), have not yet developed their markets. The study *"Unlocking the Sunbelt Potential of Photovoltaics"* was launched in 2010 and analyses the financial and business environment in 66 countries from the Sunbelt region. Based on those assessments, it develops three possible deployment scenarios for PV up to 2030 and provides a set of recommendation to policy makers, utilities, PV industry and financial institutions.

Besides the continuous efforts of maintaining established PV markets and creating new ones, EPIA, together with the EU PV Technology Platform is in charge of the coordination the Solar Europe Industry Initiative; officially launched in June 2010. This initiative aims at coordinating industrial research efforts at the European level, as well as increasing the public financial support so that European industry can maintain its leadership in technology innovation and thus remain competitive in the global market.

A DEDICATED INFORMATION AND NETWORKING PLATFORM

A source of knowledge and expertise for the entire PV sector, EPIA published a number of reference documents in 2010:

- **"Global Market Outlook for Photovoltaics until 2014":**
Annual report presenting the most recent and upgraded data regarding PV market performance and short-term forecast.



Fig. 2 – EPIA Stand with IEA-PVPS Booth in Valencia, Spain, during 25th EU PVSEC.

- **"Unlocking the Sunbelt Potential of Photovoltaics":** The study examines the countries located in the sunbelt region, which have potential attractiveness for PV deployment.
- **"Solar Generation 6 – Executive Summary":** Jointly published by EPIA and Greenpeace, it provides well documented scenarios establishing the PV deployment potential worldwide by 2050.
- **"Photovoltaic Observatory – Policy Recommendation":** Based on the analysis of existing policies in several key countries, Photovoltaic Observatory identifies recommended conditions for market development and best practices for PV's sustainable development.

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 to all PV stakeholders, and in particular, for EPIA Members in 2010.

The Association organized top-level events in order to accelerate PV deployment in a sustainable way and create privileged networking opportunities in 2010. These included:

- 7th European PV Industry Forum, within the frame of the 25th EU PVSEC organised by WIP
- 5th Workshop on Market Potential and Production Capacity
- 3rd EPIA International Thin Film Conference
- 1st EPIA International Conference on Concentrator Photovoltaics
- 1st International Conference on PV Module Recycling
- Conference "Paving the Way for Building Integrated Photovoltaics"
- Technical conferences and workshops (network integration, building integrated photovoltaics, standards, power measurements, etc.)
- PV information tours



Fig. 3 – European Parliament, Brussels.

EPIA AS 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 Systems Implementing Agreement

EPIA'S IMPLICATION IN IEA PVPS ACTIVITIES 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 (USA), chair this Task, which took-off during 2008 after its beginning in 2007. Task 12 meetings were hosted by EPIA during the 25th EU PVSEC in Valencia, Spain, and in conjunction with the 1st International Conference on PV Module Recycling, organized in Berlin by EPIA and PV Cycle.

The "Guidelines for a Common Approach in Photovoltaics Life Cycle Inventory and Life Cycle Assessment" were finalized and published in September 2009. A revision of these took place in 2010, as well as the preparation of a LCI Report which is planned to be published in 2011.

Tasks 13: Performance and Reliability of Photovoltaic Systems

EPIA hosted one of the Task 13 meetings organized during the 25th EU PVSEC in Valencia, Spain, and supported the Task 13 Operating Agent in identifying industrial partners interested in the scope of the Task 13 activities.

General Support to IEA PVPS

The association hosted an IEA PVPS island booth at the EPIA Industry Area during the 25th EU PVSEC in Valencia, Spain, in September 2010.

FRANCE

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

YVONNICK DURAND, FRENCH AGENCY FOR ENVIRONMENT AND ENERGY MANAGEMENT (ADEME)

GENERAL FRAMEWORK

The cumulative installed power of the photovoltaic park in mainland France and overseas territories was 175 MW in late 2008 and is about 1 025 MW in 2010; a 6-fold increase in 2 years. Projects submitted to date amount to more than 4 000 MW. These results show the advances made regarding the objectives defined at the end of the "Grenelle de l' Environnement" plan of actions launched in 2007 (1 100 MW installed in late 2012 and 5 400 MW in 2020).

This growth seems to show that the seed stage of the PV industrial sector is completed. The development is now entering a more mature phase and the cost of materials and facilities are following a steady decline.

To avoid a windfall effect and considering continued productivity gains and lower cost modules on the market, the Government conducted a review of tariffs for photovoltaic electricity in order to adapt the support to this new phase of development.

For professional projects and large facilities, purchase prices have been lowered by 12 % from 1 September 2010. Tariffs for domestic installations with a capacity of less than 3 kW remain unchanged. In addition, a decree was promulgated on 2 December to suspend the obligation for three months to purchase photovoltaic electricity. (The production facilities with a capacity less than or equal to 3 kW are not affected).

During this moratorium, the government wants to initiate a dialogue to discuss the decline in tariffs or the introduction of a quota system. Discussions involving players of the photovoltaic sector, elected officials, consumer representatives and environmental groups began from 20 December and should result, in March 2011, in a new regulatory framework providing visibility to those who work in the sector.

New industrial operators are taking place, and the value chain of the sector is complete. The French modules production capacity amounts to 440 MW. According to a report released by the Renewable Energy professional framework "Syndicat des Energies Renouvelables" (SER) in December 2010, the whole industry is a source of jobs, from "upstream" activities (production of manufacturing equipment and manufacture of materials and products, 6 500 jobs) to "downstream" activities of integration, installation and operation of plants producing electricity from photovoltaics. (19 000 jobs).

PHOTOVOLTAIC PROGRAMME

The current national goal in 2020 is to have an electrical PV power production capacity of 5,4 GW.

The Agency for Environment and Energy Management (ADEME) is the public 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 OSEO funding agency has allowed leveraging for R&D funding.

ADEME acts in two ways in supporting the R&D sector:

- It plays a coordinating role and in funding R&D through its demonstrators program and technology platforms that aims to conduct operations in close to real size and to demonstrate their technological efficiency. The fund is piloted by a committee which comprises competent ministries, ADEME and the "Commissariat Général de l'Investissement" (CGI); working through roadmaps that give rise to call for expressions interest.
- Moreover, ADEME supports the emergence of start-ups, particularly in the field of thin films technology (SOLSIA and NEXCIS in the CIS). ADEME also continues to support projects implementers training (PHOTON and PHOTON NETWORK training sessions).

At the international level, ADEME supports the cost-shared projects within the International Energy Agency (IEA) Photovoltaic Power Systems Programme (PVPS), particularly in the IEA PVPS working groups 1, 2, 9, 10, 11, 12 and 13. Support was also given to the activities of French teams involved in the development of technical specifications for rural electrification by renewable energy sources. (IEC 62257 series of specifications).

Having funded a program from 2005 to 2007, known as "Solar Photovoltaic," ANR launched HABISOL as part of its 2008-2010 program, grouping research activities on building and solar.

With regard to OSEO, its contribution to the development of photovoltaic takes two forms:

- The program innovation and industrial strategy (ISI, from the Agency for Industrial Innovation IIA)
- The Interministerial Fund (FUI), which funds research projects and collaborative development of competitive clusters.

The clusters Capénergies (Provence-Alpes-Côte d'Azur), Derbi (Languedoc-Roussillon), Tennerdis (Rhône-Alpes) and Science and Electrical Energy Systems (Central Region) are involved in the field of renewables. These clusters allow the structuring of projects, often undertaken in partnership (firms, research organizations, communities) and coach actions to obtain financial support from national funding structures (ADEME, ANR, OSEO), the European Union (PCDD) or local authorities (county councils, regional councils, other communities).

The program for the construction of a solar power plant by 2011 in each region with a total capacity of 300 MW, was, in the meantime, abandoned.

RESEARCH AND TECHNOLOGICAL DEVELOPMENT

Research in the photovoltaic sector is mainly driven by the "Institut National de l'Energie Solaire," (INES-250 researchers in 2010), established in 2006, and the "Institut de Recherche et Développement sur l'Energie Photovoltaïque" (IRDEP- 45 researchers in 2010), established in 2005, and some twenty other teams from the "Centre National de la Recherche Scientifique" (CNRS) spread over the territory.

The INES research program covers the area of photovoltaic cells, modules, systems and storage. Under the PV ALLIANCE program, INES is working on two areas of innovation:

- Improved performance of multicrystalline silicon cells produced by PHOTOWATT as part of a pilot plant called "LabFab" with 25 MW.
- The development on its own site of heterojunction cells with high efficiency, in conjunction with the Korean OEM JUSUNG, with the objective to establish a "Labfab2" with 25 MW in two years.

The work of the IRDEP, positioned in the field of thin films, focuses on reducing production costs of PV modules, improved photovoltaic conversion efficiencies and processes for thin film deposition.

Three areas of investigation are underway:

- The CIS thin film technology
- Cells with high efficiency (multijunction cells)
- The search for new advanced structures (nanostructures hybrid cells, transparent conductive oxides) .

A proposed combination of IRDEP with other R&D structures is currently being considered with the creation of an Institute that would aggregate other solar R&D activities around the IRDEP:

- The laboratory of physical interfaces and thin films (CNRS-Ecole Polytechnique)
- Teams of R&D from Total Group
- A master's degree from Ecole Polytechnique and ParisTech, currently, represented by 150 people in all, with the aim of creating a structure of 200 to 250 people, including the recruitment of foreign researchers, located at a common site in the Paris region.

In the same vein, the Ministry of Research proposes a scheme for controlling the R&D in photovoltaics, based in particular on:

- A clarification in the positioning of the various centers (upstream research / technology research and integration)
- A control mode harmonized from these two categories of research
- Strengthened partnerships with industry .

Recommendations are made by the "Mission on the regulation and development of the photovoltaic sector in France," to engage discussions on the relationship between the funding agencies (ADEME, ANR, OSEO) and setting up the establishment of a comprehensive R&D sector.

The HABISOL program funded by the ANR for 2008-2010 aims to mobilize the scientific community and industrial sector to meet the challenges of very ambitious energy savings in buildings. Three complementary approaches are developed in this program:

- Method of energy management in housing;
- Energy efficiency and development of renewable energy use in buildings;
- Development of photovoltaics for its widespread use in buildings.

11 new R&D projects were selected in 2010 to complement the 24 projects supported since 2008.

OSEO supports important programs dedicated to different technologies: silicon homojunction and heterojunction, as well as thin film organic solar cells, as illustrated in TABLE 1 - MAJOR PROGRAMS SUPPORTED BY OSEO IN THE PHOTOVOLTAIC INDUSTRY.

TABLE 1 - MAJOR PROGRAMS SUPPORTED BY OSEO IN THE PHOTOVOLTAIC INDUSTRY

PROGRAM	PERIOD	GOALS	PARTNERS
Solar Nano Crystal	2008-2012	Lowering the costs of basic materials, producing direct solar grade silicon. Develop efficient technologies through the use of nanotechnology in the sector of the silicon thin film.	PV Alliance (Photowatt International, EDF Energies Nouvelles, CEA-Vaorisation), Emix, Photosil, Apollon Solar, INES
PV20	2010-2012	Re-design the whole chain of crystalline silicon module production in order to have "100 % made in France" modules at competitive prices.	MPO, Emix, Semco, Tenesol, INES
SOLCIS	2010-2012	Bring forth a stream-based industrial CIS technology with: <ul style="list-style-type: none"> • The first generation of dual-glass modules, based on a mixed process of electroplating coupled with annealing at atmospheric pressure • A second generation of CIS at reduced production cost and innovative encapsulation process, designed for light products for roofing. 	Nexcis, Semco, Impika, Amlitude systèmes, Komax, Solems, Rescoll, CNRS, Armines, Enthone, Arkema, with support without financing of IBM and ST Microelectronics
OSCAR	2010-2013	Produce organic photovoltaic films (OPV) from innovative active materials and substrates and using industrial printing techniques.	Armor, INES, LCPO, Plasto, Alca Packaging

Another major R&D project is the POLYSIL project, funded by ADEME, the Rhone Alpes region and the General Directorate of Competitiveness, Industry and Services (DGCIS), which started in December 2009. Focused on industrial development of a thin film photovoltaic technology, the project aims to give France a leading industry on the global market for photovoltaic thin film modules. A young start up, SOLSIA, coordinates the work program implemented between laboratories and companies.

The following projects are also to be noted:

- Research supported by APOLLON SOLAR and INES in developing a new concept of modules that does not require encapsulation of cells, and allowing a simplified realization of contacts. (NICE process). Modules produced on the pilot line in INES facilities have passed the certification tests IEC 61215 and 61730.
- Project SOLAR JET (Ardeje, CEA-INES, Hutchinson) for the development of printed cells (at a very low energy cost).
- The project SOLION for the development of photovoltaic systems including a storage function.
- In the field of module recycling, the VOLTAREC project, managed by the RECUPYL Company. VOLTAREC includes 2 large companies, a regional agency and 2 laboratories.

IMPLEMENTATION

Public Action

Public policy supports the growth and structure of the market: it takes the form of regulating the PV electricity purchase price, with a special focus given to building integration, and various fiscal incentives for individuals and businesses.

A supply contract is established for a period of 20 years between the producer and distribution company. The previous set of rules has been widely reviewed in 2010.

In 2006, the government established a tariff attractive for BIPV systems. Measures were announced in late 2009 to reverse a drift in the speculative production of solar electricity that could eventually lead to higher electricity prices. At the request of regulation bodies, new pricing rules have been implemented from January 2010 as well as the rules for classification of projects to benefit from these prices.

A new tariff frame replaces the one set up in 2006. Following comments made by the "Mission on the regulation and development of the photovoltaic sector in France," the pricing conditions set in January 2010 were reviewed downwards during the year. A decree of 31 August 2010 establishes new conditions for purchasing electricity from a photovoltaic system as given in Table 2.

The major difficulty induced by the concept of BIPV (building integration) lies in the delineation of equipment that might fall into this category.

From the definition of rules of eligibility for the premium of full building integration and for simplified integration issuing by the "Ministry of ecology, energy, sustainable development and the sea, in charge of green technologies and climate negotiations," a committee was established to examine the admissibility of building integrated technical solutions. This Committee of building integration evaluation (CEIAB) examines the processes of integration of

TABLE 2 - FEED-IN TARIFFS FOR PHOTOVOLTAIC ELECTRICITY FROM 1 SEPTEMBER 2010 (EUR CTS / KWH)

BIPV STATUS	LOCATION		APPLICATION		
			Residential	Building for education or health activities	Other buildings
BIPV Systems	Metropolitan area / Corsica and overseas departments		Existing or new: <ul style="list-style-type: none">• P < 3 kW: 58 cts• P > 3 kW: 51 cts	Existing since more than 2 years: 51 cts EUR	Existing since more than 2 years: 44 cts EUR
«Simplified» BIPV Systems			37 cts EUR		
Non BIPV Systems	Metropolitan area	Northern part	33,12 cts EUR	For P > 250 kW, 27,6 cts EUR feed in tariff is adjusted from 0 to + 20 % considering location from South to North	
		Southern part	27,6 cts EUR		
	Corsica and overseas departments		35,2 cts EUR		

photovoltaic submitted to determine whether they comply or not with the criteria for BIPV as defined in the new tariff decree of 31 August 2010. A list of products and processes that meet the technical criteria for simplified integration and full integration is maintained and free for access.

Events

Several important events were held during the year to promote the technology and applications of photovoltaics. Following a public oriented "Solar Family Event" held in June, "SOLAR Meetings" were held for professionals in November. Intended for researchers, developers, architects, businesses, etc., these meetings organized by the regional actors in Rhone Alpes have aimed to take stock of market conditions, to present the issues and advances in research and to promote business opportunities.

The 4th edition of ENERGAIA from 8 December to 11 December hosted in Montpellier had 30 000 visitors. This international event brought together 400 international exhibitors and offered an extensive program of conferences, symposia, forums on employment and training and organization of business meetings.

The European project PV Legal, started in July 2009, aims to reduce administrative barriers on the photovoltaic market in order to decrease the timeout of a PV system connection to the grid. In this context, the trade association and SER-SOLER/ENERPLAN associations organized a conference on 25 November, "Opportunities and barriers to the deployment of photovoltaics in France and Europe." Nearly 150 players participated in the photovoltaic workday.

Furthermore, associations that drive the renewable sector (CLER, ENERPLAN) have again organized "open days" allowing thousands of people visit photovoltaic systems and meet professionals. Positive public feeling is real. People are attracted by these opportunities to learn more about the PV domain and seduced by the appropriate national and regional incentives.

ENERPLAN has also established a forward-looking, open to all, "France Solar 2.0" to analyze the prospect's 2020 Solar Energy Plans in France regarding technology, socio-economy, development of the professions, urban development etc.

Quality

Quality procedures initiated in 2008 have been widely developed. QualiPV is a trusted name recommended by the ADEME and local authorities, supported by professional organizations and industrial sector, supported by energy operators and quoted frequently in the media as a quality benchmark for the consumer. The label assigned by Qualit'EnR certifies that installers of photovoltaic systems in individual homes meet the criteria of professional competence for the implementation of solar equipment and receive the necessary assurances in order to the practice their specialized work.

According to the "Qualit'EnR", 5 600 enterprises received the label "QualiPV" since its inception. By following the "QualiPV" approach, each company agrees to comply with the ten points of the "QualiPV" charter established by the profession.

One third of qualified "QualiPV" installers were audited in 2010. QualiPV and its audits intend to build a qualitative and sustainable photovoltaic know how and are complementary to the Consuel organization's certificates of electrical conformity, which are mandatory on all PV systems lower than 250 kW, since 24 March 2010.

In addition, CERTISOLIS laboratory, implemented near the INES facilities, is now the laboratory on the French territory for photovoltaics energy performance certification.

INDUSTRY STATUS

The development of the industrial sector continued throughout the entire photovoltaic materials, cells, modules, systems and power generation value chain.

In Silicon Technology

Upstream of the chain, a new path grows with the PHOTOSIL project, through the partnership FERROPEM (Group FERRO-ATLANTICA No. 1 worldwide silicon metal process), INES and OEMs. The results currently achieved in the development of solar-grade silicon used to obtain cell yields above 16 %. The pre-industrial production in the Rhone Alpes is scheduled for 2011.

At this stage, other industry players are already in place: ECM Technologies (manufacturer of crystallization furnaces), VESUVIUS (a global manufacturer of crucibles for photovoltaics), CARBONE LORRAINE (leading supplier of graphite for PV), EMIX (electromagnetic casting ingots -annual capacity 360 tons- and silicon wafers manufacturer).

PHOTOWATT Technologies (a subsidiary of ATS), an historical player of this industry, produces multicrystalline silicon ingots, wafers and cells primarily dedicated to its own modules production activity. Its production capacity is around 70 MW per year with a view eventually to 100 MW.

Considering cells, the pilot unit "LabFab" operated by the consortium PV Alliance (Photowatt-CEA-Liten, EDF Energies spread) has been developed with technology transfer from research to industry, leading ultimately to the development of an installed capacity of 2 units of 100 MW, one for the production of cells based on upgraded metallurgical grade silicon, and one for the production of high efficiency cells (> 20 %) using "heterojunction" technology which combines crystalline silicon nanotechnology.

A production unit with a capacity of 78 MW in 2012 is in progress within the project PV20 (OSEO program) carried by MPO-ENERGY,

involving TENESOL and SEMCO Engineering (diffusion furnaces, turnkey lines). The objective is to implement a production process of modules 100 % "Made in France" at reduced cost.

Considering modules, industry players are already installed (see Table 3), bringing the production capacity of silicon modules to 440 MW.

TABLE 3 - MAIN PRODUCERS OF SILICON MODULES

COMPANY	CAPACITY 2010 (MW)	TECHNOLOGY	STARTING
Photowatt	70	Multicrystalline	1984
Tenesol	85	Mono and multicrystalline	2005
Auversun	22	Mono and multicrystalline	2009
Sunland 21	35	Monocrystalline	2009
Sillia	20	Mono and multicrystalline	2009
Fonroche	90	Mono and multicrystalline	2009
Systovi	12	Monocrystalline	2009
Solarezo	50	Monocrystalline	2009
Voltec Solar	20	Mono and multicrystalline	2010
France Watts	5	Mono and multicrystalline	2010
Solaire Direct (in South Africa) Afrique du sud)	30	NC	NC

Note also the production of silicon wafers of high quality from the ribbon manufacturing technology (SOLAR FORCE).

In addition, Free Energy produces modules and systems based on amorphous silicon technology (1 MW capacity).

Following the developments made by INES, APOLLON SOLAR INDUSTRIES Vincent and the OEM in the project NICE, automatic encapsulation chains modeled on the prototype developed at INES were sold abroad.

In the field of thin films (CdTe, CIGS) technology is not developed at the industrial level. However, the start-up "NEXCIS, which opened its pilot facility in March, aims to produce 50 MW of CIGS thin films modules by 2014, from R&D performed in IRDEP.

FIRST SOLAR has also signed an agreement with EDF-Enr to build a factory for CdTe modules production (25 MW), with the prospect of other industrial implementations, to meet the EDF Enr needs. The project was temporarily suspended at year end, pending the new regulatory measures and the associated feed-in tariff.

SOLEMS, an independent SME produces cells and thin film sensors.

Regarding systems, numerous players are in place to design and develop projects (SOLAIS, TRANSENERGIE, SUNVIE, CLARTENE, ENEVIA, TCE SOLAR, TENESOL), to produce and install systems, including turnkey systems (TENESOL EVASOL, SUNNCO, PHOTON, SPIE, CEGELEC, etc.).

Connected to the above activities, diversification has been undertaken in the field of industrial electrical design or to develop specific components for photovoltaics: cables (NEXANS OGIER, etc.), transformers and inverters (SCHNEIDER ELECTRIC, AINELEC, IES Synergy), batteries (SAFT, PROLION), connectors (RADIALL), trackers (HELIOTROP, EXOSUN) or monitoring systems (GREENERCOS, EHW, MULTICONTACT).

Other industry players contribute to the development of equipment for the photovoltaic industry (Air Liquide, Saint-Gobain) or to the development of new products for building integration. (IMERYYS Toiture, LAFARGE Couverture, KAWNEER EUROPE, ARCELOR, SOPREMA, etc.).

At the end of the value chain, we observe the development of companies whose objective is to develop, build, finance and operate facilities for photovoltaic power generation, including ground mounted plants, on the national territory and abroad.

The total capacity (in operation and under construction on the territory) of EDF Energies Nouvelles in early 2010 was 83 MW; POWEO operates 2 MW. SOLAIRE DIRECT has implemented a program of four plants for a total capacity of 34 MW. Other companies such as SAMSOLAR, SECHILIENNE SIDEC, SUN R are also making large solar roof mounted or ground mounted plants.

MARKET DEVELOPMENT

Applications

The market is divided into four types of applications that lead to specialization of actors: the individual systems for homes (less than 3 kW), roofing systems of collective buildings (in the range from 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. 416 MW have been connected to the network during the first three quarters of the year, marking an increase of 242 % compared to 2009 over the same period. At the end of December 2010, nearly 150 000 plants were connected to the network, for a total capacity of 1 025 MW.

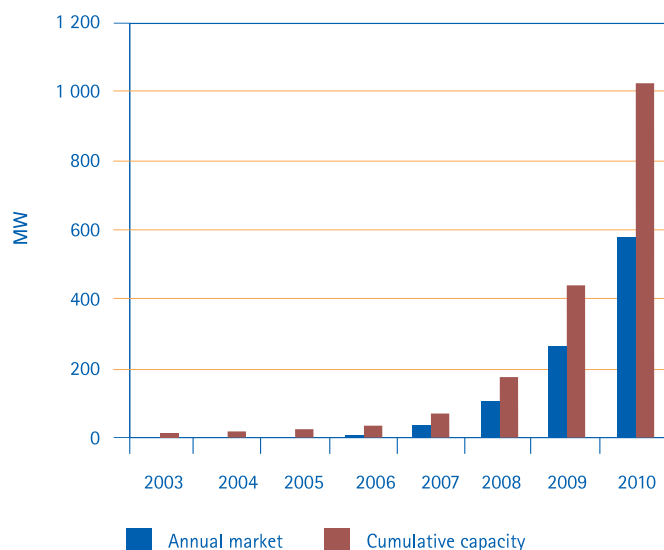


Fig. 1 - Development of the French Photovoltaic Park

Figure 1 illustrates the overall evolution of the French market in recent years.

During 2010, the individual systems market remained at a high level (in the metropolitan area, 95 % of the systems are installations of less than 3 kW; representing 45 % of installed capacity). In this market, a survey made by installers indicates an average price for a small system (typically 3 kW) of 5,93 EUR / W, including equipment and installation fees.

The development of medium and high power systems market is highlighted.

Figure 2 and Figure 3 illustrate the status of the above 100 kW power plants connected to the grid or installed, but awaiting connection (situation in late September 2010).

Figure 4 shows the increase in investments in high-power installations during the past years.

Regarding the contribution of local market development, the Regional Councils, General Councils and municipalities continued to provide financial support to the implementation of photovoltaic systems and professional bodies. This support takes the form of investment aid, fixed or proportional to the installed capacity, with a cap on aid allocated.

Products

New products have appeared on the market to meet the "building integration" demand.

To facilitate the rapid implementation of these innovations, a procedure developed by the "Centre Scientifique et Technique du Bâtiment" (CSTB) is in place. CSTB's Mission is to certify compliance

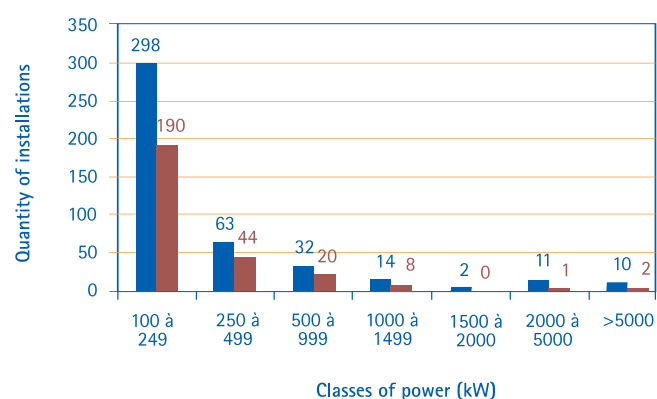


Fig. 2 - Number of Installations > 100 kW in Operation and Awaiting Connection.

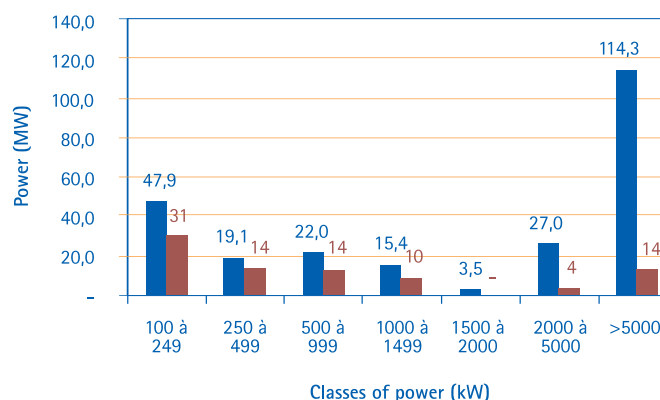


Fig. 3 - Capacity of Power Plants > 100 kW in Operation and Awaiting Connection.

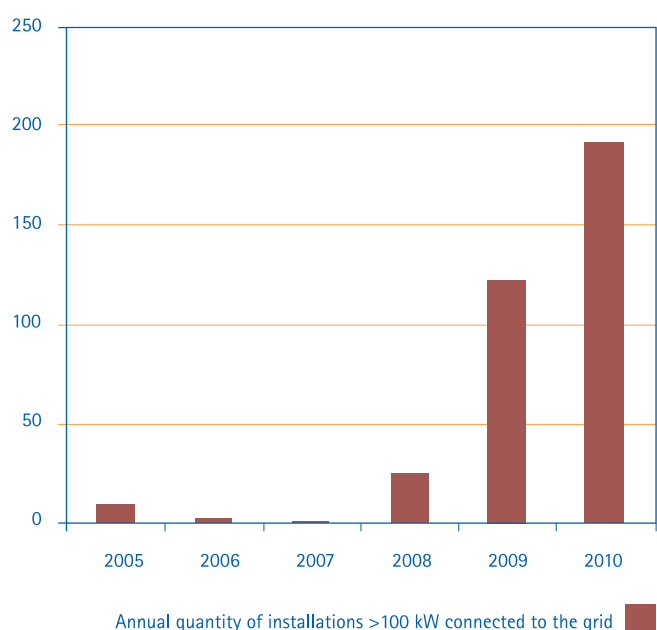


Fig. 4 - Development of the PV Plants Park > 100 kW.



