IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS annual report 2012

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2012

COVER PHOTO AND ABOVE:

Solar façade at an office building in Sursee, LU, Switzerland.

An 18 kWp solar façade with 180 m² over all generates about 12 600 kWh per year.
This PV system was built with Megasol mono-crystalline modules and Kostal inverters.

Architect and Owner: BF berger + frank ag, Sursee, Switzerland.
Planned and installed by: Schürch-Egli AG, Sempach, Switzerland.

Photo by: BF berger + frank ag.

CHAIRMAN'S MESSAGE

I am pleased to present the IEA Photovoltaic Power Systems Programme's 2012 annual report. 2012 has been a very dynamic and challenging year for the photovoltaic sector: The rapid cost reduction of photovoltaic power systems has continued throughout the year, leading to the emergence of new markets and market models on the one hand. The market has continued to grow but at a slower pace than in the years before. At the end of 2012, about 100 GW of photovoltaics were installed worldwide, with contributions up to 6 % of the electricity supply of some countries. The photovoltaic industry, on the other hand, has had the most difficult time of its young history, leading to a marked consolidation of the sector.

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 and performance assessment, cost reduction, best practice in various applications, rapid deployment of photovoltaics and key issues such as grid integration and environmental aspects. 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 constantly expanding. At the same time, IEA PVPS continuously needs to review its priorities and activities in order to provide a maximum of added value through international cooperation in the rapidly changing field of photovoltaics.

2012 marked the last year of the 4th 5-year term of IEA PVPS, thus representing 20 years of global international cooperation within IEA PVPS. Throughout the year, a new strategy was developed for the 5th term 2013 – 2017 of IEA PVPS, taking into account the profound changes of the sector and the very different position of photovoltaics compared to five years ago. Over the next five years, the focus and the activities of the PVPS Programme will move closer to market related issues, both technical and non-technical, capitalizing on the many experiences meanwhile available and striving for a further sustainable development and implementation of photovoltaic technology.

Interest and outreach for new membership within IEA PVPS continued in 2012. Belgium has joined the PVPS Programme as the 27th member during the year. Moreover, the Copper Alliance has very recently joined IEA PVPS as the 28th member, thereby introducing a new industrial dimension to our members. I welcome Belgium and the Copper Alliance as the most recent IEA PVPS members and look forward to a long and fruitful cooperation. Membership negotiations are also underway with Thailand. Contacts have continued with Greece, India, New Zealand, Singapore and South Africa as well as with EPRI (Electric Power Research Institute USA) and ECREEE (ECOWAS Regional Centre for Renewable Energy and Energy Efficiency). IEA PVPS continues to cover the majority of countries active in development, production and installation of photovoltaic power systems.

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 and workshops at the industry exhibition of the 27th European Photovoltaic Solar Energy Conference in Frankfurt (Germany), Solar Power International in Orlando, Florida (USA), as well as the 22nd International Photovoltaic Science and Engineering Conference PVSEC-22 in Hangzhou (China), attracted a large number of visitors and provided an excellent forum for dissemination purposes. I had the honour to chair the 27th European Photovoltaic Solar Energy Conference in Frankfurt on behalf of IEA PVPS. This contributed to the visibility of IEA PVPS which was underlined with three successful PVPS workshops held in the conference's programme of side events.

The detailed outcomes of the different PVPS projects are given in the Task reports of this annual report and all publications can be found at the PVPS website. The current status of photovoltaics in the PVPS member countries is described within the country section of this annual report.

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

S. Nowak

Stefan Nowak
Chairman

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA PVPS Executive Committee, Hangzhou, China, November 2012.

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 2012, fourteen Tasks were established within the PVPS programme, of which six are currently operational.

The twenty-seven PVPS members are: Australia, Austria, Belgium, Canada, China, Denmark, EPIA, European Union, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, SEIA, 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. The Solar Energy Industry Association (SEIA) joined PVPS in 2011 and Belgium joined PVPS in 2012.

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

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-domesticappli-cations, 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. (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 comingperiod. 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 – PVPower Update newsletter is based on the PVPS programme's results and activities, as well as key policy and programme information from its participating members.

OVERALL OBJECTIVE

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. These reports are available from the PVPS public website and are a key component of the collaborative work carried out within the PVPS Programme. The responsibility for these national reports lies firmly with the national teams. Task 1 participants share information on how to most effectively gather data in their respective countries including information on national market frameworks, public budgets, the industry value chain, prices, economic benefits, new initiatives including financing, electricity utility interests, standards and codes, and an overview of R&D activities.