Fig. 5 - PV System integrated to the roof of a church (Alsace department) - 43 kW (photo: Saint Gobain Solar).



Fig. 6 - Photovoltaic power plant in Puylobier (Bouches du Rhône department) - 6,5 MW (photo: EDF EN).

with the regulations in force for innovations in construction. CSTB offers three main services to assess innovative products such as: the Technical Advice (ATEC), the Technical Experimental Assessment and Pass'Innovation. They are designed to provide, to those involved in building, an independent scientific opinion on the behaviour of work done with products and processes involved.

14 ATEC have already been awarded, including 8 in 2010 and 62 Pass Innovation in photovoltaic processes are currently being issued (list available on www.cstb.fr).

CONCLUSION AND OUTLOOK

France has set a goal of having 5 400 MW PV installed in 2020 to reflect its commitment to Europe; that means 23 % of renewables in final energy consumption.

The incentives introduced since 2006 have continued to produce their effects and greatly stimulated investment. The year 2010 was mainly marked by the development of important plants of medium and high power, as well as the emergence of new players in the photovoltaic industry.

Soaring demand, initiated in 2009, led to the creation of a queue of contracts which was reaching 4,1 GW at the end of September 2010, making it very close to achieving the goal set at 5,4 GW in 2020 by the Grenelle of Environment.

A new feed-in tariff schedule was put in place by January 2010. To avoid the formation of a speculative "bubble," an overview of the development of the photovoltaic sector in France was requested by the government.

Following its analysis of the adequacy of measures taken by the Government on the development of photovoltaics in France, the

"Mission on the regulation and development of the photovoltaic sector in France" made the following recommendations:

- Act in September 2010 to lower the feed-in-tariff for photovoltaics and tax incentives for investment
- Establish a perennial regulation system with visibility for the sector
- Maintain resources on R&D
- Mobilize the major industry players to participate to the photovoltaic growth and organize the networking of actors at the national level.

Individuals, small and medium companies, industry groups, public R&D communities engaged in the financing and construction of facilities, as well as professional associations are a very active network bearers of development.

The dialogue initiated between the government and stakeholders in the area should identify acceptable terms to continue the harmonious development of the industrial sector which is now, with 25 000 jobs created, a significant sector.

Note:

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GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY – STATUS AND PROSPECTS

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Fig. 1 – PV is not only an environmental friendly energy source. It also fits nicely with architecture (photos: Würth Solar GmbH & Co.KG / Schwäbisch Hall).

GENERAL FRAMEWORK

Today, energy policy is a prominent topic on the political agenda in Germany. In August 2010, the German National Renewable Energy Action Plan was published. The action plan outlines that the binding domestic target of an 18 percent share of renewable energies in gross domestic energy consumption will be reached by 2020 and may even be surpassed and amount to 19,6 percent [1]. In addition to this, the Federal Government submitted an energy concept in autumn 2010 [2] whose outline is broader than that of the national action plan. The concept comprises conventional energy sources as well as renewable energies and takes energy efficiency developments into consideration. The aim was to develop and implement an overall strategy for the period up to 2050. Concerning renewable energies, it states that this energy source will contribute the major share to the energy mix of the future.

Photovoltaic (PV) is part of this development. At present, a PV capacity of roughly 17 GW is connected to the grid; meaning an increase of around 7 GW in 2010 alone. The installation of PV systems in Germany is still driven by the Renewable Energy Sources Act (EEG) on the one hand and a noticeable decrease of system prices on the other hand.

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) [3]. 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.

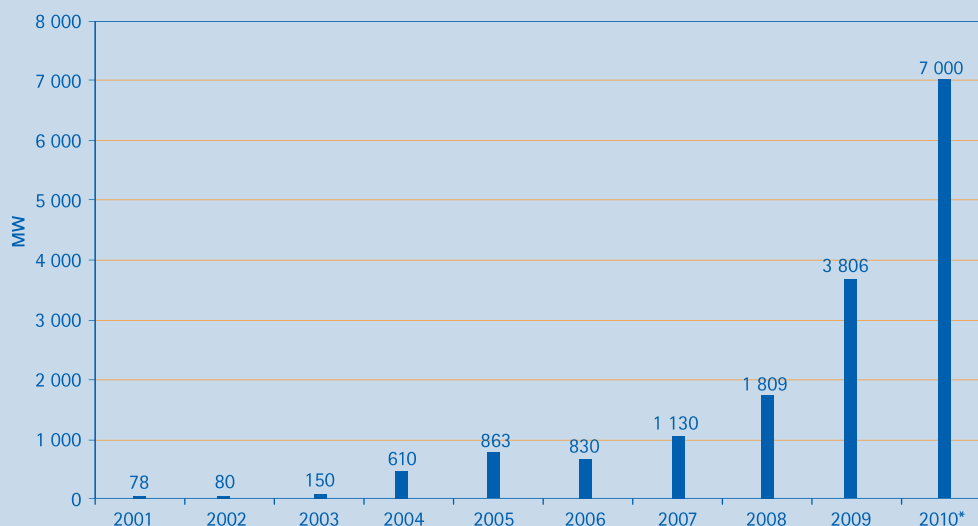


Fig. 2 - Development of grid connected PV capacity in Germany; *first estimate as of January 2010.

Research and Development (R&D) is still conducted under the 5th Programme on Energy Research and Energy Technology "Innovation and New Energy Technologies" [4]. 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 still open. 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
- Cross-cutting issues like lifetime enhancement or recycling.

In 2010 the BMU support for R&D projects on PV amounted to about 39,1 MEUR shared by 152 projects in total. The focal point is still on silicon wafer technology. The second centre of attention lies on thin-film technologies especially on silicon and CIS thin-film technologies. Furthermore, the German contributions to the PVPS Tasks 11, 12, 13 and 14 are part of the programme.

During 2010, 45 new grants were contracted. The funding for these projects amounts to 39,8 MEUR in total. Details on running R&D projects can be found in the BMU "Annual Report on Research Funding in the Renewable Energies Sector" [5] or via a web-based database owned by PtJ [6].

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.

- A call for networks aiming for the development of thin-film solar cells was initiated in 2008. First projects started in 2009, putting 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.
- 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 federal grants of 40 MEUR for a period of four years.

Innovation Alliance PV – a Joint Initiative of BMU and BMBF

In summer 2010, BMU and BMBF initiated the Innovation Alliance PV. Under this scheme R&D projects will be funded which support a significant reduction of PV production costs in order to enhance the competitiveness of Germany's industry. Therefore, projects under industrial leadership integrating different steps of the PV value chain are sought. In particular, cooperation between PV industry and PV equipment suppliers is of importance.

Together, BMU and BMBF will support this initiative with 100 MEUR. The German PV industry agreed to raise additional 500 MEUR to accompany the Innovation Alliance. First R&D projects will start at the beginning of 2011.

IMPLEMENTATION

Since 2004, Germany is among the countries with the highest annual PV installation worldwide. This remarkable development is based on the "Renewable Energy Sources Act (EEG)" [3]. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. 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. For the current tariffs see [7].

Initially, a steady yearly reduction of the PV tariffs was foreseen. On the background of a constantly rising number of installations, a mechanism was introduced to adapt the EEG tariff to the market growth. Under this scheme, the reductions are increased or decreased if the market deviates from a predefined corridor. For 2009 this

TABLE 1 - PV PRODUCTION CAPACITIES FOR 2010 AFTER [8], [10]
(Numbers have been rounded for clarity's sake).

	NUMBER OF ACTIVE COMPANIES	PRODUCTION CAPACITY 2010	CHANGE COMPARED TO 2009
Silicon Wafer Technologies			
Silicon feedstock	4	29 300 t*	+72 %
Wafer production	6	2 500 MW	+25 %
Solar cell production	11	2 300 MW	+15 %
Module production	>24	~2 500 MW	+25 %
Thin-film technologies			
Silicon thin film	10	420 MW	+27 %
CIS technologies	11	310 MW	+35 %
CdTe	3	260 MW	+15 %
Concentrated PV (CPV)			
CPV cells	1	200 MW	+100 %
Systems	1	25 MW	±0 %
System technology [10]			
Inverter for grid-connection	19	15 200 MW	+90 %

* Equivalent to ~4 000 MW

corridor was defined to be between 1 000 MW and 1 500 MW – which was significantly exceeded as the market reached 3 800 MW.

For 2010 to 2012, a new corridor between 2 500 and 3 500 MW was defined. Furthermore, for 2010 two additional reduction steps were agreed to adapt the tariff to the system price level. This resulted in an overall reduction of roughly 1/3 from end of 2009 to early 2011. With around 7 000 MW installed in 2010 the new corridor was surpassed again considerably. Therefore, it is foreseen to implement the reduction foreseen for 2012 already partly in July 2011.

INDUSTRY STATUS

While the German PV industry showed a strong and steady growth over the last years, burdens resulting from the world economic crises and from increased competition resulted 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 [8] creating a turnover of 8,6 BEUR in 2009 [9]. In addition, 62 PV equipment manufacturers supply tools for every step of the PV value chain [8]; they generated an additional turnover of 2,0 BEUR in 2009 [9]. Both figures on the turnover show a reduction compared to 2008 reflecting the world economic crisis. But there are indications that already 2010 showed a recovery.

Beside this, the development of inverter industry is a true success story. It is estimated that in 2010 production capacity arrived at roughly 15 GW [10].

On the background of the comparably high number of companies, it is 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 [8], [10]. The list shows that the German PV industry is expanding along the whole value chain. During the last years, equipment and production companies became the most experienced ones world-wide. At the end of 2009, around 63 000 workers were employed in the PV industry, in hand-craft and trade companies [9].

MARKET DEVELOPMENT

The EEG accelerated the installation of grid-connected PV-systems in Germany significantly. In addition, the decrease of system prices continues which makes 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 2 724 EUR/W in the last quarter of 2010 [9]. After a reduction of 25 % from 2008 to 2009 this is another drop of 13 % from 2009 to 2010.

For 2010, current estimates assume an additional PV capacity of around 7 000 MW [11]. Since the beginning of 2009 the 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 November 2010 and show an additional capacity of 6 414 MW for the first eleven months of 2010 [12] being in fair agreement with the above mentioned estimate for the entire year. Thus, at the end of 2010, around 17 GW in total may be connected to the German grid, see Figure 2.

As a consequence, it is estimated that PV produced 12 TWh electricity in 2010 which are roughly 2 % of the domestic consumption. All renewable energies together are expected to have a share of 17 % [13]. At the same time, the German National Renewable Energy Action Plan includes a target of a 38,6 % share of renewable energies in the electricity sector for 2020. For PV, the scenario assumes a future development of annually 3 500 MW from 2012 to 2020. In 2010, a development of 6 000 MW and in 2011 a development of 4 500 MW is expected. This leads to an installed capacity of almost 52 GW in 2020 and a resulting electricity production of around 7 % of the overall production, see [1].

In addition to the market of grid connected systems, there is a steady request for stand alone systems. First estimates indicate that in 2010 around 4,5 MW were installed mainly for industrial applications, such as the automotive sector, traffic signals, etc.

FUTURE OUTLOOK

In 2010, the German PV market once again showed an impressive growth. Around 7 GW were added to the grid. The driving force for this development is the EEG despite significant reductions of the tariff. This is possible because of a considerable decrease of system prices in recent years. One main target of the members of the German PV industry association BSW-Solar is to cut the costs of solar power in half by 2020 [11]. Consequently, the current technical and economical status has to be further developed. Enhancement of production efficiency and at the same time lowered production costs are still important. For that reason, high-level R&D is needed. Here, the Federal Innovation Alliance PV started in mid 2010 is one important pillar.

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ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE

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GENERAL

The momentum of PV systems installation has continued during 2010, as a result of the feed-in tariffs for distributed systems that entered into effect in 2008. Cumulative installed capacity reached about 45 MWp, more than 95 % grid-connected. Many more installations are underway.

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 0,2 % 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, with an installation cap of 200 MWp over seven years (170 MWp allocated to commercial installations and 30 MWp reserved for private households). The tariffs are for up to 15 kWp residential systems (presently 1,67 NIS/kWh \sim 0,47 USD/kWh \sim 0,35 EUR/kWh), and up to 50 kWp commercial ones (Fig. 1), (presently 1,51 NIS/kWh \sim 0,42 USD/kWh \sim 0,32 EUR/kWh; this tariff will be reduced by 7 % every year). The tariffs are guaranteed for 20 years.



Fig. 1 - 50 kW_p system at the Shikmim Farm (photo: SolarPower).

- Additional tariffs were introduced by the Public Utility Authority-Electricity for power plants between 51 kWp and the largest size that can be connected to the distribution grid (1,49 NIS/kWh \sim 0,42 USD/kWh \sim 0,31 EUR/kWh). The installation cap is 300 MWp
- 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.
- 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 procedure 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. The feed-in-tariffs look 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.

An international tender for a 30 MWp PV power plant issued by the Government in April 2008 should be decided early in 2011, after a few postponements. A site for this power plant (0,65 km²) 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 more than tenfold over the last couple of years. Most companies are small and deal mainly with system integration.

Presently there is no local production of PV cells.

RESEARCH AND DEVELOPMENT

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

Among the current projects:

- The Jerusalem College of Technology is involved in the development of a high-efficiency bifacial solar cell using p-type and n-type silicon. Fabrication procedure includes mainly doping by thermal doping and ion implantation. In addition, the JCT, in cooperation with industry (B-Solar), is developing methodology and procedures for outdoor characterization of bifacial solar cells modules. Measurements were performed on a small rooftop field (Fig. 2) and monitored during sixteen months. Results were analyzed versus meteorological data collected and different albedo conditions. This technology should allow industrial production of high-efficiency photovoltaic cells at competitive costs.



Fig. 2 - Bifacial modules outdoor test site at the Jerusalem College of Technology.



Fig. 3 - ZenithSolar's combined heat and power system at kibbutz Yavne. 32 1000x mirrored dishes generate 64 kWp of electric power plus 160 kW of thermal power in the form of hot water at 75°C.



Fig. 4 - A 5 kW vanadium redox flow battery under study at Sde Boker for interfacing a PV array to the grid.

- Research in the area of high-concentration photovoltaics (CPV), begun in the 1990s by the Faiman group at Ben-Gurion University's Sde Boker Campus, resulted in the spin-off company ZenithSolar (Fig. 3).

Given that CPV can now in principle solve the economic problem hitherto associated with solar power, the next step is to research appropriate storage methods for rendering solar power compatible with grid requirements. The required properties of such batteries have been studied by the group theoretically. At present, a modest experimental program is in progress at Sede Boquer to study the properties of some actual batteries (Fig. 4).

DEMONSTRATION AND DEPLOYMENT

- SolarEdge Technologies is the first and only manufacturer of solar inverters in Israel. The company develops and manufactures in Israel an innovative end-to-end distributed solar power harvesting system. Independent studies, such as a survey by Photon Magazine (11/2010), demonstrated that the SolarEdge system increases PV power generation by up to 25 %, by eliminating power losses inherent to traditional PV systems, such as losses due to module mismatch, partial shading and dynamic irradiation changes. The unique SolarEdge architecture is comprised of three elements - PowerBoxes which are DC-DC power optimizers that perform MPPT per individual module while monitoring performance of each module, a wide range of high efficiency (>97 %) single-

phase and three-phase solar inverters, specifically designed to work with power optimizers, and a web-based monitoring application that provides module-level and system-wide performance monitoring and accurate troubleshooting.

The SolarEdge innovative system provides module manufacturers, installers and system owners with extraordinary reliability (12- to 20-year warranty on inverters, 25-year warranty on PowerBoxes). The innovative system architecture enables constraint-free design and optimal roof utilization, due to the ability of combining together strings of different lengths and module types, and modules in different orientations and roof facets. Module-level monitoring enables enhanced maintenance and pinpointed troubleshooting, thus reducing maintenance time and cost. The unique SafeDCTM mechanism prevents electrocution through automatic module shut-down during installation, maintenance and fire-fighting.

SolarEdge systems are deployed in over 25 countries worldwide by leading PV installers and can be integrated with most PV modules. The company delivered 50 MW of systems worldwide in 2010. The systems are suitable for residential, commercial and large-scale installations (Fig. 5 and Fig. 6).



Fig. 5 - A 50 kW_p SolarEdge installation on a cowshed in Kfar Vitkin; PowerBoxes are attached to each of the solar modules, for energy maximization.



Fig. 6 - A 15 kW_p installation on four facets of a roof in Kfar Vradim, enabled by SolarEdge's design flexibility.



Fig. 7 - PVT plant at kibbutz Yakum, 50 kWp electric and 200 kW thermal (photo: Millennium Electric).

- Millennium Electric is a PV manufacturer, and a leader in the field of PVT technologies. The company has installed about 26 MW worldwide (Fig. 7) and has a capacity of 300 MW for manufacturing high-efficiency PV mono/poly-crystalline panels. Millennium Electric has developed a number of unique PV technologies that have competitive advantage.

EDUCATIONAL ACTIVITIES

The first Solar Student Conference (SSC2010) took place in April 2010 in Zikhron Ya'akov, at the initiative of the Weizmann Institute of Science. The idea behind SSC, a student-organized and guided conference, is to promote interaction between the participants, coming from the entire spectrum of solar research activity. During four days, 70 higher-degrees students from all over the country listened to tutorial background lectures and to specialized lectures on solar energy, mostly given by participating students. Plenty of time was dedicated to discussions. In the framework of the conference, a competition was held between nine teams to build a solar concentrating system from cheap and readily available materials (Fig. 8).

GOVERNMENT ACTIONS

It is expected that the Government activity described above (solar power plant tender and feed-in 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. Expenditures in PV R&D by the Ministry of National Infrastructures (MNI) were about 550,000 USD in 2010; additional funding is available in this area from other research foundations.
- Partial funding (up to 30 %) of innovative deployment-support projects.



Fig. 8 - The winners of the SSC2010 competition.

ITALY

PV TECHNOLOGY STATUS AND PERSPECTIVES

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Fig. 1 – Building integrated 2,14 kW PV plant, Villa Bartolomea, Verona, Italy (photo: GSE).

GENERAL FRAMEWORK

With a very attractive incentive scheme, Italy became the world's second largest PV market, during the year 2010. The ongoing phase of the Italian "Conto energia" Programme is in fact resulting in a large participation and, now, a high increase of PV installations. Moreover, its recent new phase (the third one of the Programme) adopted with the Ministerial Decree of 6 August 2010 has defined the incentive tariffs for photovoltaic generation in the period 2011 – 2013.

The barriers due to bureaucratic problems are still evident, but they began to have a progressive decreasing impact on PV plant installations. A preliminary evaluation of PV power installed in Italy during 2010 shows, in fact, to be around 1,700 MWp. Thus, the total installed power in Italy at the end of 2010 should result in about 2,900 MWp with a growth rate around 140 %, with respect to the previous year. In this situation, the overall cumulative power supported by this second phase of the "Conto energia" Programme (1,200 MWp) was more than doubled.

From the technical point of view the main barrier is represented by the electric grid that becomes to be inadequate in some regions of southern Italy, where the installed power of wind turbines and photovoltaic power stations is almost the same order of magnitude as peak load. As a consequence, the growth of the photovoltaic market must be accompanied by an adequate plan for MV and HV grid development.

NATIONAL PROGRAMME

The first phase of the "Conto energia" Programme (issued in September 2005) was completed during 2009. In this context, 5 733 plants have been installed, corresponding to a total power around 164 MWp.

The second phase of the Programme started in February 2007, was completed at the end of 2010. During this period, it resulted in setting into operation about 125 000 plants; corresponding to a total power of 2,736 MWp.

Taking into account both the first and second phase, the installed PV power that was reached at the end of December 2010 was over 2,900 MWp; with an increase of 140 %, in respect to the previous year.

In July 2010, a new edition of the "Conto Energia" decree was established for the third phase:

- an increase of the national objective from 3 GWp by 2016 to 8 GWp by 2020;
- an increase of the supported capacity from 1,200 to 3,500 MWp, to which must be added the power of plants that will be put in operation within 14 months after the supported capacity has been reached. In particular, for ground-mounted and on-building based plants the limit is 3,000 MWp; for building integrated application with innovative features the limit is 300 MWp; while for solar concentration plants the foreseen limit is 200 MWp.



Fig. 2 - Building integrated 6,72 kW PV plant, Formello, Rome, Italy (photo: GSE).



Fig. 3 - Building integrated 65,3 kW PV plant, Bolzano, BZ, Italy (photo: GSE).

The decree has also introduced new incentive tariffs in the period 2011-2013 that depends on the installation typology, the technology utilized, and the size of the plant. With respect to the tariffs for plants that have been installed up to 31 December 2010, (that remain regulated by the second Conto Energia Decree of 19 February 2007), the new tariffs for the year 2011 result decrease from 10 % to 23 %.

For calendar year 2012 and 2013, the tariffs for ground-mounted and on-building based plants will be reduced by 6 % per year while those of building integrated or concentration plans will be reduced by 2 % per year, commencing on 1 January 2012. The tariff reduction rate for 2014 will be defined or could remain similar to the one of the previous year.

A further novelty regards a tariff increase if the plant:

- is located in industrial or commercial areas, in waste treatment areas, in exhausted or in polluted areas;
- allows daily grid injection with day-ahead nominations having shortfalls over a 300 days/year average lower than 10 %.

Moreover, a significant step forward towards the simplification and harmonization of the authorization process for the construction of PV power plants has been done with the issue of National Guidelines. Such guidelines, left aside for many years, have been adopted on 8 July 2010. As a consequence, the Italian Regions will have to adapt their rules to comply with the National Guidelines within 90 days. If this is not done, the National Guidelines will prevail over the Regional Rules. The authorization process for plant construction is in fact one of the main bottlenecks for the PV sector in Italy and the lack of clear procedures defined at the national level allowed for the proliferation of regional rules.

As far as the connection to the grid, the "reservation" of the grid capacity has proved to be a problem in some southern regions.

In order to reduce such problems, the Italian Authority for Electricity and Gas (AEEG) has introduced some specific provisions concerning the requests of connection in areas (or lines) where the capacity of the grid is critical.

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 RSE (previously CESI RICERCA, a research company owned by 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 few private laboratories.

ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest regard: crystalline silicon, Cu_2O solar cells, microcrystalline Si devices, micromorph tandem solar cell as well as concentrators technologies.

RSE 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 Italian electric system research programme RdS (Ricerca di Sistema) and in the European project "APOLLON." Furthermore, RSE is involved in components' characterization and performance evaluation of PV innovative systems, as well as in research and demonstration activities for electrification of remote communities, again in the frame of the RdS programme.

It is worth mentioning that the public and private budgets for research and demonstration initiatives, amounting to about 5 MEUR, remain flat with respect to the previous years, and very small with respect to the budget allocated for promoting tariffs.



Fig. 4 - Building integrated 33,8 kW PV plant, Bolzano, BZ, Italy (photo: GSE).



Fig. 5 - Building integrated 688 kW PV plant by Industrial products, Mottola, TA, Apulia Region, Italy (photo: GSE).

IMPLEMENTATION OF SYSTEMS

According to a preliminary evaluation a total capacity of about 2,900 MWp result installed in Italy at the end of 2010. Taking into account that during this year about 1,700 MWp have been installed (more than 1,000 MWp in the fourth quarter), the annual growth recorded has been around 140 %.

The installations in Italy in the three significant sectors of PV power system applications are estimated as follows:

off-grid systems:	amounting to 15 MWp;
on-grid centralized systems (>200 kWp):	reaching about 1,500 MWp (*) (starting to dominate Italy's cumulative installed photovoltaic power)
on-grid distributed systems:	amounting to about 1,400 MWp (*)

(*) preliminary evaluation

INDUSTRY STATUS AND MARKET DEVELOPMENT

In the year 2010, about 15 main producers of crystalline silicon cells and finished PV products have been identified in Italy. On the whole, a total production of around 300 MW has been estimated. As a consequence, the share of installed modules that have fabricated in Italy remains still low, while the amount of modules imported from China is increasing.

Instead, the position of Italian firms operating in the power conversion system field is different. In fact, about 50 % of the inverters installed in 2010 have been produced in Italy while a larger figure has been exported. Taking into account also exported volume, about 2,000 MW of inverters have been produced in Italy during 2010.

FUTURE OUTLOOK

The low pay back time, corresponding to the current tariffs and system prices, has attracted many solar investors. Also, despite the tariff decrease from 2011, the internal rate of return of solar investments in Italy still will be higher than in other countries. In this context, the Italian national target of 8 GW by 2020 is expected to be reached within few years.

Such market expansion should be accompanied by an adequate growth of the national PV industry in order to balance the import and export of photovoltaic products as well as a major involvement of the research sector; up to now characterized by a very small budget with respect to the one allocated for market promotion.

On the other hand, tariffs might be reduced more quickly than scheduled, regions might introduce constraints in land use for photovoltaic installations (especially if devoted to agriculture) and the grid connection is beginning to be critical, especially in southern Italy.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

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OSAMU IKKI, RTS CORPORATION



Fig. 1 – Gunma Bank Oizumi Branch (Oizumi-machi Ora-gun, Gunma Prefecture), 17 kW.

GENERAL FRAMEWORK

The general framework for Japan's energy policies and measures regarding PV power generation is classified into the following items according 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 national energy strategy: Basic Energy Plan (compiled in 2010)
Basic Energy Plan that stated the direction of Japan's energy strategies toward 2030 was formulated in 2010 by reviewing New National Energy Strategy compiled in 2006. The Plan set the future goal of renewable energy and stipulated that Japan will significantly enhance dissemination of renewable energy and increase its share to 10 % of the primary energy supply by 2020.
- 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 midterm 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 20 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 JPY/kWh to 7 JPY/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" (enforced in 2009)
Basic purchase price of surplus power generated by PV systems for FY 2009 and FY 2010 is 48 JPY/kWh.
- 9) Obligations to purchase electricity generated by renewable energy (gross feed-in tariff scheme): new bill is in preparation
METI finalized the draft of the detailed scheme in 2010 and is preparing for its legislation in FY 2011.
- 10) Advancement of the PV industry: the New Growth Strategy and the Industry Structure Vision 2010 (both established in 2010).
The sectors that Japan will strategically promote the growth are identified. "Japan as a global power in the environment and energy by green innovation" as one of the core strategies and "Environment related new market with the size of over 50 trillion JPY" and "Job creation of 1.4 million in the environment sector" and other targets are listed. The PV industry is positioned as one of the industries to support the sector.
- 11) Measures for dissemination: METI, the Ministry of the Environment (MoE) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), etc.
These ministries implement various measures to introduce PV systems such as Subsidy for measures to support introduction of residential PV systems, Project supporting acceleration of the local introduction of new energy, research and development of PV technologies and "Eco-school Pilot Model Project."

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. The Ministry of Economy, Trade and Industry (METI) restarted the subsidy program for residential PV systems from January 2009 with the supplementary budget of FY 2008 and continued the program in 2010 with a budget of 40,15 BJPY. 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. In 2010, MoE implemented the Project to purchase solar environmental values.

The budgets for major national PV programs implemented in FY 2010 are as follows;

- 1) Subsidy for measures to support introduction of residential PV systems: 40,15 BJPY + 14,53 BJPY for FY 2010 supplementary budget

- 2) Technology Development of Innovative Photovoltaic Power Generation: 5,98 BJPY
 - R&D for High Performance PV Generation System for the Future: 4,08 BJPY
 - R&D on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program): 1,9 BJPY
- 3) Field Test Project on New Photovoltaic Power Generation Technology: 0,14 BJPY
- 4) International Cooperative Demonstration Project for Stabilized and Advanced Grid Connected PV systems: 0,208 BJPY
- 5) Verification of Grid Stabilization with Large-Scale PV Power Generation Systems: 0,20 BJPY
- 6) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources: 0,80 BJPY
- 7) Japan-U.S. Smart Grid Collaborative Demonstration Project: 1,83 BJPY
- 8) Project supporting acceleration of the local introduction of new energy (New integrated program of FY 2009 Project for Supporting New Energy Operators and Project for Promoting the Local Introduction of New Energy): 34,48 BJPY
- 9) Project to purchase solar environmental values: 0,45 BJPY

The budget for item 6) – 8) includes those for PV and other types of new and renewable energy.