The *Trends* report presents a broader view of the current status and 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 editorial group within Task 1 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. From 1995 until the end of 2012, seventeen issues of *Trends* have 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. More recently the newsletter was called *PVPower Update*. Task 1 participants provided material of interest to the newsletter editor and ensured that the newsletter reached its target audience in the respective countries. From 2013 this activity will be incorporated in the website activities.

Thirty seven issues of the newsletter have been published by the end of 2012.

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.

Fig. 2 – Mr. Ruggero Schleicher presented, "How Renewables will Change Electricity Markets," at the Task 1 Workshop, "Assigning a Fair Price to Photovoltaic Electricity, 27th EUPVSEC, Frankfurt, Germany, September 27, 2012.

Fig. 3 – Trends in Photovoltaic Applications – Survey Report of Selected IEA Countries between 1992 and 2011; Report IEA-PVPS T1-21:2012.

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, PV in tomorrow's electricity grids – problem or panacea?, Driving future PV deployment – electricity utility business models and Assigning a fair price to photovoltaic electricity. 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 2012

A key Task 1 priority is to meet 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.

SUBTASK 1.1: Status Survey Reports

Full national survey reports for calendar year 2011 were received from most participating countries during 2012, as required by the Programme.

The 17th issue of the *Trends in Photovoltaic Applications* report was published in September 2012. Electronic versions of the information, including a Trends Preview, were made available progressively on the public website and conference papers were developed based on the *Trends* report information.

Almost 28 GW of PV capacity were installed in the IEA PVPS countries during 2011 - about double the amount as in the previous year. This brought the cumulative installed capacity to 63,6 GW. By far the greatest proportion (60 %) was installed in Italy and Germany alone. If China, the US, Japan and France are also included, then over 86 % of PV installations in 2011 occurred in six countries. Continued dramatic growth of annual grid-connected PV installations was evident, with significant growth of the annual market in a number of the largest markets. Nine (almost 11) countries rank in the GW cumulative installed PV capacity grouping (up from five the previous year). Nine countries have, or are close to achieving, annual markets exceeding 1 GW. Total PV cell production for 2011 in the IEA PVPS countries is estimated to be 29,9 GW, a 70 % increase from the previous year and around 80 % of global PV cell production. China was the lead producer of PV cells in 2011, manufacturing around 20 GW of cells, double the amount manufactured in China in 2010. Other PVPS countries manufacturing at the GW scale in 2011 include Germany with 2,5 GW, Japan with 2,7 GW, Malaysia with an estimated 2 GW, South Korea with 1 GW and the US with 1,1 GW. Taiwan produced 4,3 GW of PV cells; other major non-PVPS countries manufacturing PV cells are the Philippines, Singapore and India.

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, *PVPower Update* #37, was published in time for the EUPVSEC conference and highlighted recent achievements as well as looking forward at the future of PVPS. Current and back issues of the newsletter are available on the public website.

SUBTASK 1.3: Special Information Activities

A Task 1 workshop was developed for the EUPVSEC 2012 held in Frankfurt. The title for this workshop was "Assigning a fair price to photovoltaic electricity" and it addressed the plethora of PV support ideas currently being discussed – FiTs, net metering issues, self-consumption regulation and rewards and so on. All presentations can be found on the PVPS website www.iea-pvps.org and participation was at a healthy level of 100+ persons. Another workshop was developed by the Chinese Task 1 members, in Hangzhou, China in November 2012 in conjunction with the PVSEC. Task 1 input, and PVPS involvement in general, was significant and delegates were able to hear the latest information on international PV collaboration and market developments worldwide. All presentations were made available from the PVPS website.

Fig. 4 – The www.iea-pvps.org website provides access to the outputs of the PVPS programme.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2013

Task 1 activities will continue to focus on development of quality information products and effective communication mechanisms in support of the PVPS communication strategy. Further, Task 1 has identified a general goal of providing assistance to policy makers and others by actively identifying market support solutions that can last for 5-10 years, and provide win/win/win scenarios (for customers/ investors, electricity utilities and governments). In addition, Task 1 will continue to progress ideas for future PVPS work arising from the PVPS strategy development process – in particular, enhancing the understanding of the value of PV in electricity markets, and elaborating the environmental aspects of PV.

SUBTASK 1.1: Status Survey Reports

The deadline for receiving the next National Survey Reports (NSRs) is April 2013 – earlier than previously. These will all be made available via the public website.

The target date for publication of the 18th issue of the *Trends in Photovoltaic Applications* report is August 2012. Electronic versions of the information will be made available progressively on the public website. 'Country pages' will be published first and then be updated in April with more reliable data from draft NSRs to form the Trends Preview (also published on the website). Conference papers will also be developed as in previous years.

SUBTASK 1.2: PVPS News

The newsletter in its old format has been discontinued and it is planned to incorporate a PVPS news function in the website. It is also planned that one-pagers (fact sheets), report summaries, contributed articles and press releases will all contribute to the PVPS outreach efforts from 2013.

SUBTASK 1.3: Special Information Activities

Task 1 (perhaps in conjunction with another Task and/or others) plans to develop workshops for EUPVSEC in Paris in early October 2012 and PVSEC in Taiwan, later in 2012.

Other specific topics that continue to receive attention from the Task 1 group include the evolution of the global PV market and the non-technical issues (particularly financial, policy, regulatory and new business) associated with large-scale deployment of PV. Eventually, some of these may be developed into new PVPS activities, feature in the various outreach products being developed or be addressed as workshop topics.

INDUSTRY INVOLVEMENT

Task 1 activities continue to rely on close co-operation with government agencies, PV industries, electricity utilities and other parties, both for collection and analysis of quality information and for dissemination of PVPS information to stakeholders and target audiences. This is achieved through the networks developed in each country by the Task 1 participants.

KEY DELIVERABLES (2012 AND PLANNED)

The following were published and also made available on the public website during 2012:

Trends in photovoltaic applications in selected IEA countries between 1992 and 2011.
Report IEA-PVPS T1-21: 2012 (plus papers, poster at the EUPVSEC and PVSEC conferences).
PVPower Update issues 36 and 37.

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 2013 it is planned to produce the eighteenth issue of the *Trends in Photovoltaic Applications* report and a range of country, workshop and special interest information. The website will continue to be developed during 2013. New outreach products will be developed and published.

MEETING SCHEDULE (2012 AND PLANNED 2013)

The 37th Task 1 meeting was held in Stockholm, Sweden, 20-21 April 2012 in conjunction with a Swedish/PVPS Task 1 workshop and a PVPS strategy development meeting (both involving the active participation of Task 1 members).

The 38th Task 1 meeting was held in Aarhus, Denmark, 21-22 September 2012.

The 39th Task 1 meeting will be held in Vienna, Austria, 18-20 February 2013.

The 40th Task 1 meeting is being planned for Korea in the week beginning 4 November 2013, immediately following the planned PVSEC in Taiwan.

TASK 1 PARTICIPANTS IN 2012 AND THEIR ORGANIZATIONS

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

COUNTRY	NAME	ORGANIZATION
Australia	Greg Watt	Australian PV Association
Austria	Hubert Fechner	University of Applied Sciences, Technikum Wien
Belgium	Gregory Neubourg	APERe
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 Photovoltaic Industry Association	Marie Latour	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	RSE SpA
Japan	Osamu Ikki	RTS Corporation
Japan	Izumi Kaizuka	RTS Corporation
Japan	Akiko Murata	RTS Corporation
Korea	Chinho Park	Ministry of Knowledge Economy R&D Programme, KETEP
Malaysia	Wei-nee Chen	SEDA
Malaysia	Gladys Mak	SEDA
Mexico	Jaime Agredano Diaz	IIE
Netherlands	Otto Bernsen	NL Agency, Directorate Energy and Climate Change
Norway	Fritjof Salvesen	Asplan Viak AS
Norway	Lars Bugge	Asplan Viak AS
Portugal	Pedro Paes	EDP
Solar Electric Power Association	Tom Nicholas	SEPA
Solar Energy Industry Association	Justin Baca	SEIA
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Johan Lindahl	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
Turkey	Mete Cubukcu	Solar Energy Institute, Ege University
Turkey	Metin Colak	Solar Energy Institute, Ege University
United Kingdom	Paul Rochester	Department of Energy and Climate Change
United States of America	Carol Anna	NREL

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

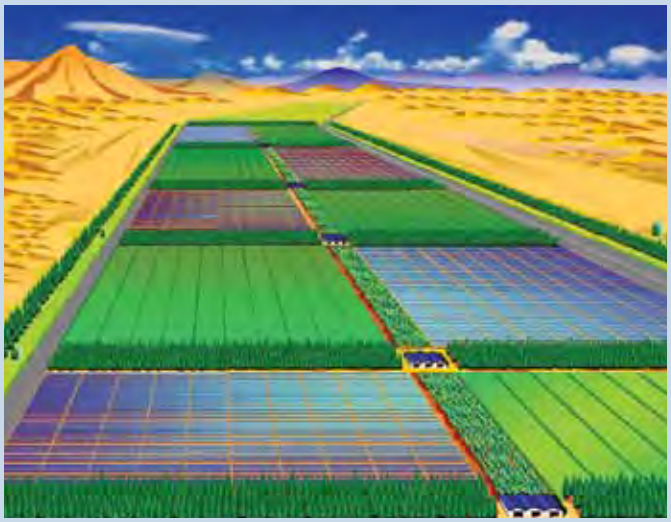


Fig.1 - Image of a VLS-PV System in a Desert Area.