R&D, D R&D

Three of the four programs under the control of New Energy and Industrial Technology Development Organization (NEDO) ended at the end of FY 2009; i) Research and Development of Next-generation PV Generation System Technologies; ii) Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems; and iii) Development of Technologies to Accelerate the Practical Application of Photovoltaic Power Generation Systems. In FY 2010, "R&D of High Performance PV Generation System for the Future," has newly started as a 5-year R&D programs to achieve the following technological targets based on the Roadmap PV2030+; i) PV power generation cost of 14 JPY/kWh; ii) PV module manufacturing cost of 75 JPY/W; and iii) PV module conversion efficiency of 20 %. This program aims to further improve elemental technologies that had been developed in the previous programs and lead to commercialization by evaluating and reorganizing the R&D programs that had been conducted until FY 2009, in order to contribute to the achievement of the 2020 introduction target of PV power installation (28 GW) set by the Japanese government and strengthening global competitiveness. The program consists of 7 academic-industrial consortium-based projects covering crystalline silicon, thin-film silicon, thin-film CIGS, and organic thin-film solar cells, and 6 technological development projects proposed by industrial players. In addition, the development of evaluation technologies for PV cell/module performance that had been conducted until FY 2009 to develop technological infrastructure to support mass deployment of PV systems under the Research and Development of Common Fundamental Technologies for Photovoltaic Generation Systems has

continued in the R&D of High Performance PV Generation System for the Future, as mentioned above. A new project to establish reliability of PV systems has started as well.

Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program) that has continued since FY 2008 is a seeds-seeking research program aiming at drastically improving performances of solar cells (target conversion efficiency: 40 %) from a long-term perspective towards 2050. Midterm evaluation of the projects was conducted in October 2010 to review research results during the 2-and-a-half years since 2008 and to discuss development direction until 2014. Three ongoing projects that will continue until 2014 are as follows; i) research and development project of ultra-high efficiency post-silicon solar cells led by the University of Tokyo as a leading institute, ii) research and development project for thin film multi-junction solar cells with highly ordered structure, led by National Institute of Advanced Industrial Science and Technology (AIST), and iii) research and development project of thin film full spectrum solar cells with low concentration, led by Tokyo Institute of Technology (TIT).

In the field of fundamental research, Development of Organic Photovoltaics toward a Low-Carbon Society is conducted by the University of Tokyo. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) also implements 2 programs: i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells (an individual proposal-oriented project with a research term of 3 to 5 years); and ii) Creative Research for Clean Energy Generation using Solar Energy (a team proposal-oriented project with a research term of 3 to 5 years) and new research proposals were called. Under Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells, 24 projects including 10 new projects continued aiming to research various PV elemental technologies and develop novel materials. Program of Creative Research for Clean Energy Generation using Solar Energy, has continued with a total of 11 projects, including 5 new projects, aiming to develop novel materials for thin-film solar cells.

Demonstration

Major demonstration programs were implemented in FY 2010: i) Verification of Grid Stabilization with Large-Scale PV Power Generation Systems, ii) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources, iii) Verification Test of a Microgrid System for Remote Islands (Demonstration tests of the next-generation power transmission and distribution network for solar power generation to start on ten islands), iv) Demonstration of Next-Generation Energy and Social Systems, v) Japan-U.S. Smart Grid Collaborative Demonstration Project, vi) International Cooperative Demonstration Project for Stabilized and Advanced Grid-connection PV Systems and vii) International Cooperative Demonstration Project Utilizing Photovoltaic Power Generation Systems.

(1) Verification of Grid Stabilization with Large-scale PV Power Generation Systems

With this demonstrative research program, a wide variety of demonstrated operation tests were carried out in the installations of a 5-MW PV power plant in Wakkanai City, Hokkaido Prefecture and a 2-MW PV power plant in Hokuto City, Yamanashi Prefecture. The term of this research project is from FY 2006 to FY 2010. FY 2010 is the final year of the program.

(2) Development of an Electric Energy Storage System for Grid-connection with New Energy Resources

This project focuses on development of electricity storage technologies with the aim of minimizing output fluctuations of power generation using new and renewable energy. Research and development of new model nickel hydride batteries and lithium rechargeable batteries and development of evaluation methods are in operation. This project is a 5-year project between FY 2006 and FY 2010.

(3) Verification Test of a Microgrid System for Remote Islands

Verification tests on micro grids in remote islands are conducted by Kyushu Electric Power and Okinawa Electric Power. Installed PV capacity of Kyushu Electric Power and Okinawa Electric Power are 120 kW and 4,500 kW including 4,000 kW systems in Miyako Island, respectively. The term of this verification test is from FY 2010 to FY 2014.

(4) Demonstration of Next-Generation Energy and Social Systems

Demonstrative research are conducted in 4 cities; Yokohama City, Toyota City, Kyoto Prefecture (Kansai Science City) and Kitakyushu City. Each site's own objectives of the demonstration tests are as follows: i) Yokohama City is for the comprehensive demonstration in a metropolis, ii) the demonstration with its focus on the next generation vehicles in Toyota City, iii) Kyoto Prefecture is for the demonstration in an area where residential research institutes are dispersed into relatively large area, iv) Kitakyushu City is for the regionally specific demonstration. The term of this research project is from FY 2010 to FY 2014.

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

This program is one of the international cooperative demonstration programs which aims at a stable electricity supply constructing micro-grids using PV power generation. 4 projects implemented in Thailand, China, Indonesia, and Malaysia were completed successfully by FY 2009.

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

This international cooperative demonstration program verifies PV systems under conditions which are usually not available in Japan. From FY 1992 through FY 2010, a total of 19 projects were carried out in various Asian countries. Two projects were implemented in FY 2010: i) "Demonstrative Research Project to Stabilize Output of Hybrid PV Power Generation Systems", using PV and small-scale



Fig. 2 - Cycle Station (Kokurakita-ku Kitakyushu City).

hydraulic power generation and capacitors in May County of Phongsaly Province, Laos, ii) "Development of Design Support Tools for Photovoltaic Power Generation Systems", developing appropriate design support tools reflecting demonstration results.

(7) Other International Demonstration Projects

Nine projects were in operation in FY 2010: i) Smart Community Demonstration Project in Lyon, France, ii) Comprehensive Cooperation for Collaborative Projects in the Solar Energy Field with Moroccan government, iii) Joint projects in the environment and energy efficiency fields with Thai government, iv) a collaborative research and demonstration of Smart Grid-related technology with the Centre for the Development of Industrial Technology (CDTI) of Spain, v) Japan-U.S. Smart Grid Collaborative Demonstrative Project in New Mexico, United States, vi) a task force of Japan-U.S. Cooperation on Clean Energy Technologies in Hawaii, United States, vii) Japan-U.S. Smart Grid Collaborative Demonstration Project in New Mexico, USA, viii) Feasibility Study of Smart Community for an industrial area in Java Island, Indonesia, and ix) Study on PV system introduction and grid-connection in Mongolia.

IMPLEMENTATION

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

The Ministry of Economy, Trade and Industry (METI) is leading the support of the dissemination of PV systems for residential houses and public and industrial applications. Besides the subsidy for installation of facilities, METI is implementing the program to purchase surplus PV power. METI also support local governments to establish their own vision for introduction of new and renewable energy. Through related organizations, METI also offers some programs such as low-interest loans and tax credits.

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

METI implements the subsidy program for the individuals and companies who install residential PV systems. The amount of subsidy for the FY 2010 is 70 000 JPY/kW. There are requirements for the

subsidy such as maximum output capacity must be less than 10 kW and the price of the system is less than 650 000 JPY/kW. It is expected that the number of PV system installations supported by the subsidy with initial budget of 40,15 BJPY for FY 2010 will reach approximately 150 000. The number of applications for the subsidy exceeded 130 000 in December 2010. It has also been decided to add 14,53 BJPY (almost 66 000 installations) as the supplementary budget, thus the expected number of PV system installations and the installed capacity will be approximately 216 000 and 820 MW, respectively in FY 2010.

2) Program to purchase surplus PV power

Based on the "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers", METI has been implementing the program to purchase surplus PV power since November 2009. Purchase prices for FY 2010 are 48 JPY/kWh for residential PV systems with less than 10 kW (twice as much as the typical retail price for household) and 24 JPY/kWh for non-residential (less than 500 kW) and residential applications with more than 10 kW of output capacity. Purchase term is 10 years and all electricity users share the purchase costs evenly. This program, coupled with the subsidy program for residential PV system, is the powerful driving force of the PV demand.

3) Project for Promoting the Local Introduction of New Energy

This program aims at accelerating introduction of new and renewable energy by supporting projects for installation of facilities as well as projects for awareness towards dissemination, which are implemented based on plans for introduction of new and renewable energy in areas designated by local public organizations and nonprofit private organizations. New and renewable energy installation projects which are locally integrated and collaborative work of local public organizations and private institutions are also eligible for this program. In FY 2010, the subsidy was provided for facilities using new and renewable energy such as PV power generation, advanced technology of innovative energy such as fuel cells, and microgrid. PV systems with the output capacity of 10 kW or more are qualified under the

program. Qualified PV projects can receive the subsidy of the lower amount of either up to half of the installation cost, or 400 000 JPY/kW. 354 PV projects with total installed capacity amounting to 15 000 kW were adopted for subsidy in FY 2010. From the initiation of the program in FY 1997, the cumulative number of qualified systems and installed capacity were 1 300 systems and 116 MW respectively.

4) 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. In FY 2010, the subsidy is provided for facilities using new and renewable energy, advanced technology of innovative energy, and microgrid. 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). Amount of subsidy is the lower amount of either up to one third of the installation cost or 250 000 JPY/kW. 401 PV systems with the total installed capacity of 22 MW were qualified in FY 2010. From the initiation of the program in FY 1997, the cumulative number of qualified systems and installed capacity were 1 200 systems and 90 MW respectively. The installations of MW-scale PV power plants have been installed mainly by utilities and large scale factories taking advantage of this program and the abovementioned "Project for Promoting the Local Introduction of New Energy."

(2) The Ministry of the Environment (MoE)

MoE is promoting projects to reduce CO₂ emissions by the use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming." In the "Project to support active introduction of technological measures", MoE has been providing subsidy for the introduction of new and renewable energy including PV systems with the output capacity of 50 kW or more and enhancement of energy conservation. Under the "Project to purchase solar environmental values", MoE provides fixed subsidy for facilities with total capacity of 20 to 500 kW (with the amount of up to 300 000 JPY/kW), on condition that Green Power Certificates issued for commercial PV facilities of private institutions are transferred to MoE. Besides, MoE implements supports of Eco-Renovation of Schools and development of practical use of renewable energy technologies such as PV systems.

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

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. For the private sector, MLIT subsidizes a fixed amount of grant or a part of maintenance cost to the projects which contribute to the implementation and awareness towards dissemination of renovation for longer operation life and eco-CO₂ reduction at houses and buildings. For the introduction of technologies such as PV systems to reduce CO₂ emissions, MLIT provides subsidy for private institutions that conduct projects which are highly effective as model projects.

MLIT also considers leasing of nationally owned land such as road space to the private institutions to install commercial facilities and PV systems.

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

MAFF implements 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. Introduction of PV systems are also included for the comprehensive maintenance supports of living environment in villages dependent on the primary industries. In order to strongly support the introduction of PV and other renewable energy facilities in such villages, MAFF implements a study on installation of these facilities as well as a demonstrative research on the technology of PV systems with novel structure.

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

In cooperation with MAFF, METI and MoE, MEXT has continued the "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, junior high and high schools across the nation. By FY 2010, MEXT certified 1 091 schools as Eco School Pilot Model Projects. Of the 1 091 schools, installation of PV systems has been promoted at 732 schools. Under the School New Deal Concept formulated in 2009, MEXT is forwarding the installation of PV systems in 12 000 public elementary and junior high schools nationwide. Moreover, MEXT implements the subsidy program intended for the national universities and private schools.

(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 600 local governments and municipalities established subsidy programs for 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 CO₂ emissions by 25 % in 2020 compared to that of 2000 under the "Tokyo in 10 years" plan and announced a plan to introduce 1 GW of solar energy. Accordingly, TMG decided to provide subsidy of 100 000 JPY/kW in FY 2009 and FY2010. This provides support for the introduction of solar energy devices to 40 000 households in total over the period of 2 years. As of December 28th, 2010, TMG received more than 14 000 applications for the subsidy. In parallel, environmental values of electricity which were generated by PV power generation and used for self consumption for the period of 10 years will be converted into Green Power Certificates, to be owned by TMG.

(7) Utilities

Voluntary programs to purchase surplus PV power that electric utilities continued was replaced by a new program to purchase surplus PV power from November 2009, based on a newly-enacted "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use



Fig. 3 - Tokyo Toyopet Katsushika store (automobile dealer of the Toyota Group), 50 kW (Katsushika Ward, Tokyo).

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 retail 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 2009, 1 323 public facilities including schools across Japan were subsidized by the fund and the total installed capacity reached 24 064 kW. In FY 2010, 186 sites were selected, and a total 2 890 kW of PV systems received subsidy as of the end of 2010.

Electric utilities achieved the obligation amount of purchasing electricity generated from new and renewable energy for FY 2009 designated under the RPS Law that was enforced in FY 2003. Usage of electricity generated by new and renewable energy by utilities in FY 2009 was 8 873 TWh in total, including 264,8 TWh from specific PV power plants (facilities intended for "New PV Power Purchase Program") which is not counted as the obligated amount. The obligation amount of 681,2 TWh was completed. The accredited facilities for power generation using new and renewable energy under the RPS Law was 519 966 systems totaling 6 486 MW cumulatively, of which PV systems accounted for 83 systems and 18 MW and specific PV power accounted for 518 648 systems and 1 919 MW respectively. Electric utilities have continued introduction of PV systems in their own facilities, which represent their commitment to taking the initiative in introducing PV systems. They also announced a plan to construct 30 PV power plants with a total capacity of 140 MW across the nation by 2020 by 10 electric utilities and most of those PV power plants are under construction in each site with the aim to initiate their operation by 2012. 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. Besides, environmental investment in foreign countries as well as support and coalition in the field of environmental business have been initiated with emphasis. Some leasing companies entered PV business to deal with PV equipment lease projects.

INDUSTRY STATUS

In the PV industry, PV players developed and enhanced activities in the residential-oriented domestic market as well as the global market mainly targeting the large-scale PV power plant market. Also activities on business enhancement and new entries into the PV market were frequently observed.

In 2010 in particular, the following trends were observed in Japan as well as in the world: i) Preparation for GW-scale production framework not only for PV cells/ modules but also for feedstock, related equipment and manufacturing lines, ii) enhancement of value chains symbolized by global-scale M&As; and iii) Integration of PV systems to comprehensive energy management system at homes and buildings in combination of Home Energy Management System (HEMS,) Building Energy Management System (BEMS,) and other technologies.

Highlights of PV cell/ module manufacturers in 2010 are as follows. Sharp started operation of its thin-film silicon PV module plant in Sakai City of Osaka Prefecture. In Sakai Plant, Sharp signed a joint venture agreement for the production of thin-film silicon PV modules in Italy and power generation business. The company announced to manufacture back contact crystalline silicon solar cells. Overseas production of crystalline silicon solar cells is also planned. Sharp acquired Recurrent Energy of the USA to make it a wholly owned subsidiary. The company received large-scale orders for PV power plants in Thailand. Sharp aims to establish integrated framework of PV business from solar cell production to PV power plant development.

Kyocera opened its first manufacturing base in the USA, with a consideration for production enhancement in Mexico and the Czech Republic, aiming to achieve 1 GW/year production capacity worldwide by FY 2012. The company has strengthened the franchise network for PV system integrators for the domestic market.

SANYO Electric became a subsidiary of Panasonic as well as Panasonic Electric Works. The company will strengthen PV business as a leader of Panasonic's initiative to enhance its environment and energy business. In addition to the production capacity enhancement of HIT PV modules in Japan, SANYO Electric will also launch a next generation PV module into the market. The company is considering to establish integrated production framework outside Japan.

Mitsubishi Electric released single crystalline silicon PV modules to the residential PV market. The company aims for early commercialization of thin-film silicon PV modules.

Kaneka increased its production capacity of thin-film silicon PV modules to 150 MW/year ahead of schedule. The company strengthened development and sales of building integrated PV (BIPV) modules for the domestic market. Kaneka also plans to open a new manufacturing plant in Europe.

Showa Shell Sekiyu established Solar Frontier to integrate its PV business and build its brand. The company is constructing its third manufacturing plant with a production capacity of 900 MW/year. Showa Shell Sekiyu released a number of announcements in rapid succession, including plans of medium- and large-scale PV system installation in Japan and alliance with Saudi Aramco of Saudi Arabia and General Electric of the USA.

Suntech Power Japan aims to acquire a double digit percent of the domestic market share by upgrading services such as insurance for residential PV systems as a standard service. Overseas PV cell/ module manufacturers entered the Japanese market by establishing offices in Japan. They drew attention by expanding their marketing activities and improving quality.

In the area of sensitized/ organic solar cells, companies such as Sony, Fujikura, Mitsubishi Chemical, Sumitomo Chemical, and Konarka Technologies (Toppan Forms, Konica Minolta HD) enhanced their businesses by improving performance and commercializing their products.

In the area of silicon feedstock, manufacturers have been increasing their production capacities, expanding their business overseas. Some companies are planning new entries in line with the demand for solar cells.

Tokuyama achieved its total production capacity of 9 200 t/year and plans to construct a new manufacturing plant in Malaysia with a production capacity of 6,200 t/year.

M. Setek, now a member of AU Optonics (AUO) Group of Taiwan, plans to increase its polysilicon production capacity from 3,000 t/year to 7,000 t/year.

In the area of crystalline silicon wafers, Ferrotec plans to expand its plant in China by raising fund of 2 BJPY.

Osaka Fuji Corporation plans to expand its production capacity of silicon wafers for solar cells to 8 million wafers/year.

TKX will also be enhancing its production capacity to 18 million wafers/year.

Nakamura Choko plans to increase its production capacity of silicon wafers for solar cells to 3 million wafers/year and start the sales of diamond wire saws.

Space Energy plans to double the productivity of silicon wafer production by introducing diamond wire saws. The company also started silicon scrap recycling.

In the area of materials/ components manufacturing, demand for backsheets, encapsulants, and their material for those products are booming; thus accelerating production capacity enhancement and technology development to respond to GW-scale PV production framework. In addition, production capacity expansion and market cultivation has also been observed in the area of cables, connectors, aluminum frames, fillers, glass for PV modules, and coating materials, etc.

In the area of BOS systems, brisk activities have been observed in the development and commercialization of large-sized power conditioners for large-scale PV power plant at home and abroad. New entries to the market of large-scale PV power plant business by heavy electric machinery manufacturers and others have been continuously observed. General trading companies are also strengthening their PV business, expanding the sales of PV products, materials, and components manufactured by domestic and overseas manufacturers, as well as PV system introduction and power generation business.

In the area of production equipment, demand has been expanding in line with increased production of solar cells worldwide. Strong demand was observed in the area of polysilicon manufacturing equipment, crystalline silicon solar cell manufacturing equipment, thin-film silicon PV module manufacturing equipment (turnkey, single unit), etc. Manufacturing equipment producers responded to the growing demand by expanding sales and production capacity of manufacturing plants in and outside of Japan. Production capacity enhancement was also seen in the area of various components used in manufacturing equipment; especially drawing attention were such products as quartz crucibles, special carbon materials, saw wires (especially diamond fixed abrasives), slurry, etching agent, cleaning agent, industrial gas, etc. The market for evaluation and measurement equipment has been booming as well.

MARKET DEVELOPMENT

In the newlybuilt residential house market, prefabricated 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 CO₂ emissions. As well as the traditional distribution channels of residential PV systems

consisting of local builders, electric contractors, electric appliances stores and roofers which was developed by PV manufacturers, large-scale home electric appliances stores and large-scale retail stores entered the PV market for existing houses.

As for medium- to large-sized PV systems for public and industrial facilities, the Project for Promoting the Local Introduction of New Energy and the Project Supporting New Energy Operators are core elements in the field. 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 nationwide 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. Under the policies such as the School New Deal program, more than 2 000 elementary and junior high schools introduced PV systems by FY 2009. In Japan, the installed PV capacity was 843 MW in 2009 and that is expected to grow to about 950 MW in 2010.

FUTURE OUTLOOK

The Japanese government established Basic Energy Plan as directions for Japan's future energy policy and set the target toward 2030; raising the zero-emission power source ratio to 70 % and energy independence ratio to 70 %. In the Plan, the government stressed 3 issues; 1) further escalation of constraint both in Japan and abroad regarding stable supply of energy and resources, 2) increasing needs for enhanced and strengthened measures on energy policy to tackle the issues of global warming, and 3) strong demand for energy and environment sector as a driver for the economic growth and will make efforts to introduce non-fossil energy such as renewable and nuclear energy to the maximum extent by employing all policy measures. Especially, the government will seek aggressive dissemination of renewable energy sources because they have a smaller environmental burden, are mostly domestically procurable and promise diversification of energy resources, creation of job opportunities and other effects, while their cost and stable supply are the issues at this time.



Fig. 4 - Higashi-Kanto Expressway Shisui Parking Area (Shisui-machi Inba-gun, Chiba Prefecture), 100 kW.

A new feed-in tariff program to be proposed in the Diet and research and development will be the core measure to archive further dissemination of renewable energy. In these backgrounds, dissemination of PV systems is indispensable and the government will move toward drastic introduction of PV power generation by implementing enhancement and relaxation of institutions and regulations, support measures, promotion of research and development and reinforcement of electricity supply framework. It is expected that Japan will be moved into the new growth stage for dissemination of PV systems. The government makes advancement for enactment of the bill for the new feed-in tariff program for renewable energy at the moment. METI already has compiled the draft of "the detailed design of feed-in tariff scheme for renewable energy" and the bill for the scheme is scheduled to be submitted to the next ordinary session of the Diet, starting in early 2011. If the bill is enacted, purchase price and period for renewable energy based electricity will be finalized and the Feed-in Tariff program will start in FY 2012.

Under such circumstances, it is assumed that the Japanese PV market is expected to further expand following the trends of PV system dissemination in 2010 and to promote introduction of PV systems mainly in the residential sector driven by the subsidy programs for residential PV systems by the national and local governments and the surplus PV power purchase program as well as reduction of PV system prices. It is also expected that Japan's PV market will be broadening with the taking off of large scale PV plant market for electric power supply in addition to the PV market for industrial and commercial applications. Meanwhile, toward over 1-GW domestic PV market, frameworks for manufacturing, distribution and sales and installation are being developed in the PV industry with the involvement in the related industries against the backdrop of the support for the introduction, lead by the government and outlook for the market expansion.

As presented above, the government has been enhancing the efforts to disseminate PV systems aiming at achieving a low-carbon society. Japan will contribute to the global introduction of PV power generation as a country with 1 GW annual installed capacity in the future.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
DONGGUN LIM. CHUNGJU NATIONAL UNIVERSITY



Fig. 1 - 18,4 MW PV power installed at Gimcheon, North Gyunsang Province.



Fig. 2 - SolarCube (2,2 kW BIPV system) at Hanbat National University.

GENERAL FRAMEWORK

The Korea government announced a plan to invest 40 trillion KRW (Korean Won, 1,100KRW/USD) by 2015 into boosting its competitiveness in renewable energy, aiming to join the world's top five countries in the sector. Under the plan, the government will work together with the private sector to invest 20 TKRW in solar power, 10 TKRW in wind power, 900 BKRW in fuel cells and another 900 BKRW in the bio sectors. The Ministry of Knowledge Economy projected that such investment will be able to create 110 000 jobs while elevating the country's exports of new renewable energy to around 36,2 BUSD. It intends to obtain 15 percent of the global market share by 2015. The investment is part of the Korea government's "green growth" strategy aimed at turning environmental technologies into the main drivers of economic growth and new sources of jobs. The Korea government wants to nurture PV industries as the 'next semiconductor' industries and make them the backbones of the future national economy.

The government budgets in 2010 for renewable energy R&D were 252,8 BKRW, which is a small increase over the 241 BKRW in previous year. The total solar cell production capacity has reached as high as 1,3 GW/year in 2010.

About 157 MW were installed in Korea during 2010, and the cumulative installed PV power was about 680 MW. The PV installation in 2010 shrunk over the previous year due to the reduction of government budget mainly in the FIT programs.

NATIONAL PROGRAMME

Korea government has been pushing "low carbon, green growth" as a major agenda, holding campaigns to reduce Asia's fourth-largest economy's dependence on oil and gas imports and tackle greenhouse gas emissions. Also the government mapped out a plan to raise its renewable energy sector as a key exporting industry to add exports of 36,2 BUSD and create 110 000 jobs. The total budgets for new and renewable energy programs amounted to 808,4 BKRW in 2010 and PV Korea's national PV programs have been based on the 2nd 10-year basic plan for new and renewable energy R&D established to enhance the level of self-sufficiency in energy supply, to meet the challenging of climate change and to consolidate infrastructure of new and renewable energy 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 institutes and universities. Five main programs are operating under the PV dissemination programs; PV subsidy, 1 million green homes, public building obligation, regional dissemination and feed-in-tariff programs.

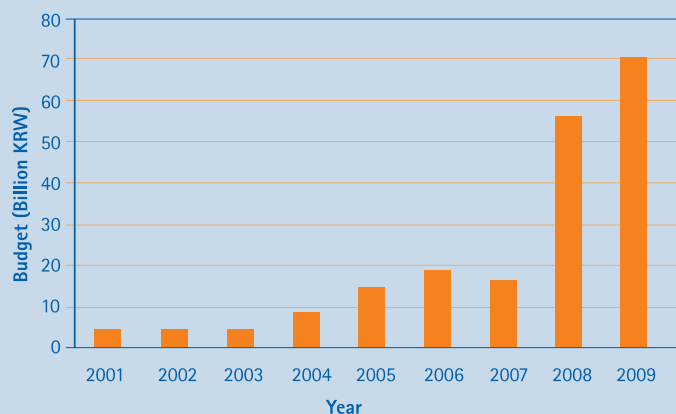


Fig. 3 - National budget for the PV R&D in Korea.

RESEARCH & DEVELOPMENT

The government budgets in 2009 for PV R&D were 70,6 BKRW, which is 25 % increase over the 56,7 BKRW in previous year. In 2010, the 25 new and 59 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 25 new projects amounts to 27,5 BKRW. The representative "Strategic R&D" projects funded newly in 2010 is "Development of commercialization technologies of high efficiency c-Si solar cells and modules with ultra-low cost."

INDUSTRY STATUS

Recently, Korea has had rapid growth in the PV industry. The total solar cell production capacity in Korea has reached 1,3 GW scale in 2010. As the result, the supply chain of crystalline silicon PV is completed from feedstock materials to system installation.

OCI has expanded their annual production capacity of poly-silicon feedstock up to 15,100 tons in 2010. The total production capacity of poly-silicon feedstock in Korea was 14,1 % of the global market share. New entries have started their production of poly-silicon feedstock in 2010. The market share of Korea firms is expected to be 22,1% in the next year. Woongjin Energy announced its plan to expand a production line in 2011 for silicon ingots and wafers. The capacity is expected to ramp up to 1 GW (350 MW capacity in 2010).

Hyundai Heavy Industry expanded their capacity up to 610 MW in the c-Si solar cells. Shinsung Holdings expanded their capacity up to 250 MW in the c-Si solar cells. The remaining several companies, KPE, STX Solar, Millinet Solar, and LG Electronics also expanded capacity currently ranging 50 to 150 MW. The Samsung Electronics starts the operation of a 30 MW 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. In 2010, Samsung announced it would invest 20,6 BUSD in solar cell production and other growth projects over the next decade. Getwatt has successfully completed a production line of a-Si thin-film modules with 20 MW capacity. Hanwha Chemical bought a 50-percent stake in Chinese photovoltaic cell maker Solarfun Power Holdings Co. in 2010. The capacity is expected to ramp up to 1,3 GW in 2011.



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.

IMPLEMENTATION AND MARKET DEVELOPMENT

Until 2008, the cumulative installed power of PV systems in Korea was 357 MW with a growing trend, showed a lessening in 2009 and 2010. The reasons were the reduction of government budget, mainly in the FIT programs. The Korea's PV installation marked a tremendous jump to 278 MW in 2008, which is about a 350 % increase over the previous year. However, the new PV installation in 2009 has shrunk to 167 MW, which is less than half over the previous year. A total of 157 MW were installed in Korea in 2010.

The south Jeolla provinces, the southwest part of Korea, have recorded the highest cumulative installation capacity up to 176,5 MW in 2009. The north Gyungang and north Jeolla provinces followed next and their plants capacity reaches about 191 MW.

The world's largest tracking-type solar power plant (594 000 m² facility with an output of 24 MW) in Shinan, South Jeolla Province, started generating commercial power in 2009.

FUTURE OUTLOOK

The Korea government will spend more than 1 TKRW of budget money for the renewable energy sector in 2011. The Ministry of Knowledge Economic (MKE) announced it will extend 1,003,5 BKRW in support for the nation's renewable energy industry and related communities, which is a 24,1 % rise from a year ago. From the budget, the support fund for R&D activities in the field represented 267,7 BKRW, up by 14,9 BKRW from last year's 252,8 BKRW. The Korea government wants to nurture PV industries as the 'next semiconductor' industries and make them the backbones of the future national economy. Also many firms in Korea will invest huge budgets into the PV industry. Under these situations, Korea PV industry will be growing rapidly.

The PV installation in 2010 was reduced over the previous year due to the reduction of government budget mainly in the FIT programs. This trend will continue for a while.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS IN MALAYSIA

BADRIYAH ABDUL MALEK, MINISTRY OF ENERGY, GREEN TECHNOLOGY & WATER (MEGTW)

AHMAD HADRI HARIS, RE/MBIPV PROJECT, MEGTW

GENERAL FRAMEWORK

Since the 1980s, Malaysia has promoted its indigenous natural gas as the main source of power generation. However Malaysia recognises that such a fuel source is finite and thus, has been developing renewable energy since 2001. At the end of 2009, the renewable energy share in the power generation capacity mix was less than one percent. To improve the situation, the Ministry of Energy, Green Technology and Water Malaysia (MEGTW) has formulated a National Renewable Energy Policy and Action Plan which was approved by the Government of Malaysia on 2nd April 2010.

Under the new National Renewable Energy Policy, the Government would introduce a feed-in tariff incentive to increase the renewable energy contribution in the power generation capacity mix to 5.5 % by 2015. This was formally announced through the 10th Malaysia Plan (Chapter 6) on 10th June 2010. Subsequently, the First Reading of the Renewable Energy Bill was delivered by the Minister of Energy, Green Technology and Water Malaysia before the House of Representatives on 15th December 2010.

NATIONAL PROGRAMME

The year 2010 marked the end of the Malaysia Building Integrated Photovoltaic (MBIPV) Project. The Project was launched by the Government of Malaysia in July 2005 to reduce the long-term cost of BIPV technology application through widespread and sustainable BIPV market development programmes. Three objective targets were established at the onset of the project which were:

- (i) 330 % increased of BIPV installed capacity against baseline,
- (ii) 20 % reduction of BIPV system unit cost from baseline, and
- (iii) Incorporation of a new BIPV programme in the 10th Malaysia Plan.

As the MBIPV Project came to a closure on 31st December 2010, the actual targets achieved were:

- (i) 539 % increased of BIPV installed capacity against baseline,
- (ii) 50 % reduction of BIPV system unit cost from baseline, and
- (iii) Introduction of the feed-in tariff incentive in the 10th Malaysia Plan.

TABLE 1 – MAJOR PV FDIS IN MALAYSIA

COMPANY	PRODUCT	NAMEPLATE CAPACITY	CURRENT EMPLOYMENT/ JOBS CREATION	STATE	STATUS
First Solar	CdTe Modules	954 MW (2010) 1,430 MW (2011)	3,500 MW (2010) 3,700 MW (2011)	Kedah	In full operation
Q-Cells	Solar cell, wafering & ingot	600 MW (2010 & 2011)	900 (2010 & 2011)	Selangor	In full operation
AUO-SunPower	Solar cell, wafering	5 MW (2010) 350 MW (2011) 1,400 MW (2013)	1,200 (2010) 2,800 (2011)	Malacca	In trial operation
Tokuyama	Polysilicon	6 000 tons	1 (2010) 300 (2013)	Sarawak	EPC, awarded, site construction (2011)
Flextronics	PV module assembling	200 MW (2010) 250 MW (2011)	1000 (2010) 1400 (2011)	Johor	In full operation
MEMC	Solar wafering	600 MW (2012)	2,400 (2012)	Sarawak	In trial operation

Fig. 1 – Major PV FDI in Malaysia.



Fig. 2 - Launching of AUO-SunPower in Melaka, Malaysia by the Prime Minister of Malaysia on 15th December 2010

The MBIPV Project is widely recognized in local and international platforms for its widespread and sustainable impact, and the high ability for it to be replicated in other countries with similar economic background. A recent 2010 UNDP Development Award conferred excellent recognition to the MBIPV Project in transforming markets for clean technologies, triggering private sector investments, working with financing institutions, and reducing green house gas (GHG) emissions.

R&D, D

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

Strategic Thrust 4 of the National Renewable Energy Policy and Action Plan which will be implemented under the 10th Malaysia Plan period (2011 - 2015) aims to further enhance R&D in the renewable energy sector. The focus will be on technology innovation instead of new invention. A systemic R&D programme will be implemented under this thrust to accelerate innovative RE products and services with the main aim to further reduce cost of RE technology deployment.

IMPLEMENTATION

The implementation of MBIPV Project was designed in a holistic framework. The multi-prong tactical approaches for the MBIPV Project include four main components:

- Component 1: BIPV information services, awareness and capacity building;
- Component 2: BIPV market enhancement and infrastructure development;
- Component 3: BIPV policies and financing mechanism development;
- Component 4: BIPV industry development and technology localisation.

Component 1 involved BIPV promotional campaigns and capacity building programmes. This included organizing conferences, seminars, workshops, local and international study mission for decision makers, information dissemination through media, advertisements and website, and conducting ISPO accredited PV training courses for PV system installers. Component 1 also implemented a quality assurance programme that included administering the Approved PV Service Providers scheme and conducting quality audits on BIPV systems. Component 2 primarily drove the local PV market by addressing cost barriers through the various financial incentive programmes such as the SURIA 1000, showcase and demonstration incentives. Component 2 also involved the formulation of standards for the installation of grid-connected PV systems which saw the launching of the Malaysian Standard (MS) 1837 in 2005.

Component 3 worked closely with policy makers in improving the institutional and financial supports for a sustainable BIPV market. Specifically, this component was instrumental in addressing policy, financial and fiscal issues, and in establishing a favourable environment for a sustainable BIPV market. Finally, Component 4 oversaw

the development of local PV industry and optimisation of the BIPV technology for local conditions in Malaysia. Component 4 worked closely with the Malaysian Investment Development Authority (MIDA) to draw solar related foreign direct investments to the country, and provided platforms for international PV business network and matchmaking.

INDUSTRY STATUS

Within the PV industry, there are 31 companies listed under the Approved PV Service Providers (APVSPs) scheme at www.mbipv.net.my. The MBIPV Project has thus far created a new green service industry to provide design, installation and after sales by the APVSPs. The total estimated manpower involved in the APVSP scheme is in the range of 180 to 200 people. Testing facilities for mounting structure and inverters have also been established by IKRAM and Universiti Teknologi Malaysia respectively in order to improve reliability and quality of the BIPV systems and installations.

On the PV manufacturing front, Malaysia is poised to be the number three in world ranking by 2011. This is fuelled largely by the foreign direct investments (FDIs) which amounted to more than USD 4 billion (in 2010).

In 2010, there are three local PV assembly plants in Malaysia which have a total production capacity of 43 MW and their production will commence by 2011. These three local plants (SolarTIF Sdn Bhd, PV Hi-Tech Solar Sdn Bhd, and Malaysian Solar Resources Sdn Bhd) have achieved IEC certifications for their PV modules. On 14th December 2010, a joint venture between Twin Creeks Technologies and Red Solar, an associate company of the Perak State Economic Development was formed to manufacture PV modules, with an initial production capacity of 100 MW in 2012 and eventually to grow to 500 MW by 2014.

MARKET DEVELOPMENT

As of the end of 2010, the cumulative installed grid connected PV capacity in Malaysia was 1,566 kW and the off grid PV capacity is approximately 11 MW. This represents a growth of 503 kW for grid connected and 1 MW for off-grid PV systems in 2010 alone. The grid-connected PV market is driven largely by financial incentives provided via the MBIPV Project (SURIA 1000, Demonstration and Showcase), and the extension of fiscal benefits for renewable energy (including solar PV) as delivered by the Prime Minister in the National Budget 2011 speech on 15th October 2010. The extension of fiscal benefits included pioneer status and investment tax allowance for generation of energy by solar PV until 31st December 2015, and import duty and sales tax exemption for equipment used in the generation of solar PV electricity is extended to 31st December 2012. Collectively, these incentives have generated 2,530 kW of planned grid-connected PV systems at the end of 2010. Although the off-grid PV market is the current main market, it is envisaged that the grid connected PV market will dominate the market upon the introduction of feed-in tariff incentive in 2011.

FUTURE OUTLOOK

The Government of Malaysia is committed to develop the solar PV market as well as the solar industry for the dual purposes of achieving energy security and economic growth. By the end of 2020, Malaysia aims to install at least 1,250 MW of grid-connected PV systems. In the manufacturing front, the total annual PV production capacity is estimated to reach 4,200 MW (wafer, solar cell, module) and 6,000 tonnes (polycrystalline silicon) by the year 2013. Importantly, solutions to address both these issues have simultaneously address the conditional commitment by the Prime Minister of Malaysia in December 2009 to reduce the country's carbon intensity by up to 40 % by 2020 (compared with 2005 levels).

MEXICO

PV TECHNOLOGY: STATUS AND PROSPECTS IN MEXICO

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Fig. 1 - PV Grid Connected System for municipal street lighting.

GENERAL FRAMEWORK

Grid connected PV systems continue gaining importance in the Mexican market. Total capacity installed in grid-connected systems since 2009 now exceeds that for off-grid systems, which for many years was the main application in this country. Solar systems in the range of several hundred kilowatts are now being implemented, thus becoming the main driver of the local PV industry. The first large solar farm (1,1 MW in capacity) was installed in 2010 for self-supply of electricity to a cluster of small industries and government buildings. On the basis of an April 2010 Resolution by the Energy Regulatory Commission, permitting medium-voltage PV systems of up to 500 kW for connection to the grid in the modality of net-metering, commercial PV companies along with institutions such as the Electrical Research Institute (IIE) are actively promoting these types of applications. Judging from the number of people who attend PV-related events, as well as the increasing demand for PV courses and other training activities, it can be said that the interest in PV technology among professionals, technicians and the general public is growing.

NATIONAL PROGRAMME

There is not as yet a national PV program to foster the implementation of PV technology in this country. However, a number of activities to create awareness among the population are being carried out by several government entities. For instance, a 135 kW grid connected

PV system was installed on the premises of the hotel in Cancún where the recent COP 16 summit took place. Another example is the 30 kW installation displayed at the Technology Museum of the national electric utility CFE in Mexico City; visited by hundreds of school children and the general public every day. In the field of off-grid systems, a long awaited program for the electrification of 50 000 households in remote rural communities is still under preparation by the Federal Government; it is anticipated that Solar Home Systems will be the technology of choice for the majority of households. Meanwhile, megawatt size projects are at different stages of development in at least eight regions of Mexico, either for electricity self-supply or for export of electricity to the US.

RESEARCH AND DEVELOPMENT

A number of academic institutions keep on working on their basic research projects, as reported earlier, mainly on topics related to materials for thin film technologies. Monitoring of systems' performance is another activity in progress. Results from this activity after several years of work have proved important in support of the development of further regulations, as well as to identify opportunities for systems improvement and new niches for technology development. Such is the case of a small inverter specifically designed for operation under the conditions of weak grids with frequent blackouts. The first prototypes of this inverter are now in the beta-testing phase. It is



Fig. 2 – PV Grid Connected system at Technological Museum of the Mexican National Utility CFE (photo: Conermex).

expected that a commercial version could be on the market in 2011. With the support from the Global Environment Facility (GEF), through the UN Development Program (UNDP), the Electrical Research Institute continues teaching courses on grid-connected PV. These courses are regularly attended by university professors, advanced students, PV company technicians and engineers from the national electric utility CFE.

IMPLEMENTATION

Availability of financing schemes is still a major stumbling block for the massive deployment of PV in Mexico, mainly in the grid-connected modality. The Energy Ministry of the Mexican Government is analyzing options to launch a pilot program to finance grid-connected PV systems in the residential urban sector. Projects associated with highway and toll-road construction, such as off-grid PV powered luminaries and warning signals, are becoming popular, as their financing is embedded in the road construction costs. PV powered LED luminaries financed by municipalities are also becoming a common scene in urban streets and parks. Rural electrification projects, on the other hand, are highly dependent on government assistance programs. The government-supported risk sharing trust fund FIRCO, which has been a long time promoter of stand-alone PV water pumping systems for productive applications in the agriculture and cattle sectors, is planning to extend its financial support to grid-connected PV projects of several kinds.

INDUSTRY STATUS

Companies assembling PV modules for the export market continue with their business as usual aimed mainly at the US market. Two other companies are now assembling modules for the internal market using imported cells. Except for wires and other minor elements, BOS components are mainly imported from various countries. As mentioned earlier, it is expected that production of small inverters will start in 2011.

MARKET DEVELOPMENT

PV capacity installed during 2010 is estimated at 5,58 MW and the yearly figure is expected to continue growing as the market for grid-connected systems expands. It is estimated that the capacity installed in the year 2011 may reach 40 MW.

FUTURE OUTLOOK

Lack of financing and other incentives are critical elements that have traditionally impeded a faster growth of the PV market in this country. Nevertheless, some companies anticipate that their sales in 2011 may grow two or three times with respect to their 2010 figures. This may come true if the rural electrification program enters in operation and some of the financing schemes under planning for urban applications come into effect. On the other hand, it is expected that some of the megawatt size projects will materialize in the coming months.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS

OTTO BERNSEN, NL AGENCY, DIRECTORATE ENERGY & CLIMATE



Fig. 1 - PV Cold bended PV modules integrated in roof at the train station Zuilen which is much appreciated by the travellers. Project partners Movares, ECN and BRS Building Systems. This is a SBIR innovation solar program. A study by Ecofys showed that more PV panels along the train tracks would possibly complicate maintenance work and cause longer delays which would not be appreciated by the same travellers.



Fig. 2 - Cold bended PV modules at roof train station Zuilen, see also Figure 1. SBIR project partners ECN, Movares and BRS Building Systems. The installation is in process.

GENERAL FRAMEWORK

In 2010 the centre - left government in the Netherlands was replaced by a centre - right government with a change in energy and innovation policies. The overall national goals for CO₂ reduction were lowered but remain ambitious and well within the European Set Plan and average.

Energy efficiency will become more prominent in achieving the national goal of 14 % renewable energy production by 2020. The renewable technology policy will be more focused on fewer and more promising areas. In this new approach, solar PV still has an important role to play especially in the mid and long term. In 2010 the share of solar PV of the total amount of electricity consumption increased from 0,03 % in the previous year to 0,04 %, (source: CBS Statline).

Although there was still a supporting scheme close to 94 MEUR in place during 2010, for the next year 2011 the SDE subsidies for solar power were cancelled in anticipation of a SDE plus scheme for only larger systems above 15 kWp and with a maximum of 0,15 EUR cents. The research funds have been concentrated under the newly formed Ministry of Economic Affairs, Agriculture and Innovation.

In 2010, the export of the sector has maintained itself as a major driver for both the manufacturers of production equipment and the suppliers of high end and building integrated PV systems. In spite of an economic recession and intensified competition in the sector the modest growth, starting in 2008, has continued. In 2010, an estimated value of 600 MEUR was exported by the Dutch PV sector, outperforming all other renewable sectors.

The Dutch PV home market has grown at a moderate but steady pace of approximately 10 MW installed capacity in 2010. This is according to preliminary figures from CertiQ, the entity that supplies green certificates. That signifies an increase of nearly 15 % against the 20 % growth in 2009. The total amount of accumulated PV installed capacity in the Netherlands in 2010 is estimated at 77,5 MW.

The Dutch companies are represented all through the PV value chain. The Netherlands form a small but innovative market. The main cell producers are Solland Solar and Scheuten Solar. Equipment providers like OTB (in 2010 acquired by Roth and Rau), Smit Ovens and Tempres account for a substantial portion of the export numbers.

Dutch companies are rapidly developing more sophisticated PV applications with semi-transparent solar panels, small scale solar concentrated systems, building integrated systems and targeting specific market segments. Despite this agility and diversity of the industry and the strong research community the PV innovation system in the Netherlands remains fragile due to its relative small home market, the lack of major international players and changing policies.

PV systems are still seen by the public as a relatively expensive option for renewable energy and this is mainly due to the high upfront costs and longer pay back periods. It is within the Netherlands national culture to find solutions for these financial bottlenecks. Several local initiatives are setting up new forms of organisation to deal with these ranging from lease and mortgage constructions to cooperatives and virtual power plants. For the public appreciation of PV aesthetics play an important role. People want to feel good about PV in all aspects.

NATIONAL PROGRAMMES

In 2010, a total SDE budget PV of 94 MEUR was planned, of which 69 MEUR went to the category of small PV installations (up to 15 kWp) and 24 MEUR went to the category of larger systems. These amounts correspond to 20 and 5 MW installed capacity, respectively.

In the fourth quarter of 2010 it was announced that the SDE subsidies for solar power in 2011 were cancelled in anticipation of a SDE plus scheme for only larger systems above 15 kWp and with a maximum of 0,15 EUR cents.

The Energy Research Subsidy (EOS) scheme covers the entire range from fundamental research, applied research to demonstration projects. Other organisations that fund PV research are STW, NWO and the Joint Solar Program JSP. Direct funding is available at the research institutes ECN and TNO.

While the previous yearly amount of EOS and ECN combined has diminished to 9,8 MEUR in 2010, the total amount of RTD funds has risen due to the contributions of STW, regional funds and an additional 3 MEUR in the SBIR for BIPV. A broader calculation, including the RTD project not labelled as PV but related to the subject, gives a much higher number of research expenditure. The Solliance Initiative was financed by the Province of Noord Brabant with a contribution of 28 MEUR which will be matched by industry (Source Solar Magazine).

In 2008, the IPZ innovation program for solar PV was launched which is now in its last year. In this program an SBIR call was published in 2010 with a total budget of 3 MEUR as part of the Innovation Program Solar PV (IPZ).

The SBIR call focused on PV in the built environment and also targeted new products and services on specific bottlenecks for the large scale roll out like:

1. The lack of standardisation
2. Uniform connections
3. Integrated building practises
4. Regulation

In the local scheme "more with less" (MMM) a national part could be acquired in addition to the local budget. This scheme works with assigning energy labels to houses and investments.

RESEARCH AND DEVELOPMENT ACTIVITIES

In the Netherlands, the most important research areas are still crystalline (cSi), thin film Silicium, thin film CIS/CIGS, thin film organic and new materials/techniques such as quantum dots. Besides research into the solar cells and its mass production, the amount of research and into PV applications is increasing as well as the socio-economic research. The result is that solar related research is becoming more diverse, complimentary and also moving up the innovation S curve. The additional SBIR call in 2010 is an example of this and targets a national priority of BIPV. The integral energy



Fig. 3 - Prefab PV system, project partners Ecofys, NPSP and Ubbink/Centrotherm.

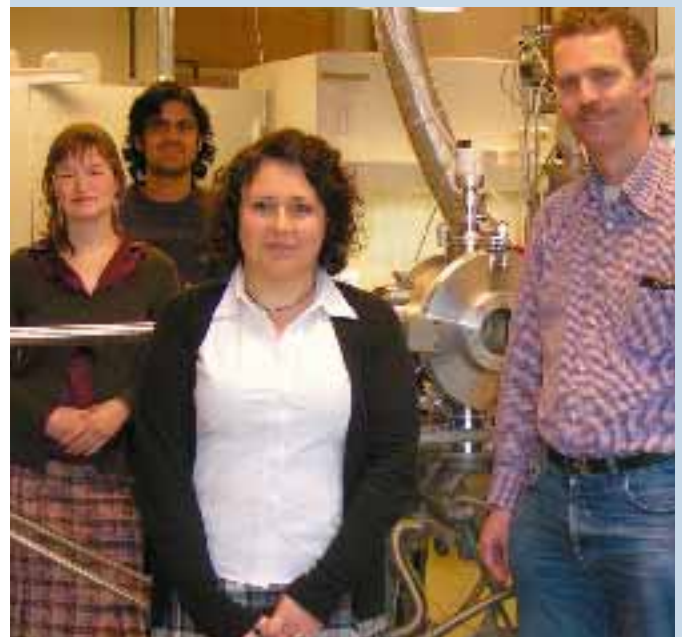


Fig. 4 - International members of the Novasil research project from the TU Eindhoven and TU Delft. The project is about thin-film crystalline silicon on glass. The process developed is based on high-rate deposition of amorphous silicon using the expanding thermal plasma CVD and subsequent solid-phase crystallization. The next step of amorphous silicon development could be tandem cells.



Fig. 5 - HELICO project concept model. Project partners Helianthos and ICOPAL.



Fig. 6 - HELICO project combining thin film and roof materials for a watertight fit. Project partners Helianthos and ICOPAL. A demonstration project involves IKEA.

research groups are another example, which were formed at several universities in 2010. They bring together researchers from different disciplines and bundle their efforts. At the TU Delft energy expertise centre ETIS started and at the TUE the Eindhoven the Energy Institute (EEI). At the University of Amsterdam and faculty of Law the Centre for Energy Issues was opened.

The amount of research and educators is steadily rising over 200 FTE in the Netherlands. The bulk of these researchers are located at ECN and TNO/Holst with a considerable staff at TUD, TUE and UU in the range of 20 FTE's each. Smaller teams are active at the RUG, FOM, UvA, WUR and Radboud University of Nijmegen. The national academies for professional education are not included in this number and neither is the Solar Academy that offers courses for managers, engineers and operators.

In 2010, the research alliance Soliance started with the participation of ECN, the Holst Centre, the Technical University of Eindhoven and TNO. It is well placed in the so called ELAT region between Aachen in Germany, Leuven in Belgium and Eindhoven in the Netherlands. Its focus on PV process and production technology, integrated systems and PV applications and its approach is the open innovation model. Several spin offs from the universities have become active in PV.

INDUSTRY STATUS

As in all other European countries, the PV sector is undergoing profound changes. The international consolidation, noted already in earlier annual reports, is still continuing with the acquisition of OTB by the German Roth & Rau as the latest example. In 2010, there was also a notable interest of especially German project developers for the Dutch market. Several set up shop in the Netherlands bringing with them an experience and know how. The year 2010 also showed clear signs of the industry becoming more mature and gradually moving out of the pioneering phase.

The industry cluster around Eindhoven has become much more active and seems to have found its role in the value chain. The developing agencies BOM and LIOF from the provinces of Noord Brabant and Limburg deserve special mentioning for their stepped up activities. Together, they also bring the PV industry closer to the semiconductor and chemical industries that are located in these areas. In much the

same way, each province brings specific skills and experiences to the table. The province of Gelderland in the mid east has a strong and active energy cluster and the KEMA, a leading authority in energy testing and consulting located near Arnhem, has set up a solar PV group. The Northern provinces united in Energy Valley have set ambitious goals for solar PV and develop specific applications for the agricultural and near the waterfront sectors.

This increasing regional activity in the provinces and cities reinforces and complements the national endeavours and often bridges the gaps between science and business. The opening of an ECN office in these southern provinces testifies to this new reality.

DEMONSTRATION PROJECTS

There are many demonstration projects at the local level. Some cities such as Lochem and Meppel are starting and some earlier initiatives, such as the City of the Sun in the townships of Heerhugowaard, Alkmaar and Langedijk, and are in their last phase. There are special projects for schools and the University of Groningen (RUG) has an equipped travelling bus for science projects including PV. Students themselves can make simple solar cells using titanium sulfide and graphite. Also from the North comes the Solar Challenge initiative, which is a solar power driven boat race through a picturesque landscape.

At Rotterdam Central Station, almost one third of the roof will be covered with PV panels; setting a record when it is finished in 2012 for train stations in Europe with PV. Public funds from the Province were used and the Rotterdam Climate Initiative financed part of the project. However, the bulk of the budget will come from the Prorail, which is responsible for the railway infrastructure.

IMPLEMENTATION AND MARKET DEVELOPMENT

The DEN (Sustainable Energy Netherlands) program targets specific bottlenecks in the large scale roll out of PV; such as the lack of standards, connections, regulation and monitoring systems. It also gives advice to the parties involved in these scenarios.

The Dutch PV home market has grown at a moderate but steady pace to approximately 10 MW installed capacity in 2010, according to preliminary figures from CertiQ. The total amount of accumulated

PV installed capacity in the Netherlands in 2010 is estimated at 77,5 MW which is still a very modest 0,04 % of the total electricity production. This amount may change later this year since a considerable part of the PV installation does not receive a feed in tariff and is not registered by Certiq.

Still, the export market is the largest driver for PV activities in the Netherlands. This export oriented industry consists of solar cell manufacturers, equipment manufacturers and, to a lesser extent, module makers and installation companies.

Dutch companies are rapidly developing more sophisticated PV applications with semi-transparent solar panels, small scale solar concentrated systems, building integrated systems (BIPV) and are targeting specific market segments with these new products. They are represented throughout the value chain.

Several cities in the Netherlands have their own PV projects in newly built areas or renovation projects. In the North of the Netherlands several cities and Provinces have joined forces in Energy Valley for a large scale roll out of PV. The benefit lies in the bundling of demand and the stronger negotiating position of the joint partners.

FUTURE OUTLOOK

Will the modest growth of the Dutch home market continue or slow down? The subsidy scheme for smaller installations has stopped but there are still substantial amounts of already granted projects in the pipeline from previous years that have not been installed yet. Still these may never be realized if prices are thought to stay too high. The new subsidy scheme SDE Plus for larger systems is under way and may give a new impulse to the thinking about PV in the Netherlands, for medium sized applications (ranging between 15 kWp and several MWp). The maximum tariff of 0,15 EUR cents will oblige parties to look for additional and maybe alternative forms of financing.

The growth of the export market depends heavily on the emerging markets and the global economy which is expected to reach a conservative 30 % for the PV markets. Dutch companies are well positioned to take advantage of this growth and to help develop these markets.

The Netherlands itself offers a small but diverse and innovative home market with still a strong research position all along the value chain. This position will continue to attract foreign investments and help to keep activities based in the Netherlands, while the industry is rapidly becoming global. Increased regional activities in the provinces will strengthen this position with a focus on integrating PV in the built environment and innovative production lines. However, without strong international connections and partnerships this balancing act can easily be disturbed.

NORWAY

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



Fig 1. - Oseana: To be finished spring 2011. The building has the largest BIPV system (60 kWp) in Norway so far. The curved wall-roof construction will be covered with PV modules.

GENERAL FRAMEWORK

The Norwegian electricity system is mainly supplied by hydropower, but at the same time highly integrated in the Nordic power market. Despite a net population increase in recent years, the power consumption is relatively stable, due to energy efficiency measures and reduced activity in the aluminium and ferro alloy industry. 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 about 200 MEUR in 2010, 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. 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 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, also supports fundamental research tied to development of new materials of relevance for future PV solutions. Finally also the programme BIA - User-driven Research based Innovation finds projects within the field of photovoltaics. The focus in the latter programme is improvement and optimization of fabrication and processes for manufacturing PV-cells.

The total funds for PV-related R&D projects were appr. 144 MNOK (18,5 MEURO) for 2010. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells research, but also related fundamental material research and production processes.

By 2010, the Norwegian Research Centre for Solar Cell Technology completed its first full year of operation (www.solarunited.no). 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 is expected to receive annual budgets around 20 MNOK in the coming seven years.

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 universities and institute sector of Norway:

- **IFE (Institute for Energy Technology):** Focuses 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 Nanotechnology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.
- **NTNU (Norwegian University of Science and Technology) Trondheim:** Focusing on silicon feedstock, refining and crystallisation.
- **SINTEF Trondheim and Oslo:** Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.
- **Agder University (UiA):** Research on silicon feedstock with Elkem. Renewable Energy demonstration facility with PV, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.

Institute for Energy Technology (IFE) is an autonomous research foundation with about 550 employees. (IFE), near Oslo, is working on R&D tied to solar cell production technology. IFE has an international expertise on characterization, development and processing of solar cells based on crystalline silicon. The PV-related activities at IFE are closely tied to the new solar cell laboratory that was inaugurated in 2009. The solar cell laboratory contains a complete production line for the manufacturing of wafer based solar cells and advanced processing equipment for thin film technologies. There is also a well-equipped characterization lab for solar cells.

University of Oslo (UiO), The Centre for Materials Science and Nanotechnology (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 modelling. This competence will help developing Si-based solar cells of more conventional design towards higher energy efficiencies, and it provides the materials science basis for very high energy efficiencies in third generation solar cells. Among materials/components in focus are ZnO and SiC. The activity at SMN spans from synthesis by means of CVD to characterization, components and theory.

NTNU (Norwegian University of Science and Technology) NTNU's solar cell research is mainly carried out by the PV-Solar Cell Materials Gemini Centre. This centre represents the unifying organizational structure for solar cell materials research at NTNU and SINTEF, which includes their joint laboratory facility "Heliosi." The main scientific- and market related research areas for the Gemini Centre are: production, characterisation, modelling, fabrication and/or use of materials in the solar cell manufacturing system.

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. Participation in PVPS Task 10 "Urban Scale PV Applications," ended in 2010.

SINTEF Materials and Chemistry. The research at SINTEF Materials and Chemistry has its main focus on casting, crystallization and characterisation of silicon-based materials, primarily for use in solar cells. The researchers are engaged in both experimental and theoretical research and development of crystallization processes, furnace technology, processes for improvement of materials and characterization methods. The laboratories contain both laboratory and full scale furnaces for production of multi and mono crystalline Si-ingots and blocks. In addition, researchers are capable of determining chemical composition and electronic properties of PV materials by means of a series of established techniques and methods during development. The research team works within both competence building and strategic national research programmes, and towards short- and long-term assignments for the Norwegian and international PV-industry. They are also involved in a number of projects financed by the EU.

University of Agder (UiA). In August 2010, 2500 engineering, nursing and teacher education students moved into Norway's newest higher education campus in Grimstad, in southern Norway. Along with the ten year old energy park with a 20 kW photovoltaic array installation, the new facility has laboratories for development of PV technology.

A PhD-programme continues in partnership with Elkem Solar. Upcoming activities include degradation of solar grade silicon, third generation PV concepts and solar spectrum measurements. The research group on PV technology has about 8-10 people; including 2 professors, 1 Postdoc and 4 PhD students. The university has a study program in renewable energy at bachelor and master levels.

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 1 840 installations with a total of 3 600 PV-modules. The smallest are equipped with one single module of 60 W, the largest with arrays counting up to 88 modules. The average is 135 W per installation. The cumulative installed PV capacity seems to remain at a level of 315 kW.

Norway does not have any incentive schemes supporting the installation of PV systems, and consequently the use of PV technology in Norway is limited compared to other countries. Norway's largest

building integrated PV project so far commenced construction in 2010. The 60 kWp, 470 sq metre system is integrated as part of the roof and southern wall in "Oseana," a combined culture- and arts centre located in Os, 30 km south of Bergen, on the Norwegian west coast. Facing south on the waterfront, towards the beautiful Bjoernafjord, the building represents the latest in modern architecture, combined with energy efficient building principles. The complex is expected to become a landmark and a major tourist attraction when it opens in June 2011. Norwegian Getek AS has delivered the PV installation.

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 an industrial production plant in Kristiansand. The plant started ramp up production during 2009. The ramp-up phase continued in 2010 with high costs and planned production stops. The production stopped at 400 Mt in first quarter, 348 Mt in second quarter, and 598 Mt in third quarter 2010. Elkem reported new contracts with leading solar energy companies, for deliveries in 2011 and 2012.

Renewable Energy Corporation (REC) REC is among the world's largest producers of polysilicon and wafers for solar applications, and a rapidly growing manufacturer of solar cells and modules. REC is also engaged in project development activities in selected PV segments. More than 4 100 employees work in REC's worldwide organization. REC is thereby among the leading vertically integrated players in the solar energy industry.

The 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, in Norway and Tuas, Singapore. The solar cell production is in Narvik, Norway and Tuas, Singapore, and solar modules are produced in Tuas, Singapore. The head office is located in Oslo. REC has signalled that its solar module plant in Glava, Sweden will be taken out of operation.

In November 2010, REC opened its new integrated wafer, cell and module plant in Tuas, Singapore. The 1,3 BEUR plant, represents the largest investment REC has done so far. REC experienced 2009 as a year characterized by challenging markets and considerable declines in average selling prices, brought about by modest demand growth and oversupply. REC's average selling prices for modules declined 36 percent from 2008 to 2009. Although revenues grew from 8 191 NOK in 2008, to 9 156 MNOK in 2009, the operating profit of 2 529 MNOK in 2008, dropped to minus 1 824 MNOK in 2009. The results from 2010 are not yet published (January 2011).

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 exceeds 200 MWp. The company has a third production facility under construction in Singapore. When phase one is completed in 2013, the Norsun Jurong plant is expected to reach a capacity of more than 500 MWp.

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 with the Metallkraft recycling services as of April 2010. The Singapore plant was officially opened November 1, 2010.

Fesil Sunergy AS. FESIL Sunergy AS is a joint venture between FESIL AS and DELTA NV and has developed a proprietary process for the production of solar grade silicon, specifically designed for the solar industry. The process directly produces solar grade silicon with high cell efficiencies being achieved. FESIL Sunergy claims its SOLSILC process represents a number of commercial advantages compared to competing processes, including 65-80 % lower capex, 20-40 % lower opex, a significantly reduced CO2 footprint and an accelerated ramp-up time.

Innotech Solar AS (ITS). ITS specializes in returning rejected cells to their capacity through a multi-step testing and optimization process. The company turns such cells into solar modules and also assemble entire solar power plants. The ITS-cell processing plant is located in Narvik, in northern Norway.

CruSiN AS, a start up company evolving from the SINTEF/NTNU R&D environment in Trondheim, aims at producing silicon nitride crucibles for ingot manufacturing. In February 2009, CruSiN GmbH was founded as a wholly owned subsidiary of CruSiN AS. CruSiN GmbH deals with production and R&D under the auspices of CruSiN AS.

SIC Processing AS is owned by the German company SiC Processing GmbH, a provider of conditioning of used slurry from the photovoltaic industry and the semiconductor industry. In Norway, the company has two plants, adjacent to REC Wafers operations at Herøya and Glomfjord.

PORTUGAL

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



Fig. 1 - 12 kWp CIS array at LNEG parking lot (photo: LNEG).

GENERAL FRAMEWORK

In 2010, the Council Resolution 29/2010 revised the energy policy framework in line with the European Union Directives, namely those related with the 20-20-20 Climate-Energy Package. The main objectives of the national energy strategy are:

- i) To reduce fossil fuel energy dependency to 74 % in 2020 (currently about 85 %);
- ii) To ensure compliance with EU commitments in the framework of the European climate change policy;
- iii) To reduce imports by 25 % through the use of endogenous sources (renewables);
- iv) To create value and build energy clusters in the renewable energy sector in Portugal, generating 100 000 more jobs and a significant impact on the GDP;
- v) To develop an industrial cluster associated with the promotion of energy efficiency;
- vi) To promote sustainable development by creating conditions for achieving the GHG emission reduction targets assumed by Portugal in the European framework.

The government programme for deployment of renewable energy sources (RES), in accordance with the recently approved 2009/28/EC Directive, is described on the Renewable Energy Action Plan, approved in June 2010. Portugal has to meet the EU mandatory target of 31 % for the overall share of energy from renewable sources in gross final consumption by 2020. In particular for the electric sector (RES-E), this represents an additional installed capacity of about 9,6 GW. Table 1 shows the power breakdown by source

NATIONAL PROGRAMME

A feed-in tariff mechanism is the main instrument for promoting renewable electricity. Some of the existing PV frameworks (see Table 2) under the special regime production (the Independent Power Producer (IPP), in force since 1988, the Producer-Consumer (2002) and the Micro-generation scheme (2007)) were revised in 2010: Decree 118-A/2010, micro-generation (capacity up to 10 kW), substitutes for Group I installations in the producer-consumer framework. Mini-generation (capacity up to 250 kW) will substitute the remaining 68/2002.

TABLE 1 - RES-E TARGETS

RENEWABLE SOURCES	CURRENT CAPACITY 2010 (MW)	TARGET 2020 (MW)
Large Hydro	4 800	8 800
Wind onshore	4 260	6 800
Solar (PV + CSP)	160	1 500
Mini-hydro	600	750
Solid biomass	175	250
Wave	5	250
Biogas	34	142
Wind offshore	0	75
Geothermal	25	75

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 118-A/2010, REVISING DL 363/2007)
Maximum capacity per system	No upper limit, but government may adopt special tender procedures	150 kW	5,75 kW single or 3-phase; 10,04 kW 3-phase in condominiums
Starting Tariff	Building integrated <ul style="list-style-type: none"> Less than 5 kW - 0,469 €/kWh 5 kW to 150 kW - 0,354 €/kWh Ground based <ul style="list-style-type: none"> 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 - 0,40 €/kWh (in 2011) applicable to <ul style="list-style-type: none"> Up to 3,68 kW production capacity or 10,04 kW (condominiums) and Up to 2,4 MWh sold per year and At least 2m² solar water heating system installed or equivalent biomass boiler Regular tariff - Annual LV 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	<ul style="list-style-type: none"> Premium tariff revised down 0,02 €/year Regular tariff revised annually
On-going update	Monthly updated at inflation rate	<ul style="list-style-type: none"> Monthly updated at inflation rate Annually updated with revised BTE regulated tariff 	Special regime (Premium tariff) <ul style="list-style-type: none"> Fixed for the first 8 years after installation. Starting tariff in 2011: 0,40 €/kWh (-0,02€/kWh/year for subsequent years) Fixed for the next 7 years of operation. Starting tariff in 2011: 0,24 €/kWh(-0,02 €/kWh/year for subsequent years), General regime (Regular tariff) - Annually set at LV regulated tariff
Time frame	Tariff secured for 15 years or 21 MWh/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 LV regulated tariff.
Capacity cap	<ul style="list-style-type: none"> Building integrated - 50 MW Ground based - 150 MW (shared with CSP) 	Not defined	25 MW per year
Other restrictions		Producer must consume (or sell to third parties) 50 % of the power generated	<ul style="list-style-type: none"> Up to 50 % of contracted consumption capacity can be injected to the grid, 100 % for condominiums 30 % CAPEX deductible on income tax up to 800



Fig. 2 – 6,6 kWp MagPower CPV – Ferreira do Alentejo (photo: GENERG).



Fig. 3 – 82 kWp a-Si PV System – Oliveira do Bairro (photo: courtesy SolarPlus).

Under the IPP framework, which practically granted no licences since 2005, a 150 MW capacity (75 blocks of 2 MW each) were awarded through a public tender adopted by the Government in October 2010. The three main conditions for tendering were:

- Power plants should be connected to pre-determined substations;
- Competitors should provide a minimum payment of EUR 800 000 for each 2 kW block in favour of the Portuguese state;
- Monthly feed-in tariff of 0,257 EUR/kWh, updated at inflation rate and secured for 20 years or until a power generation of 34 GWh/MW were attained.

A significant number of national and foreign companies responded, forcing the award decision to be taken based on the amount the promoters were willing to pay for each one of the 2 MW blocks.

A new support regime for PV systems with installed power up to 250 kW (but higher than micro-generators), special oriented to SMEs (tertiary, commerce and industry), was approved in December 2010 and will likely be launched during the first quarter of 2011. With a 500 MW target by 2020, i.e., 50 MW/year, this so-called mini-generation scheme substitutes the consumer-producer framework which didn't attract promoter's interest. The licensing process as well as the feed-in

tariffs will be established according to three different capacity ranges:

- 1st range – up to 20 kW;
- 2nd range – from 20 to 100 kW;
- 3rd range – from 100 to 250 kW.

Besides the feed-in tariff 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).

TABLE 3 - PV MODULE MANUFACTURERS

COMPANY	MAXIMUM CAPACITY (MW)	CURRENT CAPACITY (MW)	PRODUCTION IN 2010 (MW)	TECHNOLOGY
Open Renewables	65	65	27	c-Si (mono and poly)
Martifer Solar	50	33	30,5	c-Si (poly)
SolarPlus	10	10	~5,5	a-Si (double junction)
Goosun	10	10	n.a.	c-Si (poly)
Fluitecnik	20	20	n.a.	c-Si (poly)
Earth Life	25-30	-	-	CIGS (thin film)

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).

Among the R&D projects underway, involving universities, national laboratories industry and utility consortiums, the following deserve emphasis:

- "SolarSell project": development of a Dye Sensitized Solar Cell, using an innovative seal, for potential application in BIPV. 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. Consortium: MagPower and EDP.
- Photovoltaic Acoustic Barriers: installation of photovoltaic modules in existing highway acoustic barriers. EDP's project.
- Sunlab: demonstration of the correlation between climatic variables, module position and energy production in different sites and for different PV technologies, along Portugal. EDP's project.
- "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.
- "NanoSi - PVCELLS": Development of Nano-structured Si PV devices. Consortium: FCTUNL University and SolarPlus, S.A.

IMPLEMENTATION

In 2010, about 10 MW additional capacity was realised under the IPP framework, including 3 large scale solar projects in the south of Portugal: 6,3 MW in Almodôvar, 1,3 MW in Mértola and 1 MW in Ferreira do Alentejo. Following a public tender specially oriented to schools and private social solidarity institutions, a capacity of about 670 kW was also installed.

Under the micro-generation scheme, as of 31st December 2010, about 9 191 systems with 3,5 kW average unit capacity were installed and operating, with the following share:

Cumulative PV Power Capacity Installed (2000-2010)

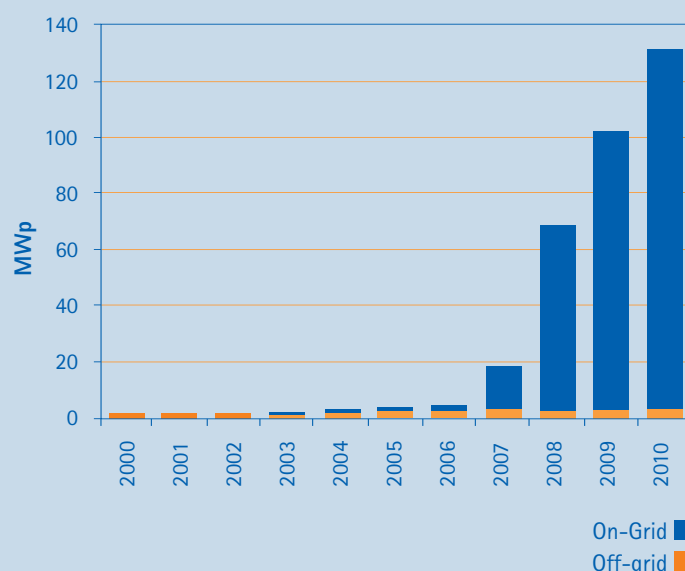


Fig. 4 - Cumulative PV Power Capacity Installed in Portugal (2000-2010).

- PV: 9 011 units (98,0 %)
- Wind: 156 units (1,7 %)
- Hybrid PV+Wind: 21 units (0,2 %)
- Micro-hydro: 3 units (0,03 %)

The total installed power under this scheme is near 32,6 MW, 98 % of which are PV (31,9 MW). About 19 MW PV systems started operation in 2010.

LNEG added to the existing on-grid installation (12 kW c-Si on the façade + 6 kW a-Si on the parking lot) an additional 12 kW PV system based on CIS modules (Figure 1). The modules also serve as

TABLE 4- ANNUAL AND CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (2000-2010)

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
2010*	0,10	28,65	28,65	130,85

*Data for off-grid installation are estimated

shading devices in the parking lot. The Solar XXI office and laboratory (towards zero-energy) building, where these different PV technologies are being demonstrated together with other passive solar strategies, has now a total installed PV power of 30 kWp.

INDUSTRY STATUS

There are currently five PV module manufacturers in Portugal (c-Si and a-Si) as shown in Table 3, with a total production capacity of about 140 MW. A new company will start producing CIGS modules in 2011.

Two companies are developing and manufacturing concentration systems: WS Energy and Magpower.

- **WS Energy:**
Concentration systems based on different registered technologies:
 - **DoubleSun®:** low concentration ratio (1,93x CPV, aluminium flat-plate reflectors, mono-crystalline Si modules. The modules can be mounted either on one-axis solar trackers (Horizon) or two-axis solar trackers (T1000). The tracker's control is performed through SungravityControl® with web-based diagnosis. The annual manufacturing capacity is 40 MW for the one-axis tracking system, and 15 MW for the two-axis tracking system. In 2010, WS Energy produced 300 DoubleSun systems totalling about 500 kWp.
 - **HSUN®:** medium concentration ratio (22x CPV, aluminium curve reflectors). A 1 MW line of production (expandable to 10 MW) will be built in 2011.
- **MagPower:**
 - CPV systems based on III-V triple junction cells and Fresnel concentrating optics (Figure 2). The company uses a fully robotized line of production for manufacturing the CPV and assembly of panels and trackers, designed for a production capacity of 54 MWp/year. In 2011, MagPower expects to

provide about 43 MW for different projects, either in Portugal and abroad. The current system prices (not including installation) range from 3 to 3,5 MEUR/MW.

MARKET DEVELOPMENT

The Portuguese PV market grew 22 % in 2010, achieving a total cumulative PV power capacity of about 131 MW (see table 4 and Figure 4). The new additional capacity came mainly from on-grid micro-generators (19 MW) and IPP generators (10 MW). 98 % of the total installed systems are grid-connected.

FUTURE OUTLOOK

The new framework introduced by the government in 2010, aligned with the EU climate-energy strategy and the corresponding RE mandatory target, for which the contribution of PV will be very significant (1,500 MW by 2020), will allow a much quicker deployment of PV during the next decade.

The new rules established under the IPP law – public tenders for 75 blocks of 2 MW each, to be likely adopted every 2 years – will allow an installation rate of 75 MW/year, i.e, 750 MW by 2020. On the other hand, the annual 25 MW cap for micro-generation together with the 50 MW cap for mini-generation, if realised, will provide the remaining 750 MW to reach the 2020 target.

Given the difficult economic situation the country is currently facing and will likely face in the near future and the fact that RES-E represent an additional burden for electricity consumers, who support the extra cost of renewables in their electricity bills, the main future challenges for PV in Portugal are:

- to maintain a stable framework, attractive enough for promoters and minimize investment risks
- to consolidate the PV industrial cluster.

SEPA

THE SOLAR ELECTRIC POWER ASSOCIATION

TOM NICHOLAS, SEPA REGIONAL UTILITY OUTREACH, REGIONAL DIRECTOR, CENTRAL USA

UTILITY SOLAR TRENDS

Despite the economic downturn, the solar electric power industry continued to grow – a clear indication of the technology's staying power. From single-panel micro-systems and residential and commercial rooftops to the opening of the country's largest photovoltaic power plant, the solar industry continued to expand, in part, because of a new level of electric utility involvement.

Focusing only on the amount of new solar generation coming online is a simplification of the underlying maturation of the solar industry and its relationship to electric utilities, as there is far more to the story. Solar is changing and quickly.

As identified by SEPA, here are the most important solar trends of the year that impacted utilities:

Declining Photovoltaic Prices

Photovoltaic system prices have dropped significantly in the last two years – more than 40 percent in many cases – largely due to solar panel oversupply, but also from a combination of manufacturing expansion, the economic downturn, and international incentive programs. As a result, the solar industry faced a buyer's market last year, in stark contrast to the seller's market of just a few years ago. With these price declines, solar is beginning to reach retail "grid parity" in some locations where electricity prices are high. Solar installations, however, are still driven by incentives. These rapid price changes, combined with existing or potential state and federal policies, are leading more utilities to think strategically about solar in the near-term.

Utility-Scale Solar

In the utility industry, "utility-scale" generation had traditionally meant centralized power generation on the transmission system, but that definition has begun to change.

For solar, concentrating solar power (CSP) has always been considered a "utility-scale" technology. While only 5 MW of new CSP generating capacity came online – bringing the total U.S. capacity to 424 MW – plans for new plants expected to generate gigawatts of power were announced.

Now, in addition to CSP, "centralized" photovoltaic (PV) projects are beginning to reach "utility-scale." In the past, PV projects in the range of 1 MW drew industry attention. Today, 1 – 5 MW systems are commonplace, with "newsworthy" projects being even larger in scale.

- Recently, a 25 MW PV system – the largest in the United States – was commissioned in DeSoto County, Florida. It is owned by Florida Power & Light Company.
- A 21 MW project was completed in Blythe, California, with Southern California Edison purchasing its output.
- Utilities across the country have announced plans to own or purchase the electricity from centralized PV projects that will range from 10 – 250 MW, with many in the 10 – 30 MW range outside of California, the market leader.



Fig. 1 – DESOTO Next Generation: 25 MW plant in Florida, owned by Florida Power and Light. Annual estimated generation is about 42,000 megawatt-hours or enough power to serve about 3,000 homes. The plant consists of more than 90,500 solar panels.

In one of the most significant trends of the year, distributed solar is becoming utility-scale. Traditionally, distributed PV has referred to customer systems connected to the utility's grid. However, several utilities announced or started construction of "distributed plants" that will provide, in aggregate, up to 500 MW each. A large portion of these will be utility-owned and managed as a single project – hence distributed, but "utility-scale."

These trends demonstrate that the utility industry's involvement in solar power is just beginning to unfold, and will become more strategically important to our electric power supply in coming years.

Diverse Solar Business Models

The third key trend is the growing diversity of business models being applied to support the solar programs of electric utilities. Rather than taking a reactive approach to the rapidly changing solar market, utilities are now developing business models that offer direct cost savings and other benefits from integrating solar power into their generation portfolios.

Many investor-owned utilities have announced utility ownership of solar assets either on the utility's or the customer's property. Beginning with Southern California Edison, this model has now been mirrored by others on the West and East Coasts. Most of these are



Fig. 2 - WAPA: Western Area Power Authority (WAPA) – new, 2-megawatt, ground mounted solar photovoltaic array occupies the site of a former landfill at Ft. Carson, Colorado. Covering 12 acres, the system will generate 3,200 megawatt-hours of power annually, according to the Department of Energy, or enough to power the equivalent of 540 Fort Carson homes per year.



Fig. 3 - Solar Panel Inspection SMUD: Solar Panel Inspection by Sacramento Municipal Utility District, Sacramento, California.

utilizing the "distributed power plant" model to varying scales. Arizona Public Services' "Community Power Project" is using solar ownership, the smart grid, and fixed-price solar tariffs as a demonstration project on a single distribution feeder, looking to the future for a unique business and grid management opportunity. Several public power utilities, including the utilities of Ellensburg, WA, Sacramento, CA, and St. George, UT, and United Power in Colorado are offering customers variations on a "community solar" model. Customers can invest and benefit from a locally sited project, rather than individually on each home.

These varied business models offer value to the utility and customers, and provide paths for other utilities to follow.

SEPA, through its Utility Solar Business Models Project (USBM), has been reporting on a variety of approaches where utilities can become more integrally involved in the solar value chain over time. To learn more, visit: <http://tinyurl.com/UtilitySolarBusinessModels>

Solar Integration: A Utility-Wide Engagement

For many utilities, solar is no longer just the purview of the distribution engineer or renewable energy program manager who is interconnecting customers' net-metered systems. Solar is moving up and across utility divisions.

This expansion, driven by declining prices, federal and state policies, and utility interests, is moving solar deeper into the utility's business planning and strategic development units. Even if the projects are not coming online today, the planning aspects of these customer and utility programs require utilities to be proactive with their solar strategies across departments and divisions – a trend reflected by the number and types of utility employees engaging with SEPA.

MEMBER ENGAGEMENT: UTILITIES AND THE SOLAR INDUSTRY

Learning about utility solar business models, the latest in technologies, and policy requires in-person and virtual "face time." SEPA creates

the forums that bring utility leaders together with one another and with the solar industry.

Solar Power International

SEPA's flagship event – Solar Power International – presented in partnership with the Solar Energy Industries Association (SEIA), is North America's largest solar event. This trade show doubled in size between 2008 and 2010 with more than 900 exhibitors representing all segments of the solar industry.

Total attendance at the show topped 27,000, with more than 6,500 attending educational sessions. Throughout the week-long event, SEPA offered programming addressing solar topics of most interest to utilities. SEPA members participated in more than 60 sessions on topics ranging from micro-inverters to feed-in tariffs.

Utility Solar Conference

In 2010, SEPA presented its second annual Utility Solar Conference – the only solar conference in which attendance is restricted to utilities only. Created by utilities for utilities, the conference explored how to develop a viable long-term solar strategy of benefit to the utility and its customers, shareholders, and stakeholders. The conference provided a new forum for 150 utility professionals, ranging from executives to engineers, to share information, exchange ideas, and talk through solar developments with their utility peers.

MARKET INTELLIGENCE AND ANALYSIS

SEPA's best-in-class research offers solar intelligence that helps utility employees across departments make educated decisions about solar programs and projects.

Throughout the year, SEPA's research team serves as an extension of our members' own staffs, providing answers to questions related to solar energy and producing research reports and data.



Fig. 4 - 4.6 MW of solar at the Springerville Generating Station Solar System (SGSSS) in northeastern Arizona by Tucson Electric Power. This site generates enough electricity to power about 700 homes. Total array coverage area is 44 acres with 34,980 panels.



Fig. 5 - Xcel Energy: Colorado

Utility Solar Business Models Project

Another exciting area of SEPA research is the ongoing Utility Solar Business Models Project (USBM) which began in 2007.

In 2009 and 2010, the USBM Project focused on tracking and sharing the innovative solar projects and programs initiated by utilities in 20 summary sheets, posted on SEPA's member-only USBM web page. In addition, the project held a series of webinars for members, a session at the Utility Solar Conference, a round-table breakfast at Solar Power International, and a number of presentations by staff at utility and solar events. A final report and new USBM web page was released in mid-2010. To learn more, visit: <http://tinyurl.com/UtilitySolarBusinessModels>

Other Research Reports included:

- Utility Solar Tax Manual
- Photovoltaic Incentive Programs Survey: Residential Participant Demographics, Motivations and Experiences
- Distributed Photovoltaic Generation for Regulated Utilities
- Decoupling Utility Profits from Sales: Issues for the Photovoltaic Industry
- Utility Solar Procurement Study

OUTREACH

Supported in part by a cooperative working agreement with the U.S. Department of Energy and a grant from the American Public Power Association, SEPA's outreach and interaction programs encompass a wide range of activities.

Regional Directors

2010 marked the second year that SEPA members had a full 12 months of one-on-one support from Regional Directors in the United States. The Regional Directors - one each for the Western, Central, and Eastern regions of the nation - utilized their many years of experience and knowledge, from working at and with electric utilities, to provide

technical assistance and share best practices with SEPA's utility members. Examples of one-on-one support include:

- Facilitated utility cross-department solar strategy sessions.
- Provided guidance to utilities on how best to work with solar companies in preparation for submission of a proposal for regulatory approval.
- Facilitated utility employee peer exchange with other utilities that had solar programs they wanted to replicate.
- Worked with a utility's economic development team to determine the value of a solar program to the local community.
- Coordinated meetings for utilities within a state to discuss solar issues.

SEPA Website and Solar Toolkit

SEPA's new website contains a comprehensive Solar Toolkit. The Toolkit is a resource portal which allows visitors to intelligently filter through hundreds of documents, multimedia items, news, and events by technology, market sector, job function, and other options. In addition, the Solar Toolkit features a RFP section where utilities can post their renewable RFPs and four other distinct tools of value to SEPA members:

- *Solar Data & Mapping Tool* - A powerful resource that provides both extensive project data and a visual overview of the distribution of photovoltaic (PV), concentrating solar power (CSP), and solar project announcements in the United States.
- *Solar Solutions Tool* - An online evaluation tool that helps utilities think strategically about solar electricity options.
- *Solar Networking Tool* - The Solar Networking Tool lets members make contact with other solar and utility professionals.
- *Utility Case Studies Tool* - A tool that allows members and non-members to search and filter utility solar case studies based on the criteria selected, generating a list of studies best suited to = fit a utility's needs.

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

ANA ROSA LAGUNAS ALONSO, CENTRO NACIONAL DE ENERGÍAS RENOVABLES, CENER



Fig. 1 - BIPV in a Cultural Centre in Alcobendas (Madrid) (photo: Martifer Solar).

GENERAL FRAMEWORK

During 2010, Renewable Energies have covered the 35 % of the total electrical demand in Spain, 6 points more than in 2009. Wind energy is the clear leader on that fact (16 % of total demand) while PV production was responsible for the 2,5 %, with a peak of 4 % in June (values estimated from data out of CNE and grid operator REE). Nevertheless, uncertainties with the regulatory frame for the tariffs have led to a slow down on certain potential initiatives.

Specifically on the side of the Photovoltaic Solar Energy and after the explosive growth of PV installed in 2008, subsequent modifications of the regulatory frame have reduced significantly the annual installations during 2009 and 2010. Recent new laws in November (important reduction of tariffs for new PV installations) and December (limitation of equivalent working hours on installations) are going to have impact on future plans of PV professionals and the industry in general.

NATIONAL PROGRAMME

The PANER (Plan Nacional de Energías Renovables) 2011 - 2020 has adopted the objectives established in the European Parliament directive 2009/28/CE, with respect to Renewable Energies. According to this directive, by 2020 every member State should achieve a 20 % of primary energy supply coming out of Renewable Energies, and 10 % for transportation.

The proposal from the Spanish Government through the IDAE (Instituto para la Diversificación y el Ahorro de la Energía) following that directive has been to achieve a 22,7 % of total energy supply in Spain, as of 2020, provided by Renewable Energies. That number will imply a 42,3 % of electricity obtained out of RREE.

With this goal in mind the Ministry of Industry, Tourism and Commerce has studied the different alternatives and elaborated a plan in order to accomplish the proposed objectives. Global and sector objectives have been identified and the means in order to achieve the goals, listed clearly.

There are mostly regulatory and financial types of actions oriented to public and private institutions, but a key point among all of them is the impulse for development of new energy evacuation structures that might handle the important volume of renewable energies expected.

Being also part of the PANER initiatives, and specifically for PV development, the next points have been considered:

- simplification of administrative procedures for the authorization of the PV installation
- support to R&D activities
- promotion of building integration projects
- establishment of an adequate frame for net metering and auto consumption.

R&D, D

During 2010, the R&D activities with respect to PV in Spain have been developed through national and regional support initiatives (apart from the 7th FP of the EU). The most relevant ones come out of the CDTI (Centre for Technical and Industrial Development). The high level goal of those initiatives is the reduction of the cost of the kWh generated by PV. The basic working scheme is based on the creation of a consortium to develop specific knowledge, or specific products. In most of the cases the consortium is lead by industrial partners that use the possibilities of the basic and applied R&D

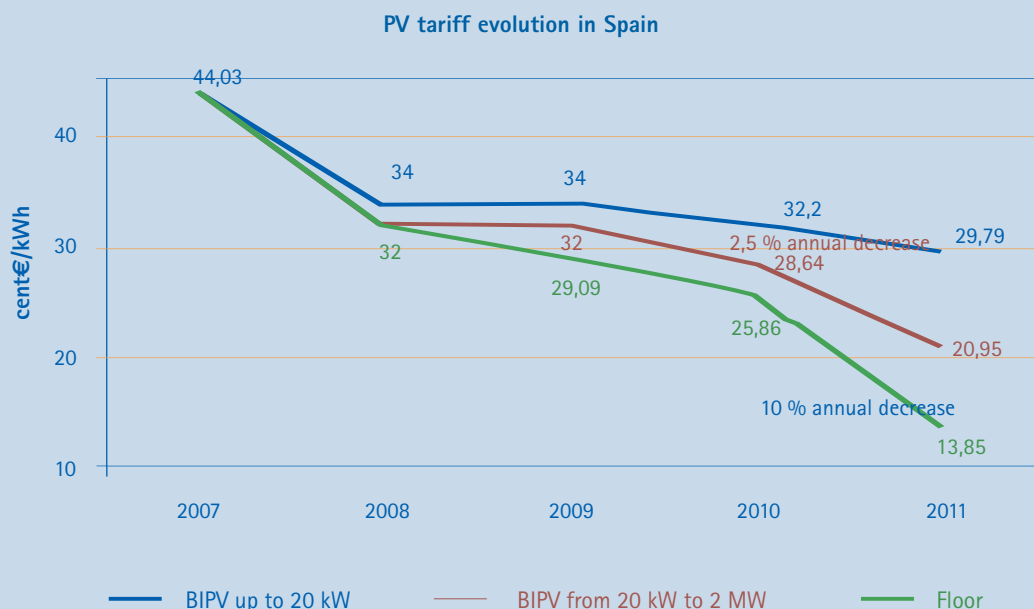


Fig. 2 - PV tariff evolution in Spain.

provided by the research centres, to complete their development initiatives. Specific mention should be made to projects with respect to next subjects:

- CPV technologies and components development
- Thin film technology, mostly CIGS but also a-Si and Organic based PV
- Improvements of wafer based Silicon to enhance efficiency and lower material consumption
- New materials on PV module construction
- BIPV

All those initiatives are aligned with the Strategic Energy Technology Plan (SET Plan) of the EU; that was presented in October 2010. The Plan, considered as a tool to coordinate R&D in the member states, has specific routings for establishing PV as a competitive energy technology, with a goal of 12 % of total electricity consumption in Europe being produced by PV by 2020.

IMPLEMENTATION

The installed PV capacity at the end of 2010 in Spain was close to 3,800 MW. That power has been able to cover 2,5 % of the total electricity demand for the year 2010.

The impressive growth in the PV installed in 2008 coming from the very good tariff conditions has been modulated for subsequent modifications on the regulatory frame. First, there was the tariff reduction (roughly 30 %) of RD 1578/2008 and the establishment of a limit to 500 MW. Recently (November 2010), the issue of RD1565/2010 with another feed in tariff reduction for new PV installations (-45 % floor installations, -25 % BIPV installations, -5 % small BIPV installations) was made. Figure 2 represents the evolution of tariff with the subsequent regulatory frames.

On top of that, the RDL14/2010 of December 24th establishes a production limit for applying the tariff on PV produced energy.



Fig. 3 - BIPV installation on a building in Paseo de la Castellana (Madrid) (photo: Martifer Solar).



Fig. 4 - 34 MW PV plant in Arnedo (La Rioja) (photo: T-Solar).

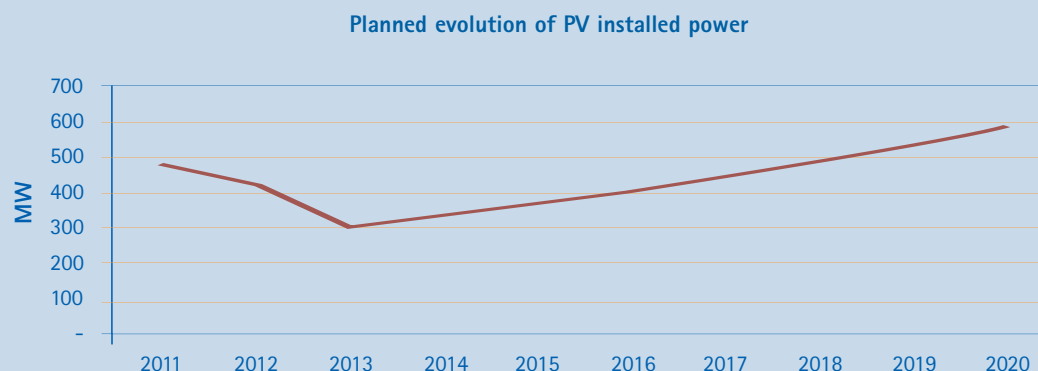


Fig. 5 - Planned evolution of PV installed power in Spain.

INDUSTRY STATUS

The regulatory frame modifications applied to PV have impacted on the Spanish industry in the sense that there has been a net lost of jobs in the sector, mostly on the PV installations activity. On the other hand, and with respect to the production of components, the activity has continued on the already active module and inverter companies, and new plants have been opened for thin film (a-Si) technologies and announced for CIGS. In those cases, the thin film technology has been thought as having a potential application on BIPV.

Finally, and based on the good experience of Spanish R&D organizations on the CPV technology, and on the support from public subvention to product development initiatives, manufacturers in the sector for components and measurement tools have opened recently activity.

MARKET DEVELOPMENT

Traditionally, the market development in Spain has been modulated by the tariff conditions. Once they were clearly established, and even after the important tariff reduction of 2008, the optimum design of the installation and choice of components could make the projects still attractive from economical point of view.

Nowadays, and after the recent new tariff modification of November 2010, a new exercise of project optimization must be done.

The application of all regulatory frame restrictions and the value approved by the Spanish Congress of Deputies for PV installed in 2020, as part of the PANER, presents the evolution for installed power, which appears in Figure 5.

FUTURE OUTLOOK

As of today, based on the quotas extracted from PANER (Plan Nacional de Energías Renovables 2011-2020) for PV installation in Spain, and in the recently established feed in tariff conditions, the future appears more favourable to BIPV type of installations.

Nevertheless, the effort on technology developments, with all cost reductions obtained and achievable, can allow for grid parity level very soon. In that circumstance, there is a large amount of electricity needs (isolated or not) that might be viable with own PV generation. Auto consumption and net metering are going to play important roles in the future of PV development in Spain.



Fig. 6 - 10 MW a-Si PV installation in Saelices (Cuenca) (photo: T-Solar).



Fig. 7 - CPV trackers various manufacturers (photo: ISFOC).



Fig. 8 - PV installation in the façade of CENER building (Sarriena).

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

LINUS PALMBLAD, SWEDISH ENERGY AGENCY; MONIKA ADSTEN, ELFORSK AB; JOHAN LINDAHL, UPPSALA UNIVERSITY



Fig. 1 - PV demonstration system by the Bixia utility company at Nääs conference estate (photo: DP Engineering AB).



Fig. 2 - PV system at the Ås school in Krokum (photo: DP Engineering AB).

GENERAL FRAMEWORK

Carbon emissions from the Swedish electricity production (approximately 150 TWh per year) are low in comparison to other developed countries. About 45 % 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 CO₂ 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 favorable 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 PV in off grid applications. Additionally Sweden hosts world renowned researchers coupled to increasing industrial activities with a lot of potential.

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. The 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 annual budget for the programme is about 100 MEUR. The agency provides funding for PV research, co-financed technological development, demonstration and business development. About 5 MEUR of the budget for 2010 was allocated for PV projects. 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, private foundations and the industry.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

PV R&D in Sweden is mostly focused on 2nd and 3rd generation PV concepts. CIGS thin film, dye sensitised and polymer solar cells are three examples of topics with world class Swedish research groups. 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



Fig. 3 - PV system at the Royal Institute of Technology in Stockholm (photo: Direct Energy AB).

technology, elimination of cadmium from the buffer layer, replacing rare metals in the absorber layer with more common ones 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.

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) and they have a research project on dye sensitised solar cells. The aim is to develop efficient nanostructured dye sensitised solar cells and modules that can be manufactured at a very low cost per Watt. There are several research groups in Sweden, for example at Linköping University and Chalmers University of Technology that are working on polymer solar cells.

At the division of Energy and Building Design at the University of Lund, research is conducted primarily on solar energy integration into buildings. One example is the project Solar Energy and Architecture, Task 41 within the IEA Solar Heating and Cooling implementing agreement, where the operating agent is placed at the University of Lund. This project deals with architectural integration of solar energy systems. The goals are to help in achieving high quality architecture for buildings integrating solar energy systems and improving the qualifications of the architects.

The SolEI 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 the end of 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. The main objectives of the SolEI 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 SolEI 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 a national forum for exchange of information about PV to different actors. Examples of projects funded by the programme are studies regarding building-integrated photovoltaics (BIPV) and city planning, policy instruments (e.g. net-billing), 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 BIPV, a general trend for companies to profile themselves as environmental friendly and also due to EU directive on nearly zero-energy building [1]. This has led to a shift of focus towards BIPV, with planning tools for architects and builders being developed. Other examples of projects and activities are regional PV seminars, international study tours, handbooks and guidelines.

IMPLEMENTATION AND MARKET DEVELOPMENT

The market for PV in Sweden has traditionally been dominated by domestic stand-alone PV systems and as a result, the market for these systems has been stable in Sweden. However, the market for



Fig. 4 - the Micasa real estate company has invested in a PV system on the roof of a health center (photo: Direct Energy AB).

grid-connected PV systems relies completely on supporting incentives. Since 2005, there have been specific subsidies for grid connected PV systems in Sweden, first from 2005 until 2008, only for public buildings and now since 2009, available for anyone. Grid-connected systems represent about half of the installed capacity today and the annual market is larger than for off grid systems so the situation is about to change towards a domination of grid connected system. 2009 became a year of waiting for the actors on the Swedish PV market due to the late start of the new subsidy programme. However, during 2010 there has been full activity again. But some projects have been delayed due to long waiting times for materials (e.g. inverters).

With the Swedish subsidy programme it is possible to get up to 60 % of the total investment cost as a grant. The budget is about 6 MEUR per year for 2009–2011. The interest for the subsidy has been considerable. Due to the high interest it was decided by the government to add an additional 5,5 MEUR to the budget for 2009 and they have also announced a suggestion to prolong the subsidy programme until 2012.

The current support program has gained a lot of interest from private households. One key issue for private households with small scale power production is how they should be compensated for the electricity that they feed into the grid. The regulatory framework has been improved somewhat during 2010 for systems below 43,5 kWp, they no longer have to pay the fixed cost that is required in order to sell electricity to the grid. But it is still the producers' responsibility to find a buyer of the electricity. Net-billing has been proposed as a simple solution by many actors, and the consequences of net-billing have been investigated by the Swedish Energy Markets Inspectorate

during 2010. However, the proposal in the resulting report was only a partial net-billing system due to tax issues. The report is now on remission and it will then be up to the politicians to decide what to do.

In 2010 we saw the first example of a small scale feed-in tariff for PV in Sweden, when the small utility company **Sala-Heby Energi** made a deal with an economical association to buy the electricity from the two PV systems that the members of the association owns for 4,5 SEK/kWh (0,48 EUR/kWh) during 10 years.

INDUSTRY STATUS

There are five module producers in Sweden that mount imported crystalline silicon solar cells. Almost all of the produced modules are exported since the internal market volume is very small compared to the combined module production capacity of the companies. Several of the Swedish PV module manufactures have experienced difficulties. **Gällivare Photovoltaic** went through a financial reconstruction in the beginning of 2010 and 330 workers lost their jobs when REC Scanmodule decided to close down their module factory in Sweden and move the module production to their new factory in Singapore. The facilities have however been purchased by a newly formed company called **Perfekta Solar AB**. The size of the production and how many of the former employees that will find a job in the new company are still unclear.

There are currently no feedstock or cell manufacturers in Sweden, but there are plans for production of thin-film CIGS cells by the company **Midsummer AB**. The founders of Midsummer AB have experience from e.g. the thin film and semiconductor industries at Midsummer and they have developed a production process for CIGS solar cells. Their aim is to reduce the production cost of CIGS cells



Fig. 5 - The Svenska Bostäder real estate company has built a PV system on one of their local offices in Stockholm (photo: Direct Energy AB).

by combining knowledge from these industries, experience from mass production and a high throughput manufacturing process. Midsummer is currently working on scaling up their production process from pilot scale to full scale production.

Another example of a company with a new approach to PV is **NLAB Solar AB**. They are developing transparent dye sensitised solar cells for integration in glass windows.

A growing number of small to medium-sized enterprises exist, which design, market and sell PV products and systems. Many of these companies depend almost exclusively on the Swedish market. The new subsidy programme from 2009 has resulted in more activity among these companies and since there has been a lot of interest from private households there are several companies that are marketing products specified for this market segment.

Low-concentrating combined photovoltaic/thermal systems is a Swedish niche, in which research and development has been conducted for more than ten years. **Absolicon AB** are marketing their X10 system, a tracking PV/thermal module adapted for large building with a need for both heat and electricity. **Solarus** has developed a low concentrating solar panel adapted for roof mounting. The Solarus solar panels are available in three different setups, solar thermal, PV/thermal-hybrid and PV.

FUTURE OUTLOOK

Many of the Swedish PV module manufacturers have had difficulties, but there are still many good opportunities for a Swedish PV industry with several start-up companies and a lot of promising research.

The big challenge for Swedish industry and Swedish researchers is to commercialise these opportunities into products and services for the PV market.

Currently there are several urban development projects with ambitious environmental goals and targets for local energy supply that are taking shape in Sweden. PV will play an important part in these projects and it will help the PV technology to become a more natural part of the building and the city planning processes.

The PV subsidy programme is now in full swing after a stop and go situation in 2009. But the end of the current subsidy programme is already closing in, although, the government has announced a prolongation of the current PV subsidy for 2012. However, there is still uncertainty regarding long term support for a Swedish PV market. The key issue is a stable and long term framework that can create transparent and secure conditions for all actors at the same time as being effective. 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.

It is 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 political 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.

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS

STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.

AND STEFAN OBERHOLZER, SWISS FEDERAL OFFICE OF ENERGY (SFOE)



Fig. 1 - The PlanetSolar boat in Miami after crossing the Atlantic. The boat is 31 m long and 15 m wide; with further extensions it has space enough for more than 500 m² of solar panels with a total power of 93 kW. The energy is stored in 648 Li-ion batteries which give the boat an autonomy of about three days. (photo: © PlanetSolar).

GENERAL FRAMEWORK

The development of the photovoltaic sector in Switzerland builds on a strong research base, an increasing industrial activity and, more recently, an acceleration of the market deployment efforts. A comprehensive research programme covers R&D in solar cells, modules and system aspects. The Swiss energy research strategy is defined by an energy RTD master plan updated every four years, with 2010 as the third 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.

Market deployment continued at a moderate level, thanks to the feed-in-tariff scheme which became effective the year before. The size of the Swiss photovoltaic market is however limited by the cap on the amount of support attributed to photovoltaic projects and many projects are presently on a waiting list. To support the deployment of renewable electricity through the feed-in tariff model, a levy up to presently 0.9 cCHF per kWh consumed electricity is being perceived, yielding a total annual amount up to 480 MCHF. This amount is divided into maximum contributions for different

renewable energy technologies (hydropower up to 10 MW, biomass, photovoltaics, wind and geothermal energy) depending on their specific generation costs. Concerning photovoltaics, these maximum contributions begin with 5 % of the available financial envelope and can increase over time, as the photovoltaic 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.

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach (www.photovoltai.ch). This national photovoltaic programme focuses on R&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. Activities in pilot and demonstration projects continued to be limited during 2010. On the technical level, thin film solar cells and building integration continue to be the topics of highest priority. The programme is organised along the entire value chain and addresses the critical gaps from technology to the market place. Through component and system analysis aim at increasing efficiency and performance. Accompanying measures to raise the quality and reliability of photovoltaic power systems include work on standards and design tools.



Fig. 2 - Edison Power 840 kW PV on 3 different roofs at the PISTOR facility in Rothenburg (photo: PISTOR).



Fig. 3 - Solar Impulse flying near Mont Blanc in July 2010. (photo: © Solar Impulse).

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In the third year of the present RTD master plan, around 65 projects, supported by various national and regional government agencies 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). Work on thin film silicon at the Swiss Federal Institute of Technology (EPFL) in Neuchâtel concentrated on micromorphous solar cells with a particular emphasis on silicon oxide intermediate reflector layers. Significant progress was also achieved in the area of high-efficiency heterojunction silicon solar cells. Industry co-operation was extended with various companies. Based on these co-operations, the Oerlikon Solar company announced a new record efficiency of 11,9 % for micromorphous solar cells.

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. As a highlight, a new record efficiency of 17,6 % was announced for CIGS solar cells on plastic substrate. 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 expanding and recently includes the largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf, www.pytest.ch) as well as a new test centre for IEC module certification (Lugano, www.isaac.supsi.ch/pv/lab0). 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.

From vision to reality: The first prototype of the solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard has reached a major milestone by achieving a first 26 hour non-stop flight. On the other hand, the solar powered boat PlanetSolar (www.planetsolar.org) finished its construction phase early in the year and started its world tour in September in Monaco. The boat reached Cancun right in time for the 16th United Nations Climate Change Conference in December 2010.

International co-operation continues to form a strong pillar of the R&D activities with 18 projects running in the 7th framework RTD programmes of the European Union during 2010. During 2010, a second joint call was terminated 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), the European Photovoltaic Technology Platform (www.eupvplatform.org) and the European Solar Industry Initiative.

INDUSTRY STATUS

Since a few years, Swiss industrial PV products cover the full value chain starting from materials, production equipment and small scale manufacturing of solar cells, over diverse components and products all the way to system planning and implementation.

On the PV industry supply side, different products count among the world leaders, e.g. for wiresawing machines from Meyer Burger as well as from Applied Materials Switzerland ; and measuring equipment for PV module manufacturers from Pasan (now a part of Meyer Burger Group). Solar plugging systems are offered by Multicontact as well as Huber & Suhner.



Fig. 4 – Building integrated systems benefit from higher feed-in tariffs and represent 25 % of the systems installed: 46,8 kW system on a farm house in Uettiligen (Berne) (photo: Swiss Federal Office of Energy).

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 have merged their activities thereby becoming the largest PV industry group in Switzerland.

In the inverter area, some products have achieved a high export rate. The Sputnik Company produces grid-connected inverters at a capacity of 800 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.

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 at more than 2 000 MCHF in 2010.

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 (www.sarasin.ch).

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 Swiss legislation explicitly foresees the possibility of switching between the feed-in tariff and the voluntary green power marketing approach.

The feed-in tariff for PV systems distinguishes between three different categories of systems, namely ground based, building applied and building integrated systems (BIPV) for which the highest tariff can be obtained. The applicable feed-in tariff also depends on the size of the PV system. In this way, a differentiated scheme is used which is based on regular market analysis to follow the dynamics of the market. Due to the tariff applied for BIPV systems, this market segment corresponds to 25 % of the installed systems. The majority of systems are realised as building applied systems (74 %) whereas ground based systems only account for 1 %.

The annual market volume for grid-connected systems is estimated to a value around 30 MWp. The total installed capacity has thus risen to more than 100 MW (Figure 5), corresponding to more than 13 W/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 2009 is thus approaching 50 GWh.

FUTURE OUTLOOK

The photovoltaic sector in Switzerland developed considerably in the year 2010, be it in research and technology, industry or the market. On the technology front, the key competence centres continued their efforts in their respective domains (solar cells, modules, systems) while increasing their cooperation with industry and on the international level.

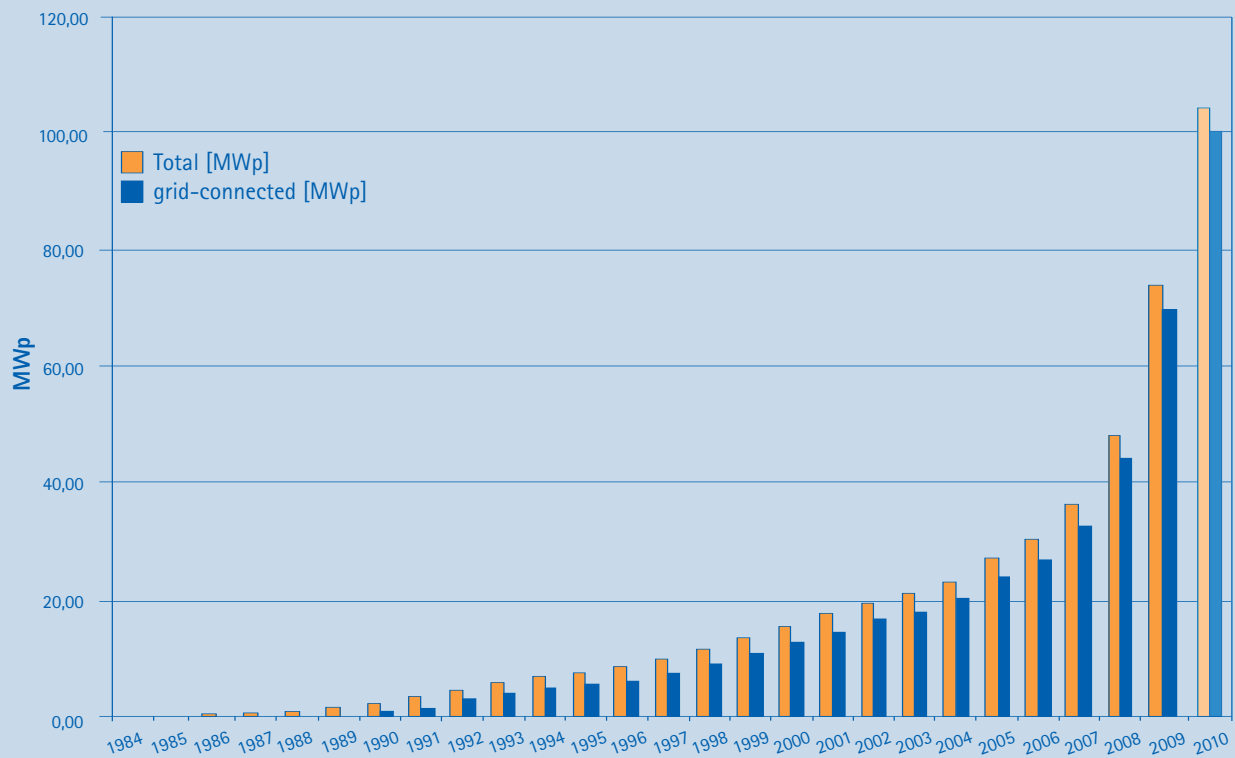


Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2010 (total and grid-connected, estimated values for 2010).

The support of the national PV RTD 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 - 2009 (GRID-CONNECTED SYSTEMS)

YEAR	NUMBER OF NEW SYSTEMS	TOTAL NUMBER OF SYSTEMS	INSTALLED CAPACITY [MWp DC]	ENERGY PRODUCTION [MWh]	SPECIFIC ENERGY-PRODUCTION [kWh / kWp]
1989	60	60	0,3		
1990	110	170	0,8	400	
1991	210	380	1,8	1 100	
1992	110	490	3,1	1 800	800
1993	110	600	4,0	3 000	810
1994	80	680	4,8	3 500	800
1995	60	740	5,4	4 000	815
1996	80	820	6,2	4 700	825
1997	130	950	7,4	6 000	880
1998	150	1 100	9,2	7 100	860
1999	125	1 225	11,0	7 700	770
2000	100	1 325	13,0	10 000	810
2001	125	1 450	15,0	11 000	800
2002	75	1 525	16,6	12 000	810
2003	75	1 600	17,9	15 100	875
2004	100	1 700	19,5	15 200	815
2005	200	1 900	23,6	18 200	850
2006	250	2 150	26,1	21 000	845
2007	525	2 675	32,6	25 700	875
2008	1 200	3 875	44,1	33 400	865
2009	1 900	5 775	69,6	49 000	860

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS

NEW HORIZONS FOR THE TURKISH PV SECTOR

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Fig. 1a - Module fabricated at GUNAM facility, Ankara.

Fig. 1b - GUNAM's a-Si solar cell laboratory, Ankara.

GENERAL FRAMEWORK

Having a surface area of 78 Mha and 73 Million population, Turkey's production and consumption based on primary energy resources are projected to increase by 76 % during 2010-2020 period according to the "Blue Book" published by Turkish Ministry of Energy and Natural Resources at the end of 2010. (http://www.enerji.gov.tr/yayinlar_raporlar/Mavi_Kitap_2010.pdf)

Gross electric energy consumption of Turkey in 2009 decreased by 2,4 % while the production decreased by 2,0 % in reference to 2008. These figures are 193,3 billion kWh and 194,1 billion kWh respectively. Total installed capacity of electricity is 46 126 MW as of July 2010. Total electric production in 2009, broken down by specific resources, stands at 48,6 % natural gas, 28,3 % coal, 18,8 % hydro, 3,4 % liquid fuels and 1,1 % renewables. The cumulative installed PV power in Turkey at the end of 2010 was estimated to be about 6 MW.

NATIONAL PROGRAM

The law titled "Utilization of Renewable Energy Resources for Electrical Energy Production" has been consented by the Parliament in 2005. Incentives amendment to this law remained in the agenda of the Parliament since 2008 and approved at the end of 2010. A purchase guarantee of 13,3 USDcent/kWh is given for solar electric energy production for ten years. Some supplementary subsidies for domestic products are as follows:

- PV module integration and mechanical solar construction, (+0,8 USDcent/kWh)
- PV modules, (+1,3 USDcent/kWh)
- Constituent cells of PV module, (+3,5 USDcent/kWh)
- Inverter, (+0,6 USDcent/kWh)
- Material focusing solar energy on PV modules, (+0,5 USDcent/kWh)



Fig. 2 - 17,2 kWp Solar Water Pumping Project by Merk Energy Ltd., Meseler-Ankara.

Another step is, The Electricity Market Regulatory Authority's (EPDK) bylaw of license exemption rules for grid connected facilities with 500 kW maximum installed power. The bylaw prescribes the financial procedures and principles for supplying energy to the grid, as well as the legislative issues concerned. Another bylaw defining the grid connection guidelines is currently being prepared by the EPDK.

R & D

Among the R&D centers founded with state subsidies by the universities and/or public enterprises, the environment and energy themed ones get the 7,8 % share for 2003-2011 period.

PV technologies related projects started in the past and supported in 2011 are listed below:

- Solar Energy Research Center (GUNAM), Middle East Technical University (ODTU), 6,92 MEUR, 2009-2011. GUNAM aims to be a national and international center of excellence in the area of solar energy science and technology. It has received significant financial support through the State Planning Organization (SPO) and Ministry of Industry and Commerce of Turkey. The primary mission of GUNAM is to carry out research programs towards development of state of the art PV based solar energy conversion system. GUNAM is forming a graduate level research and education program in the field of PV science and technology. Research activities include developing fundamental knowledge on the production techniques, characterization and methods and applications of photovoltaic solar cells including single crystal based solar cells, a-Si/mc-Si, CIGS and CdTe/CdS based thin film solar cells, dye synthesized solar cells, organic solar cells, third generation solar cells based on semiconductor nanocrystals (see Figure 1) (More details: www.gunam.metu.edu.tr).
- Nanoscience and Nanotechnology Advanced Research Institute, Istanbul Technical University, 11,44 MEUR, 2008-2012.
- Advanced Lithographic Methods Laboratory, Istanbul University, 2,15 MEUR, 2010-2011
- Infrastructure Laboratories Center, Mugla University, 19,90 MEUR, 2007-2011.
- ENAR Program, Republic of Turkey Ministry of Energy and Natural Resources (ETKB), 3,89 MEUR, 2008-2013.
- Energy Data and Technology Management Center (EBITEM), General Directorate of Electrical Power Resources Survey and Development Administration (EİE), 7,69 MEUR, 2010-2013.
- Environmental Tests Center, TUBITAK-UME, 11,44 MEUR, 2009-2011.
- Electrical Energy Storage Technologies R&D, Diagnosis and Risk Evaluation Center, TUBITAK-MAM, 3,89 MEUR, 2010-2011.

Some major projects starting by 2011 are as follows:

- Renewable Energy Technologies Center (YETMER), Ege University Solar Energy Institute (EU-SEI), 3,58 MEUR, 2011-2013. YETMER aims to make type approval tests for products and conformity certification for services for photovoltaic, wind, solar thermal, biomass and geothermal energy facilities. Vocational education and certification in mentioned areas are also in the target of the center.



Fig. 3 - PVPS test application by Bati Enerji Co. & Motif Proje Ltd., Burdur.



Fig. 5 - 138 kWp PVPS application in TOKI buildings, Kucukcekmece-Istanbul.



Fig. 4 - 15 kWp grid-connected PVPS by Solimpeks Ltd. at the KCETAS building, Kayseri.



Fig. 6 - PV power system (PVPS) application by Ekosolar Ltd. in Gazi University, Ankara.

- Ege University Solar Energy Institute (EU-SEI) has been granted Energy Efficiency Organo-opto-electronics and PV Technologies Research Center, 0,84 MEUR, 2011-2012.
- Photonics Research Center, Gazi University, 5,25 MEUR, 2011-2013.
- GAP Renewable Energy and Energy Efficiency R&D Center, Harran University, 4,06 MEUR, 2011-2013.

In addition to these highlights, the Turkish PV Technology Platform (UFTP), founded in 2008 and run by EU-SEI, continues its endeavors to bring related bodies together on a common platform and facilitate information flow. One of the results is that the National Qualifications Authority (MYK) has signed a protocol with EU-SEI for preparing vocational qualification standards of basic renewable energy (wind, PV, solar thermal, biomass) jobs. One other development on PV side, establishing a vocational test center for PV jobs has been initiated by Aegean Region Industry Chamber (EBSO) and EU-SEI with the support of MYK. EU-SEI has also become a partner of EU project titled "Benchmark of National Knowledge and Experiences to Improve Quality of Vocational Education in Renewable Energy Sector".

Established in 2009, Interaktif Ltd., is a young company carrying on R&D and production operations in SME Support Administration (KOSGEB) incubation center in the Ege University campus. Company designs new state of the art power electronic interfaces to be used in/for renewable energy systems. Their flagship is the grid connected inverter for wind turbines, more efficient and lightweight and smaller than its competitors. This new product having necessary national/international certification is expected to be on the market by the last quarter of 2011.

IMPLEMENTATION

With the stimulation of the incentives amendment made to the renewables law by the end of 2010, many companies waiting to invest in the sector accelerated their works.

- **Solar Watchtowers:** Izmir Forestry Administration's "Renewable Powered Watchtowers at the Summits of Forests" project is supported by the Izmir Development Agency (IZKA). Within the context of the project, nine $12 \times 170 = 2040$ Wp mobile PV power systems have been projected.

- **Green Hospital:** Turgutlu State Hospital with 300 bed capacity has been tendered by Health Ministry via Housing Development Administration of Turkey (TOKI) to DOYAP A. S./Gork Ltd. consortium and the foundation has been laid at the beginning of 2011. The consortium spokesman said if the preliminary project proposal is approved, Turgutlu State Hospital will be the first "Green Hospital" of Turkey. A small scale PV plant has been installed at the construction site.
- **Water Supply:** Akademi Enerji Ltd. installed a facility utilizing a solar pump at the Gordes province of Manisa to provide potable water to the Sahinkaya village. Since the drilling point is 6 km away from the village transformer substation, the solar potable water system costs one third of the expenditure for a new power line and transformer installation, with a substantially reduced operation cost.
- **Gazi University:** $32 \times 170 = 5,440$ Wp on-grid PV power system has been projected.
- **Kocaeli University:** $6 \times 60 = 360$ Wp grid-connected photovoltaic power system including thin film modules has been under operation in Kocaeli University from March 2010. R&D activities on PV power inverters, power quality and grid connection issues are continued on power electronics and power quality research laboratories in Kocaeli University. Kocaeli Metropolitan Municipality and Kocaeli University Researchers have developed a 3 kW solar tracking photovoltaic power production system. The system installation is still actively working in the garden of Kocaeli Metropolitan Municipality. The produced photovoltaic energy transferred to the grid network is about 9 MWh yearly. The system has twenty 150 Wp photovoltaic panels, for a total power of 3,000 W. Solar tracking PV system provides about 45 % more energy production compared to a fixed PV system.
- **Solarcity:** Antalya Metropolitan Municipality has officially started the program for creating Antalya's Solarcity identity on July 2010. This long running program involves defining the PV roadmap for Antalya.
- **GSM RTU Applications.**



Fig. 7 - 3 kWp Solar Tracking PVPS application in the garden of Kocaeli Metropolitan Municipality.



Fig. 8 - 42 kWp stand-alone PVPS application by Global Tower in Ozdere-Izmir.

Some attractive PV applications which were installed in 2010 are shown in Figures 2 - 8.

INDUSTRY STATUS

Having IEC 61215 certification for their PV modules, the ANEL Group plans to increase the capacity of their fully automated module manufacturing line commissioned in 2009. The current capacity of 15 MW/y will be increased to 75 MW/y. ANEL produces various goods for known European brands with TUV, IEC, CE, ISO 9001 and ISO 4001 certifications. (<http://www.anelenerji.com.tr>)

Another module manufacturer, Tera Solar Ltd., produces 5 W to 250 W mono- and poly-crystal modules and has a 5 MW/year production capacity soon to be increased to 10 MW/year.

Trakya Cam Co. as a leading flat glass supplier in the region and one of the largest glass producers in Europe is increasing sales for Solar Glass. The mother company, Sisecam, which has around 3 BEUR in sales, is composed of four groups involved in glassware, glass chemicals, glass packaging and flat glass. The solar glass business group is a part of the Trakya Cam flat glass company, which has been active in the solar glass market for years. Trakya Cam is producing two types of tempered, patterned solar glass in both 3,2 mm and 4 mm thickness called DURASOLAR P+. Durasolar P+ is tested and certified by the SPF Institute and is also certified as U1 class (http://www.trakyacam.com.tr/Islenmis_Camlar/en/).

MARKET DEVELOPMENT

Although the PV sector is in its infancy in Turkey, thanks to UFTP endeavors since 2008, significant developments are being made. Numerous parameters has been carefully and seriously studied and examined long before the sector matured. As an example, UFTP

initiated a workgroup with the Turkish Standards Institute for translation of international PV standards. This movement evolved in an official PV Mirror Committee - MTC116 and continues the job independently.

One of the most popular and awaited convention among all parties, the Solar Energy and Technologies Fair will be held on 10-13 March, 2011. (<http://www.solarfuari.com/>).

Due to the declared incentives, financing and credit viability issues of energy production facilities and systems are brought into finance bodies' agenda. Numerous financial institutions come forward with special finance plans for renewables.

Grant donors such as the SME Support Administration (KOSGEB) and development agencies are prioritizing the renewable themed projects. In the near future, it is expected that they shall open calls directly under the title of renewable energy resources.

FUTURE OUTLOOK

The Turkish Electricity Transmission Company (TEIAS) prepared a projection considering the supply and demand data and warned, "Unless the necessary steps are taken, electricity supply will not meet the demand in 2016."

With this warning also in mind, along with the environmental responsibility issues, public awareness gradually increased over the last five years and alternative energy resources have become a new area of interest.

As a tangible target, the Energy and Natural Resources Ministry 2010-2014 Strategic Plan aims to reach a 30 % share of renewables (incl. hydro) in electric energy production by 2023. In the light of this striking projection, a rapidly growing market in the near future in Turkey will not be surprising.

To pave the road for domestic and foreign investors and companies, UFTP takes the lead by holding an international convention on 16th February 2001, in Istanbul, aiming towards experience sharing among parties; with the contribution of IEA-PVPS Task 1 Experts.

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UNITED KINGDOM

PV TECHNOLOGY AND PROSPECTS
GREG SEED, PROJECT ENGINEER, IT POWER



Fig. 1 – 14,84 kWp, St. Silas Church, London by Solar Technologies Ltd.

GENERAL FRAMEWORK

Climate Change, Greenhouse Gases and Renewable Energy have been re-occurring topics in newscasts and politics in the UK over the past few years and even more so in 2010. This is also reflected in the government policy documents, statutory targets and the active mechanisms. The UK government through the Climate Change Act 2008 has set the UK's targets to reduce greenhouse gas emissions by at least 80 % by 2050, against a 1990 emission baseline, through domestic and international action. Another aspect 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 [1]. In May 2009, the levels of the first three carbon budgets were approved by Parliament and so are set in law.

Pursuant to the Climate Change Act, the Government set up the Committee on Climate Change (CCC) and Adaptation Sub Committee. These bodies are involved in policies such as the Carbon Budgets. Alongside the Climate Change Act, the UK government's other initiatives to address climate change include documents within planning policies, the Planning Act, the Energy Act and Securing the Future – the UK Sustainable Development Strategy.

In order to attain the government's challenging renewable energy production, and CO₂ and total Greenhouse Gas reduction targets, the UK also released the Low Carbon Transition Plan in July 2009 and the document Warm Homes, Greener Homes.

NATIONAL PROGRAMME

The EU Renewable Energy Directive set a target for renewable energy to provide 15 % of the country's energy by 2020 [2]. Based on this, the Renewable Energy Strategy released in July 2009 highlights how the UK can produce more than 30 % of electricity from renewables against a backdrop of approximately 5,5 % in 2009. Also, whilst noting that the UK housing stock is a large emitter of emissions, Warm Homes, Greener Homes was released to set out plans for achieving a target reduction of 29 % of non-traded carbon emissions from the household sector.

The Department for Energy and Climate Change (DECC) is involved in drivers such as the Feed-In-Tariff. The Committee on Climate Change (CCC) and Adaptation Sub Committee were setup independently to be involved in the associated issues and as such have reported on multiple issues. As part of its role the CCC provides annual reports to Parliament on the progress the government is making in meeting carbon budgets and in reducing emissions of greenhouse gases. The Government commissioned the Committee on Climate Change to provide a number of study reports including:

- Carbon Budgets.
- Building a low-carbon economy – the UK's innovation challenge. This report considers the effectiveness of current policy measures and institutional arrangements to deliver the technologies required to meet the UK's 2050 emissions target.
- 'How well prepared is the UK for climate change?' – an Adaptation Sub-Committee report.

Additionally, the Building Research Establishment (BRE) is involved in policies such as the mandatory levels of the Code for Sustainable Homes (CODE), and the commercial equivalent – Building Research Establishment Environmental Assessment Method (BREEAM).

Regional development agencies pushed activity into assessments and reporting of local issues surrounding renewable energy, although these players were disbanded in late 2010. In summary, it is evident that the UK Government believes that Renewable Energy is an excellent way forward to tackle many of the present and future issues.

IMPLEMENTATION

The Renewable Obligation (RO) that started in 2002 was still in effect during 2010 with support available until for a maximum of 20 years (up to the end date of the RO in 2037). Currently PV receives 2 ROC's for every MWh produced [3], although this is superseded (financially) by the newly introduced Feed-in-Tariff (FIT), which creates a better financial outlook for PV installations. More than 4 000 installations registered under the RO have migrated over to the FIT [4].

The FIT is arguably the most prominent and influential Government implementation of 2010 for UK PV. The scheme was put into effect in April 2010 putting to a stop the Low Carbon Buildings Programme. The FITs scheme provides incentives for gross generation from renewable and low carbon technologies; the incentives being dependent on technology and scale of generator. An additional



Fig. 2 - 50,125 kWp, Ferrier Point, London, Sundog Energy Ltd.



Fig. 3 - 9,9 kWp, All Saints Church, Buckinghamshire, Freewatt Ltd.

payment is also given for electricity exported to the network. The finance comes directly from electricity suppliers

In terms of PV, the scheme is index linked for 25 years to provide further incentive to the market, with a diminishing tariff level depending on the year of installation and in line with a predicted fall in system prices due to economies of scale and technology progression. The mechanism applies to all microgeneration technologies producing up to 50 kW of electricity. Generators greater than 50 kW but up to 5 MW can opt to access either the FIT or register under the RO. The new coalition Government has reaffirmed that the FIT will only be retrospectively applicable to the schemes installed after the 14th of July 2009 [5]. The FIT rates have been set for new entrants up to 2021. The FIT rates for 2010/11 are presented in Table 1. Further details can be obtained from <http://www.decc.gov.uk>.

TABLE 1 - TARIFF LEVELS FOR PV FINANCIAL INCENTIVES UNDER UK FIT 1/4/10 - 31/3/11

SYSTEM SIZE	GBP PER KWHP
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

As a result of the FIT, the UK has seen the creation of PV farms. Several more have received planning permission, predominantly in the Devon and Cornwall areas due to high solar radiation in those areas. There are also plans to install very large PV arrays onto industrial buildings. In February 2011, the Secretary of State for Energy and Climate Change announced that the scheme would be reviewed.

The Low Carbon Buildings Programme (LCBP) was closed to new applicants in February 2010 due to the introduction of FIT. It was able

to provide a relatively small contribution to the industry, with a combined total from the whole scheme for 2010 being 2 733 PV installations [6] with approximately 8,2 MGBP grants being committed in the year.

A similar scheme to the FIT is the Renewable Heat Incentive (RHI), whereby microgeneration technologies producing heat energy will be provided funding for doing so. RHI will incentivise solar thermal installations up to 200 kWth capacity at a rate of 8.5p per KWth for a period of 20 years, for non domestic installations. We will consider introducing support for solar installations above this scale from 2012.

In addition to the Feed-in-Tariff, a number of funding options have been available to both homeowners and community groups. Funding for the Energy Saving Scotland home renewables grant scheme was fully allocated on 14 July 2010, placing any new enquiries on a waiting list, while local community groups were still catered for by the Community and Renewable Energy Scheme (CARES). Both initiatives were established in 2009 as an evolution of the Scottish Community and Householder and Renewables Initiative (SCHRI).

The Community Sustainable Energy Programme launched in 2008, which closed on 17th December 2010, provided grants towards the cost of microgeneration technologies and energy efficiency measures, with a total of 8 MGBP being available from the Big Lottery Fund. Community organisations could apply for up to 50 KGBP or 50 % of the project cost (whichever is lower). This funding was typically used in conjunction with the LCBP or equivalent to meet a significant proportion of the costs of microgeneration installation. There are no more rounds of funding planned.

Private utility companies, predominately the electricity and gas suppliers award grants for community oriented PV and other renewable energy projects. There are also local initiatives supporting PV installations in some parts of the country.

Other policies and initiatives that have affected PV in the UK over 2010 were:

- **Building Regulations:** Building regulations were tightened. Changes to the approved documents (Part L1) in October 2010 provided tighter target emission rates of dwellings and commercial property, providing another avenue for PV to be implemented.



Fig. 4 - 6,16k Wp, Nonnington, Kent, Nu-Sustainable Ltd.



Fig. 5 - Multocrystalline blocks inside a wire saw, PV Crystalox Solar Plc.

- The Code for Sustainable Homes (CODE) – Standards for development of low carbon, and more environmentally sustainable homes, including promoting the role of renewable technologies. The CODE was launched in December 2006. CODE level increases for social housing developers.

R & D, D

UK RD&D funding encompasses a broad array of measures from fundamental research through to industry development and 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.

The approach to research in the UK is similar to that of Germany, the US and Japan where there is more emphasis on central research facilities for PV.

At national level, the Engineering and Physical Sciences Research Council (EPSRC), the Department for Business, Innovation and Skills (BIS), the Technology Strategy Board (TSB) and the Carbon Trust are the four prominent bodies enabling Research in the UK, in terms of finance, capacity building, information dissemination and information exchange.

These organisations and a handful of other UK Government departments support a large number of energy research and innovation programmes. These range from incubation research, development and pilot scale demonstration, through to capital grants assisting full scale deployment of near-market technologies.

The UK Energy Research Centre (UKERC) Research Register provided by the Science and Technology Facilities Council details solar sector research activities that are publicly funded – the details are available at <http://ukerc.rl.ac.uk>.

The push for zero carbon homes has stimulated research in incorporation of PV into buildings, raising efficiency and lowering maintenance requirements of systems. A private entity Corus

Colors, the Low Carbon Research Institute and the Welsh Assembly Government have collaborated to form an institution named the Sustainable Building Envelope Centre in North Wales. Their aim is to develop energy generating technologies that are also the fabric of the building.

INDUSTRY

There are four prominent manufacturers in the UK related to PV: PV Crystalox Solar, Sharp, Romag and GB-SOL.

PV Crystalox Solar manufactures silicon ingots in Oxfordshire. The company has a formidable output of multicrystalline silicon ingots. Production had risen 46 % in 2010 to 350 MW, with approximately 75 % of the ingots being exported to Asia, and the remaining 25 % shipped to Europe. Production capacity of the plant is currently 500 MW.

Sharp's plant in North Wales 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.

Romag in Northern England is an established specialist glass company serving a number of sectors including solar PV. Their products 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 is a relatively small company based in South Wales, which manufactures bespoke solar modules 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 based on anodised aluminium sheets.

The register of solar PV installer companies listed on the Micro-generation Certification Scheme (MCS) website identifies 1 338 MCS certificated installation companies throughout the UK. This number has increased considerably since the advent of the FITs in April 2010. See <http://www.microgenerationcertification.org/mcs-consumer/installer-search.php>

MARKET DEVELOPMENTS

The cumulative installed PV capacity had risen to 29,6 MWp at the close of 2009. A shortage of supply of inverters and modules in 2010 has meant that fewer installations have taken place than planned, although the UK has seen a huge leap forward in installations regardless of the logistics issues. The interest in FITs has meant a larger number of installations being planned and installed despite the difficulties faced by installers to find products. Figures for 2010 are not yet available.

According to the Office of Gas and Electricity Markets (OfGEM), the UK's electricity ombudsmen, there were also 6 500 new photovoltaic installations registered between 1 April 2010 and 30 September 2010, representing approximately 23 MWp of newly installed capacity to the same date. Should this trend prevail, the UK could see figures in the region of 75 to 80 MWp of total cumulative installed capacity to the end of 2010.

FUTURE OUTLOOK

There may be some changes to the UK Carbon budgets due to the continually changing factors and drivers. The Government will propose draft legislation for the fourth budget in Spring 2011.

The potential introduction of the Renewable Heat Incentive previously outlined, may stimulate the PVT industry a little. Changes to the Building Regulations (Part L1) in October 2010 will provide another avenue for PV to be implemented, although more influencing will be the raised mandatory levels of the Code for Sustainable Homes, which will also enable the promotion of all renewable technologies, especially within developments of the social housing industry.

Green Investment Bank: The Government states that they will provide 2 000 MGBP in funding for a green investment bank, as part of efforts to make the UK a leader in the low-carbon economy. The Green Party, a small opposition party, is advocating a need for a three-fold increase in this funding.

DECC and HMT have published proposals [7] to reform the electricity market to help deliver security of supply and the decarbonisation of the electricity sector. These proposals incorporate all four of the Coalition Agreement commitments relating to this area, which will be judged against the published criteria of cost-effectiveness, durability, practicality, and coherence:

- Feed in Tariffs;
- Carbon price support;
- Emissions Performance Standard; and
- Capacity payments.

The aim of the Electricity Market Reform programme is to undertake fundamental reforms to the electricity market to ensure the UK can attract the investment needed to meet its carbon emission reductions targets and have a secure, affordable supply of electricity towards the end of this decade and in the longer-term.

The consultation closes on the 10 March 2011 and will be followed by a White Paper. DECC's intention is to legislate for the reforms

before the end of Parliament to encourage new investment to come forward during the remainder of this decade.

On 12th July 2010, the Government announced a consultation on a new Microgeneration Strategy. This Strategy will look forward to 2020 and cover England only, and seeks to tackle the non financial barriers to the development of microgeneration technologies, including PV. It seeks views on four key areas: quality, skills, technology development and information/advice. Rather than follow recent practice and produce a document on which interested parties can comment, DECC invited those with the greatest knowledge and expertise in the field to contribute to the development of a consultation document which was published on 22 December 2010. The consultation closes on 16 March 2011.

2011 is set to see the largest uptake of photovoltaics in the UK, as knowledge of the FIT scheme and its financial advantages becomes more widespread. The Government has indicated that it was looking to cut payments from the FIT to large-scale PV. If this policy is implemented, it may hamper the progression of UK PV. If the FIT remains as it is, the local planning teams will certainly see more applications for PV farms, however, the UK Government has made clear that they do not want large greenfield-based solar farms to distort the available funding for domestic solar technologies. The situation is therefore likely to be reviewed to ensure this is not the case going forward.

In short, there are many to stimulate renewable energy in the UK with the FIT being the most influential by far. Although total installed PV capacity in the UK has doubled in the first 6 months due to the FIT, the PV industry believes the public needs to be well informed of its availability, merits and demerits. Solar PV will have a role to play in the coming years, and in 2010 has shown itself to be a potentially influential technology in the UK, providing it is given a helping hand.

Endnotes:

- [1] *Climate Change Act, found at:*
<http://www.statutelaw.gov.uk/content.aspx?LegType=All+Legislation&title=climate+change&Year=2008&searchEnacted=0&extentMatchOnly=0&confersPower=0&blanketAmendment=0&sortAlpha=0&TYPE=QS&PageNumber=1&NavFrom=0&parentActiveTextDocId=3539938&ActiveTextDocId=3539942&filesize=7840> accessed 19/05/09
- [2] *DECC website found at:*
http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/ored/uk_action_plan/uk_action_plan.aspx accessed 13/12/10
- [3] <http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/ored/25-nat-ren-energy-action-plan.pdf> page 114
- [4] <http://www.ofgem.gov.uk/Sustainability/Environment/fits/Newsletter/Documents1/FIT%20Update%20Issue%202.pdf> page 4
- [5] *Source:*
<http://www.publications.parliament.uk/pa/cm201011/cmhansrd/cm100916/debtext/100916-0001.htm#10091616000017> accessed 7/1/11
- [6] *BRE and Energy Saving Trust*
- [7] *The EMR consultation runs 16 December 2010 – 10 March 2011:*
<http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx>. HMT's consultation on the Carbon Floor Price runs from 16 December 2010 – 11 February 2011: http://www.hm-treasury.gov.uk/consult_carbon_price_support.htm

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 SETP funds projects along the technology pipeline, from Material and Device Concepts to Market Transformation activities.

GENERAL FRAMEWORK

In 2010, the solar PV installations in the United States grew by 92 % compared to 2009, for a total of approximately 900 megawatts (MW) installed this year [1]. The major Federal policy driver of growth in U.S. PV installations was the U.S. Department of Treasury Grant In Lieu of the Investment Tax Credit Program (Sec. 1603), funded through the American Recovery and Reinvestment Act (Recovery Act). This program, where applicants receive a 30 % cash grant for installed PV costs, is intended to make up for the lack of tax equity due to the downturn in the U.S. economy.

To spur additional large-scale solar project development, the U.S. Department of the Interior (DOI) and the U.S. Department of Energy (DOE) announced a comprehensive environmental analysis that identified proposed "solar energy zones" on public lands in six western states most suitable for environmentally sound, utility-scale solar energy production. Also spurring development was the DOE Loan Programs Office, which entered in to several loan guarantees for solar manufacturing and power-generation projects. Awards under this program, which accelerates the domestic commercial deployment and manufacturing of innovative and advanced clean-energy technologies, are also funded through the Recovery Act.

The state- and local-level policy environments in 2010 saw both positive developments and challenges for the solar industry, including the expanded adoption of strong net metering and interconnection rules, aggressive renewable portfolio standards (RPS), as well as legal challenges for both municipal Property Assessed Clean Energy (PACE) programs and state-level feed-in tariffs.

Outside of direct responses to policy, businesses put more emphasis on sustainability, which led to numerous PV installations on Ikea, Kohls, Walmart, and other "big box" stores as well as high-visibility

installations on large sports stadiums in New York, Philadelphia, and Massachusetts. Also in 2010, President Obama announced plans to install solar panels on the White House in Spring 2011, continuing to highlight the commercial readiness of solar.

"SUNSHOT" NATIONAL PROGRAM

DOE accelerates the research, development, and deployment of all solar energy technologies through its Solar Energy Technologies Program (SETP) with 225 MUSD in 2010 and an additional 117 MUSD in funding from the Recovery Act. In 2010, SETP held workshops with industry and other stakeholders to develop a roadmap to reach the goal of 1 USD per watt installed price of PV systems by 2020. Information from these workshops was used to develop the "dollar-a-watt" or "SunShot" initiative, whose main objective is to enable solar energy to achieve grid parity in the United States without subsidies by the end of the decade, thus becoming competitive with fossil fuel throughout the United States and the world. The SunShot Initiative was formally launched in February 2011 and includes investments by the Advanced Research Projects Agency – Energy (ARPA-E) and the Office of Science. Initial cost targets for the dollar-a-watt target are 0,50 USD/W for modules, 0,10 USD/W for power electronics, and 0,40 USD/W for balance of systems. Throughout 2011, DOE will actively engage industry through additional workshops and will issue additional Funding Opportunity Announcements to meet these aggressive goals. All research programs described below will also be restructured to ensure that they are meeting the SunShot objectives.

RESEARCH, DEVELOPMENT, AND DEMONSTRATION

Photovoltaics Research and Development

To bridge the gap between basic and applied solar research, SETP in 2010 funded the third and final year of the Next Generation

[1] Based on preliminary data from several financial analysts.

program projects – primarily at universities – to develop innovative, revolutionary, and highly disruptive PV approaches. DOE funded more than 20 projects in 11 different areas (see Fig. 2). For example, the University of Delaware worked on the development of a highly efficient, wide bandgap CIS/CIGS technology, which is necessary for polycrystalline tandem devices.

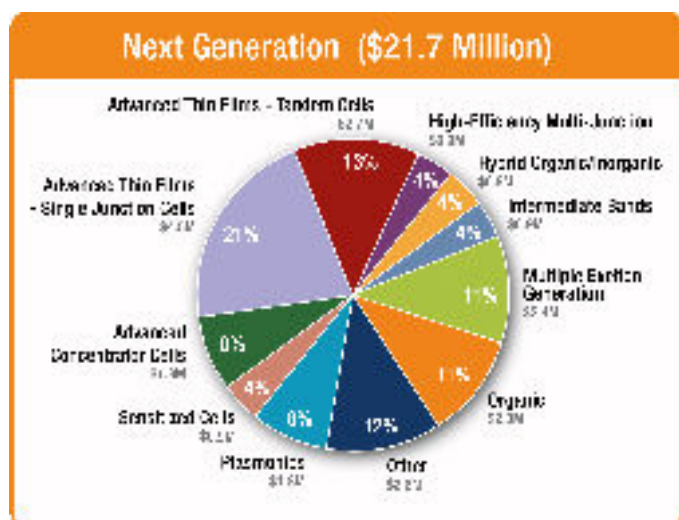


Fig. 2 - In 2010, the U.S. Department of Energy funded more than 20 Next Generation program projects in 11 different areas.

In 2010, SETP also continued to fund domestic PV startups through its PV Incubator Program for promising technologies that have been proven on a laboratory scale and are ready to transition to commercial production. SETP made four new PV Incubator awards to Alta Devices, TeraSun, Solar Junction, and Sempris. Previous awardees, including Innovalight, Abound Solar, and CaliSolar, are rapidly scaling manufacturing capabilities toward hundreds of MW of annual production and the creation of hundreds of new jobs.

Through 24 new Supply Chain and Cross-Cutting technology projects, SETP partnered with industry and universities to develop technologies that provide cost reductions and performance improvements with broad application across the industry and can be adopted directly into the current manufacturing process. These technologies range from a new moisture-resistant polymeric ultra barrier to replace glass, to laser manufacturing techniques and novel solar printing mechanisms.

Currently in its final of three years of funding, the Technology Pathway Partnerships projects have accelerated industry's progress in developing specific system approaches that address total PV system lifecycle costs. Awardee accomplishments included the development by Dow Chemical of a shingle that integrates with asphalt shingle roofs for the residential market; high-performance utility-scale CPV systems by Amonix; and industry's highest performing one sun (non-concentrating) PV system by SunPower.

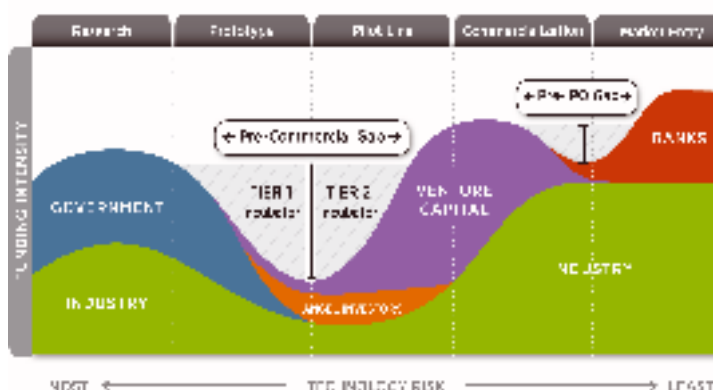


Fig. 3 - PV Incubator projects accelerate commercialization of new manufacturing processes that have been proven at the laboratory scale.

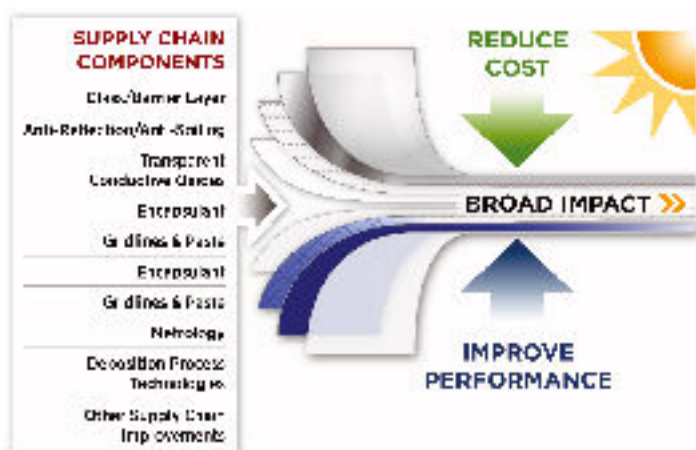


Fig. 4 - Supply Chain projects develop technologies that reduce cost, improve performance, and have broad application across the PV industry.

In 2010, SETP released a Funding Opportunity Announcement for a 5-year, 25 MUSD/year PV Manufacturing Initiative (PVMI) to support the creation of a robust U.S. PV manufacturing base and supply chain, develop a highly trained workforce with the required technical skills, and speed the implementation of new cutting-edge technologies. The initiative intends to accelerate the coordination of stakeholders and fund technology development across the U.S. PV industry. Applicants could apply under either a university-focused topic for industry-relevant research and development projects conducted by universities, or an industry-focused topic for collaborative or facility-based approaches to accelerate the development and implementation of PV manufacturing-related technologies. DOE is planning to fund the PVMI for 125 MUSD over 5 years to allow all awardees to reach financial self-sufficiency. Award winners will be announced in 2011.

Systems Integration

SETP's Solar Energy Grid Integration Systems (SEGIS) project advanced into its third and final stage, with 9.2 MUSD of funding for demonstration of inverters with advanced functionality and



Fig. 5 - The Amonix 7700 Solar Power Generator received an R&D 100 Award for innovation in 2010.

communications to enable high grid-penetration levels for PV systems. Demonstrations were conducted by teams that included utilities and inverter, energy storage, and communications equipment suppliers.

With Recovery Act funding, SETP also continued funding for High Penetration Solar Deployment activities to study the effects of high penetration levels of PV on the electrical grid. Activities by project awardees include developing modeling tools and a database of experience with high-penetration scenarios of PV on a distribution system; developing monitoring, control, and integration systems to enable cost-effective widespread deployment of small modular PV systems; and demonstrating integration of PV and energy storage into Smart Grid applications.

DOE also established a new partnership with the National Oceanic and Atmospheric Administration to advance the utilization of atmospheric and oceanic renewable energy resources in energy generation by improving our understanding of these resources.

U.S. national laboratories continued work on testing and evaluation, component and system reliability, system modeling, and codes and standards. Through the funding of the Solar America Board for Codes and Standards (SolarABCs), SETP conducted research and published findings on wind loading, permitting, and flammability.

Market Transformation

Under its Market Transformation Activities, SETP worked with DOI to complete a draft Programmatic Environmental Impact Statement designed to assess the environmental impacts of utility-scale solar projects on public lands and lands administered by the Bureau of Land Management. This inter-agency initiative was aimed at accelerating the deployment of large-scale solar installations on federal lands in six western states – Arizona, California, Colorado, Nevada, New Mexico, and Utah.

Under the Solar America Communities [2] (SAC) program, DOE used Recovery Act funding to facilitate the development and field testing in 16 cities of innovative financing approaches for distributed PV,

[2] Formerly known as Solar America Cities, this program was rebranded to Solar America Communities in 2010 to recognize the importance of counties as well as cities in furthering solar market development.

including community solar financing, group purchasing, PACE financing, and public-private partnerships between local governments and solar lease/power purchase agreement (PPA) providers. For example, DOE worked with the cities of San Jose, California, and Portland, Oregon, to develop a group purchasing program that resulted in 1.7 MW of PV installed capacity at residential sites throughout these cities. DOE also began work with the City of Seattle, Washington, to implement a community solar program and conducted economic feasibility analyses for the cities of New York City, New York, and Houston, Texas.

Through its SAC program, DOE also issued an updated guide for U.S. communities to provide best practices and aid in PV implementation projects, including best practices for streamlining the solar permitting process and updating building and zoning codes for solar technologies.

IMPLEMENTATION

In addition to support from federal policies and agencies, solar energy also saw significant advances in the adoption of various state and local policy instruments, including improved net metering and interconnection rules, regulatory acceptance of third-party financing models, renewable portfolio standards (RPS), and performance-based incentives. Net-metering activity included a new California law that raised the aggregate cap on net metering from 2.5 % to 5.0 % of a given utility's peak load. West Virginia adopted an improved net-metering policy that raised the capacity limit for commercial and industrial customers to 500 kW and 2 MW respectively, with an overall program capacity of 3 % of utility peak load. Utah improved its statewide interconnection rule by introducing standard interconnection agreements, based on system type, and raising the system capacity limit from 25 kW and 2 MW for residential and non-residential systems to a uniform 20 MW. Meanwhile, by the end of 2010, 19 states plus Puerto Rico explicitly allowed third-party PPA financing, up from only 8 states at the end of 2009.

Colorado raised its RPS to 30 % by 2020 with a solar "set-aside" increased to 3 %. Massachusetts included in its RPS a PV set-aside requiring 400 MW of PV to be installed in-state. In October 2010, Hawaii joined nine other jurisdictions and utilities in the United States that have adopted a feed-in tariff (FIT). The FIT structure employs a three-tier rate schedule differentiated by system capacity and technology, guarantees a fixed rate over a 20-year contract, and sets maximum system size caps by island and by technology. Colorado now allows community net metering or "solar gardens" in investor-owned utility service territory up to 2 MW, while California's Renewable Auction Mechanism will require regulated utilities to procure a minimum of 1,000 MW of capacity from renewable energy projects up to 20 MW in size.

Despite these successes, 2010 also yielded significant challenges for other state and local renewable energy policy instruments. In Florida, for example, four separate incentives for renewable energy expired: a capacity-based solar rebate program, a production-based tax credit,



Fig. 6 – Sempra's 48-MW Copper Mountain Solar Facility in Boulder City, Nevada, became the United States' largest solar power plant in 2010.

a capacity-based investment tax credit, and a sales-tax exemption for renewable energy equipment. Funding for the solar rebate program had been exhausted since mid-2010, with no extensions approved by the state legislature.

The PACE model, whose adoption by local jurisdictions had accelerated in 2009, was dealt a significant setback following a statement in mid-2010 from the Federal Housing Finance Authority (FHFA). As most PACE programs require a priority lien over existing mortgages, the FHFA took the position that such loans present significant risk to lenders and secondary markets. Since the statement's release, local jurisdictions have placed their PACE programs on hold pending further clarification. The legality of feed-in tariffs had also been challenged before the Federal Energy Regulatory Commission (FERC) in proceedings involving the California Public Utilities Commission and three California utilities. A FERC order issued in October resolved the uncertainty by providing clarifying validation, within strict parameters, for a state-level feed-in tariff.

INDUSTRY STATUS

Production

Module shipments, a measure of production, more than doubled in 2010, from 409 in 2009 to 1 049. Although 2010 numbers are not yet available, the following numbers show the percentage of world production by technology produced in the United States: mono-Si – 1 %; poly-Si – 1 %; ribbon Si – 79 %; a-Si – 36 %; CdTe – 13 %; CIS/CIGS – 53 %.

Acquisitions

With the upward trend in acquisitions, it appears that several PV firms are assuring demand for their products by expanding into or acquiring actors in the project development arena. Sharp acquired Recurrent Energy for 305 MUSD and brought in 2 GW of projects under development, including 330 MW under contract. First Solar, with the acquisition of NextLight Renewable Power for 297 MUSD, now has a 2,1 GW contracted utility-scale North American pipeline. SunPower acquired SunRay Renewable Energy's 1,2 GW mostly European pipeline for 277 MUSD.

In addition to expanding in the project development space, several companies made technology acquisitions. For 66 MUSD, MEMC Electronic Materials acquired a 100 % stake in Solaicx, which has a proprietary process to manufacture silicon ingots using the CZ (Czochralski) process. For 20 MUSD, Konica Minolta Holdings Inc. acquired a stake in Konarka Technologies Inc., a U.S. manufacturer of solar cells made of printable organic semiconducting material. For 50 MUSD up front, Advanced Energy Industries acquired PV Powered, a developer and manufacturer of inverters.

MARKET DEVELOPMENT

Despite the recession, U.S. solar PV markets grew by an estimated 92 % to reach 900 MW installed, according to the most recent data from various financial analysts. In 2010, California and New Jersey dominated the installation market, with Nevada, Colorado, New Mexico, Pennsylvania, Arizona, and Florida completing the top eight

state markets. Preliminary market segment data show that commercial-scale projects constituted over 50 % of the market, residential systems about 25 %, and utility-scale projects the remainder.

Notably, 2010 saw accelerated development in the utility-scale solar market. NRG Energy, a wholesale power generator, committed to several utility-scale projects that included modules from PV industry leaders SunPower and First Solar and concentrating solar power tower technology from BrightSource Energy. Other major firms with significant solar projects under development or construction include Edison International, Semptra Energy, NextEra Energy, and Duke Energy. Pacific Gas & Electric Corporation (PG&E) announced a five-year solar PV program to facilitate the development of 500 MW with projects ranging from 1 MW to 20 MWs in PG&E's territory.

In December 2010, Semptra Generation's Copper Mountain Solar Facility in Boulder City, Nevada, became the largest operating PV power plant in the United States, surpassing the 25 MW DeSoto Next Generation Solar Energy Center in Arcadia, Florida. Utilizing First Solar's Cadmium Telluride thin-film PV panels, the 48 MW Copper Mountain plant is located near Semptra's existing 10 MW El Dorado solar power plant, giving the area the capability to generate 58 MW. All power from both facilities is sold to PG&E.

First Solar and SunPower dominated the U.S. utility-scale PV market in 2010, but were not the only contenders, with an estimated 55 different project developers and at least 25 more that have not yet signed any off-take agreements.

FUTURE OUTLOOK

Several financial analysts have projected U.S. PV installations to increase to 2,63 GW per year by 2012. Sustained growth in U.S. installations is likely to be driven by a confluence of factors, including state-level policies, the Grant In Lieu of the Investment Tax Credit (Sec.1603), and the 100 % first-year bonus depreciation for eligible property under the Modified Accelerated Cost-Recovery System (MACRS). Eligibility for both the Sec. 1603 Grant and the 100 % bonus depreciation were set to expire at the end of 2010, but were extended.

With over 600 MW (AC) of new utility-scale projects expected to come under operation in 2011, this sector is expected to dominate the market, growing to close to 50 % of market share. While total megawatts in the residential sector are expected to grow, residential market share is expected to decline to significantly less than 25 %.

Sources of Information for the USA IEA PVPS 2010 Annual Report are:

U.S. Department of Energy

U.S. Department of Energy Solar Energy Technologies Program

Solar Energy Industries Association

National Renewable Energy Laboratory

Interstate Renewable Energy Council

Ernest & Young

Barclays Capital

Greentech Media/GTM Research

PV Technology, Inc.

Navigant

Bloomberg New Energy Finance

Renewable Energy World

Sandia National Laboratories

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.

CONTACT INFORMATION

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COMPLETED TASKS

TASK 3 – USE OF PHOTOVOLTAIC POWER SYSTEMS IN STAND-ALONE AND ISLAND APPLICATIONS

OVERALL OBJECTIVE

Task 3 was established in 1993 to stimulate collaboration between IEA countries in order to improve the technical quality and cost-effectiveness of photovoltaic systems in stand-alone and island applications.

When the first programme (1993–1999) was approved, the stand-alone photovoltaic sector was largely comprised of solar home systems for rural electrification, remote 'off-grid' homes in industrialised countries and PV consumer goods. PV hybrid systems and niche off grid applications such as PV powered bus shelters were also being introduced in certain countries.

As part of this programme, a number of documents were published as information about installed stand-alone PV systems worldwide. These included a lessons learned book featuring case studies from each country, as well as a survey of PV programmes in developing countries.

Task 3's second programme (1999–2004) was initiated against this background with the following overall objectives:

Considering all types of stand-alone photovoltaic systems, ranging from small PV kits to power stations supplying micro-grids, the main objective of Task 3 is to improve the technical quality and cost-effectiveness of PV systems in stand-alone and island applications.

TASK 3 Aimed:

- To collect, analyse and disseminate information on the technical performance and cost structure of PV systems in these applications
- To share the knowledge and experience gained in monitoring selected national and international projects
- To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems
- To contribute to the development of improved photovoltaic systems and subsystems"

The main target audience of Task 3 activities were technical groups such as project developers, system designers, industrial manufacturers, installers, utilities, Quality organisations, training providers, end users.

The 1999–2004 work programme included the following subtasks and activities:

SUBTASK 1: QUALITY ASSURANCE

Activity 11: Critical Review of Implementation of Quality Assurance Schemes

To develop quality assurance schemes that will lead to a warranty for all system installations at reasonable cost.

Activity 12: Technical Aspects of Performance Assessment on Field – Quality Management

To identify and establish practical performance assessment guidelines.

SUBTASK 2: TECHNICAL ISSUES

Activity 21: Hybrid Systems

To contribute to cost reduction through standardisation and modularity in order to facilitate large scale dissemination of PV hybrid systems.

Activity 22: Storage Function

To provide recommendations to decrease the cost of storage in PV and PV hybrid systems.

Activity 23: Load/Appliances : Load Management and New Applications

To provide a technical contribution to cost reduction by showing the cost efficiencies associated with effective load management and efficient appliance selection.

Collaborative activities had to develop knowledge based on project implementations, technological improvements from the equipment manufacturers, R&D programmes results, and feed-back coming from the field.

PUBLICATIONS

Task 3 publications can be downloaded from the IEA PVPS website www.iea-pvps.org and are listed below:

TECHNICAL REPORTS PUBLISHED BY TASK 3 DURING THE PERIOD 1999–2004

TITLE	REFERENCE NUMBER
Survey of National and International Standards, Guidelines and Quality Assurance Procedures for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-07:2000
Recommended Practices for Charge Controllers	IEA-PVPS T3-08:2000
Use of Appliances in Stand-Alone Photovoltaic Systems: Problems and Solutions	IEA-PVPS T3-09:2002
Management of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems	IEA-PVPS T3-10:2002
Testing of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems – Guidelines	IEA-PVPS T3-11:2002
Selecting Stand-Alone Photovoltaic Systems – Guidelines	IEA-PVPS T3-12:2002
Monitoring Stand-Alone Photovoltaic Systems: Methodology and Equipment – Recommended Practices	IEA-PVPS T3-13:2003
Protection Against the Effects of Lightning on Stand-Alone Photovoltaic Systems – Common Practices	IEA-PVPS T3-14:2003
Managing the Quality of Stand-Alone Photovoltaic Systems – Recommended Practices	IEA-PVPS T3-15:2003
Demand Side Management for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-16:2003
Selecting Lead-Acid Batteries Used in Stand-Alone Photovoltaic Power Systems – Guidelines	IEA-PVPS T3-17:2004
Alternative to Lead-Acid Batteries in Stand-Alone Photovoltaic Systems	IEA-PVPS T3-18:2004

SCOPE FOR FUTURE ACTIVITIES

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, "PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website:

www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities:

Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

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COMPLETED TASKS

TASK 5 – GRID INTERCONNECTION OF BUILDING INTEGRATED AND OTHER DISPERSED PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 5 was to develop and verify technical requirements, which served as the technical guidelines for grid interconnection with building-integrated and other dispersed PV systems. The development of these technical requirements included safety and reliable linkage to the electric grid at the lowest possible cost. The systems to be considered were those connected with a low-voltage grid, which was typically of a size between one and fifty peak kilowatts. Task 5 was officially concluded in 2003.

MEANS

Participants carried out five subtasks; Subtasks 10, 20, 30, 40 and 50 in order to achieve these objectives. The objectives of each subtask were as follows:

SUBTASK 10: Review of Previously Installed PV Experiences (From 1993 to 1998)

To review existing technical guidelines, local regulations and operational results of grid interconnection with building-integrated and other dispersed PV systems to aid Subtask 20 in defining existing guidelines and producing concepts for new requirements and devices.

SUBTASK 20: Definition of Guidelines to be Demonstrated (From 1993 to 1998)

Utilizing the results of Subtask 10 and a questionnaire, existing technical guidelines and requirements to be demonstrated will be defined, and concepts for new requirements and devices will be developed; with safety, reliability, and cost reduction taken into consideration.

SUBTASK 30: Demonstration Test Using Rokko Island and/or Other Test Facilities (From 1993 to 1998)

To evaluate, by demonstration tests, the performance of existing and new technical requirements and devices defined in Subtask 20.

SUBTASK 40: Summarizing Results (From 1993 to 2001)

To summarize the results of Task 5 and to produce a general report for all participating countries of Task 5, as well as for the ExCo members.

SUBTASK 50: Study on Highly Concentrated Penetration of Grid Interconnected PV Systems (From 1999 to 2001)

To assess the net impact of highly concentrated PV systems on electricity distribution systems and to establish recommendations for both distribution and PV inverter systems in order to enable widespread deployment of solar energy.

TASK 5 REPORTS AND WORKSHOP PROCEEDINGS:

Task 5 produced the following reports and workshop proceedings:

Task 5 Reports

1. "Utility aspects of grid interconnected PV systems", IEA-PVPS T5-01: 1998, December 1998
2. "Demonstration tests of grid connected photovoltaic power systems", IEA-PVPS T5-02: 1999, March 1999
3. "Grid-connected photovoltaic power systems: Summary of Task V activities from 1993 to 1998", IEA-PVPS T5-03: 1999, March 1999
4. "PV system installation and grid-interconnection guideline in selected IEA countries", IEA-PVPS T5-04: 2001, November 2001
5. "Grid-connected photovoltaic power systems: Survey of inverter and related protection equipments", IEA-PVPS T5-05: 2002, December 2002

6. "International guideline for the certification of photovoltaic system components and grid-connected systems", IEA-PVPS T5-06: 2002, February 2002
7. "Probability of islanding in utility networks due to grid connected photovoltaic power systems", IEA-PVPS T5-07: 2002, September 2002
8. "Risk analysis of islanding of photovoltaic power systems within low voltage distribution networks", IEA-PVPS T5-08: 2002, March 2002
9. "Evaluation of islanding detection methods for photovoltaic utility-interactive power systems", IEA-PVPS T5-09: 2002, March 2002
10. "Impacts of power penetration from photovoltaic power systems in distribution networks", IEA-PVPS T5-10: 2002, February 2002
11. "Grid-connected photovoltaic power systems: Power value and capacity value of PV systems", IEA-PVPS T5-11: 2002, February 2002

Task 5 Internal Reports (Open to Public)

1. "Grid-connected photovoltaic power systems: Status of existing guidelines and regulations in selected IEA member countries (Revised Version)", IEA-PVPS V-1-03, March 1998
2. "Information on electrical distribution systems in related IEA countries (Revised Version)", IEA-PVPS V-1-04, March 1998

Proceedings of Final Task 5 Workshop

1. Introduction and table of contents
2. Flyer of the workshop
3. List of participants of the workshop
4. Final programme of the workshop
5. Key note speech
6. Islanding detection methods
7. Probability of islanding in power networks
8. Risk analysis of islanding
9. Conclusions of task V islanding studies
10. Recapitulation of first day
11. Overview of (inter)national interconnection guidelines for PV-systems
12. State of the art inverter technology and grid interconnection
13. Impacts of PV penetration in distribution networks
14. Power value and capacity of PV systems

DELIVERABLES – Where to get them?

All reports are available for download at the IEA PVPS website: <http://www.iea-pvps.org>

A Task 5 CD-ROM including all the reports was published for distribution. This can be ordered at the contact address below.

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COMPLETED TASKS

TASK 6 – DESIGN AND OPERATION OF MODULAR PHOTOVOLTAIC PLANTS FOR LARGE SCALE POWER GENERATION

OVERALL OBJECTIVE

Task 6 officially completed its activities in May 1998. The main objective of this Task was to further develop large-scale modular photovoltaic plants for peaking and long-term baseload power generation in connection with the medium-voltage grid.

MEANS

The Task 6 work was performed by structural engineers and PV industry experts. The work was structured into four sub-tasks, for a total of fifteen activities.

SUBTASK 10: Review of Design and Construction Experiences of Large-Scale PV Plants

To perform, on the basis of the Paestum Workshop results, an in-depth review of existing large-scale PV plants aimed both to identify the remarkable technical solutions adopted in such plants and the main common criteria applied for their design, installation, operation, monitoring, and to perform a detailed cost analysis of the plants taken into account.

SUBTASK 20: Review of Operational Experiences in Large-Scale PV Plants

To perform, also utilising the work in progress of Subtask 10 and on the basis of the Paestum Workshop results, an in-depth review of operational experiences in existing large-scale PV plants. The analysis of the acquired data was focused on the comparison between the expected and actual results, both technical and economical; the information flow was continuously updated through acquisition of data from all the plants in operation.

SUBTASK 30: Development of Improved System Design and Operational Strategies for Large-Scale PV Plants

Based on the work of Subtasks 10 and 20, the evaluation work, together with the information gathering activity, let the assessment of most appropriate, innovative technical options for modular design of large-scale PV plants. Both PV and BOS components were dealt with, taking into account: performances improvement, costs reduction, and realisation simplification.

The co-operation among utilities and industries of many countries offered the opportunity to review in detail the performance data and the technical aspects which determined the design approach of the largest PV plants in the world, and to develop improved system design, and operational strategies for such plants.

SUBTASK 40: Outlook of Perspectives of Large-Scale PV Plants

Based on the assumption that large grid connected PV power plants have proven their applicability under the technical point of view, the Subtask was aimed at identifying the path in order to let such plants become a substantial option and play an increasing role in a future oriented energy concept in OECD countries, as well as in developing countries.

TASK 6 REPORTS AND WORKSHOP PROCEEDINGS

Task 6 produced the following reports and workshop proceedings from 1993 to 1998:

1. The Proceedings of the Paestum 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 Deployment Strategies for Photovoltaics in the Built Environment, R. Haas, Technische Universität Wien, 2002. To be ordered at Technische Universität Wien, AT, Fax: +43 1 588 013 7397
6. Innovative electric concepts, H. Wilk, Energie AG, 2002. To be ordered at Energie AG, AT, Fax: +43732 9000 3309
7. Reliability of Photovoltaic Systems, H. Laukamp, Fraunhofer Institute für Solar Energiesysteme, 2002. To be ordered at Fraunhofer Institute für Solar Energiesysteme, GE, Fax: +49 761 4588 217
8. PV/Thermal Solar Energy Systems, Status of the Technology and Roadmap for future Development, H. Sorensen, Esbensen Consulting, 2002, To be ordered at Esbensen Consulting Engineers, DK, Fax: +45 33 26 73 01
11. Executive Summary Report - Non-technical Barriers to the commercialisation of Photovoltaic Power in the Built Environment, P. Eiffert, National Renewable Energy Laboratories, to be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance

DELIVERABLES – Where to get them?

All reports are available for download at IEA PVPS

website: www.iea-pvps.org.

In addition, all reports and many other deliverables are summarized on CD-ROM, which can be ordered at Novem, The Netherlands.

Task 7, Project Results and Documents.

To be ordered at:

Novem, Publication Centre

PO Box 8242

3503 RE Utrecht

The Netherlands

Tel.: +31 30 2393493

Email: publicatiecentrum@novem.nl.

Task 7 book: Designing With Solar Power"

To be ordered at:

The Images Publishing Group Pty Ltd

6 Bastow Place

Mulgrave, Victoria 3170, Australia

PARTICIPANTS

In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

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Task 7 website: www.task7.org

Task 7 demosite: www.demosite.ch

PV Projects database: www.pvdatabase.com

COMPLETED TASKS

TASK 10 – URBAN SCALE PV APPLICATIONS

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.

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.

MEANS

There were 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 contributed to achieving the vision of mainstreaming urban-scale PV. Targeted stakeholders were the:

- **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.**

SUBTASK 1: Economics and Institutional Factors

This subtask provided 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 could be used to create scenarios which combined all stakeholder values to the PV system investor through sustained policy-related market drivers.

SUBTASK 2: Urban Planning, Design and Development

This subtask focused on infrastructure planning and design issues needed to achieve the vision of a significantly increased uptake of PV in the urban environment. The subtask worked to 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 concentrated 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 involved the potentially negative impact on the grid and obstacles posed by the regulatory framework. The aim of this subtask was to demonstrate best practices and to advocate overcoming those barriers associated with extensive penetration of BIPV systems on urban scale. The deliverables focused 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 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.pydatabase.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 ITA

DELIVERABLES – WHERE TO GET THEM?

All reports are available for download at the IEA PVPS website:

<http://www.iea-pvps.org> and the Task 10 website: <http://www.iea-pvps-task10.org>

PARTICIPANTS

Fifteen PVPS members supported Task 10 activities:

Australia, Austria, Canada, Denmark, France, Italy, Japan, Korea, Malaysia, European Union, Norway, Portugal, Sweden, Switzerland and the USA. Moreover, through PV-UP-Scale, Germany, The Netherlands, Spain and the United Kingdom made contributions to Task 10 work.

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ANNEX A

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National Status Reports

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