Fig. 2 - 27th Task 8 Meeting in Madrid, Spain, April 2012.

OVERALL OBJECTIVES

The objective of Task 8 is to examine and evaluate the potential and feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) systems, which have a capacity ranging from over multi megawatt to gigawatt, and develop practical project proposals toward implementing VLS-PV projects in the future.

Task 8 has recognised that states/governments all over the world consider solar power plants as a viable option for their energy electrical power supply. However, to accelerate and implement real VLS-PV projects, decision-makers should be informed on the feasibility of such projects in an appropriate manner, and Task 8 can/should contribute to achieving this vision.

Based on our previous results and changes of the market environment, Task 8 has developed the extended Workplan during 2012-2014, which includes three Subtasks as noted below:

Subtask 2: Case Studies for Selected Regions for Installation of VLS-PV System on Deserts
Subtask 6: Future Technical Options for Realizing VLS-PV Systems
Subtask 7: VLS-PV Vision, Strategy and Communication

Under the Workplan, through active disseminations and communications with stakeholders, VLS-PV vision and strategy shall be developed. Requirements for VLS-PV system to integrate with energy network, in the near-term and mid- & long-term shall be clarified, as well. As eventual conclusions, suggestions/ recommendations/drafts of how to overcome hurdles/ barriers, from technical and non-technical viewpoints shall be proposed for accomplishment of VLS-PV project.

SUMMARY OF TASK 8 ACCOMPLISHMENTS FOR 2012

Task 8 started the extended Workplan for 2012-2014 and, through Task 8 meetings and e-mail communications, discussed working items to be implemented in detail.

Also, Task 8 published the latest report: "Energy from the Desert: Very Large Scale Photovoltaic Power – State-of-the-Art and into the Future," and performed its dissemination actively.

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

Employing the concepts of VLS-PV and the criteria and other results produced under other subtasks, Task 8 participants have been undertaking case studies on VLS-PV systems for the selected regions and evaluating the resulting effects, benefits and environmental impact. Feasibility and potential of VLS-PV on deserts will be evaluated from viewpoints of local, regional and global aspects.

The following case studies are carried out:

- Environmental aspects, including biodiversity, of VLS-PV;
- Business model based on local assembly of CPV and conventional PV modules.

As for the environmental aspects of VLS-PV systems, Task 8 has carried out information exchange and collaborative work with Task 12.

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

Various technical options for implementing VLS-PV systems will be proposed and analysed. From the viewpoint of future electrical grid stability, a global renewable energy system utilizing globally dispersed VLS-PV systems as the primary electrical energy source will be also analyzed. To clarify requirements for VLS-PV system to integrate with the energy network in the near-term and mid-&long-term, combination with other renewable energy technologies or energy sources shall be discussed, as well.

Fig. 3 – 28th Task 8 Meeting in Arnstadt, Germany, September 2012.

The following items are discussed:

- Technical options for the entire energy system: Combination with other renewable energy technologies; Solar hydrogen, methane, etc., as storage technologies; VLS-PV as part of Super-Grids, e.g. competitive edge;
- Energy storages & transmission technology: VLS-PV power output intermittence and prediction issues; VLS-PV storage, transmission and energy use;
- Surveying VLS-PV trends: Lessons Learnt from existing large scale PV plants.

There shall be potential items to make a communication with Task 13 (operation and reliability of large scale PV systems) and Task 14 (grid-connection of large scale PV systems).

SUBTASK 7: VLS-PV Vision, Strategy and Communication

Based on the previous results and the changing market environment, Task 8 participants shall perform active dissemination and communication with stakeholders to develop VLS-PV vision and strategy. A possible approach and enabler to achieve the vision and implement the strategy shall be developed and identified, as well. For accomplishment of the Task 8 activity, suggestions/ recommendations/drafts of how to overcome hurdles/ barriers, from technical and non-technical viewpoints shall be proposed.

The following items are discussed:

- VLS-PV vision until 2030: Reviewing and refining Task 8 results since established; Generating clear messages for stakeholders;
- Communication with stakeholders, and obtaining feedbacks: Identification of target stakeholders: different approaches corresponding to knowledge level and experiences of LS-PVs/ Task 8; Developing summaries for the financial sector, politicians/governments, utilities and IPPs, etc.; Marketing to specific regions and countries (& translating the summary into such regions/countries' languages):
- 'ESTEEM' approach.

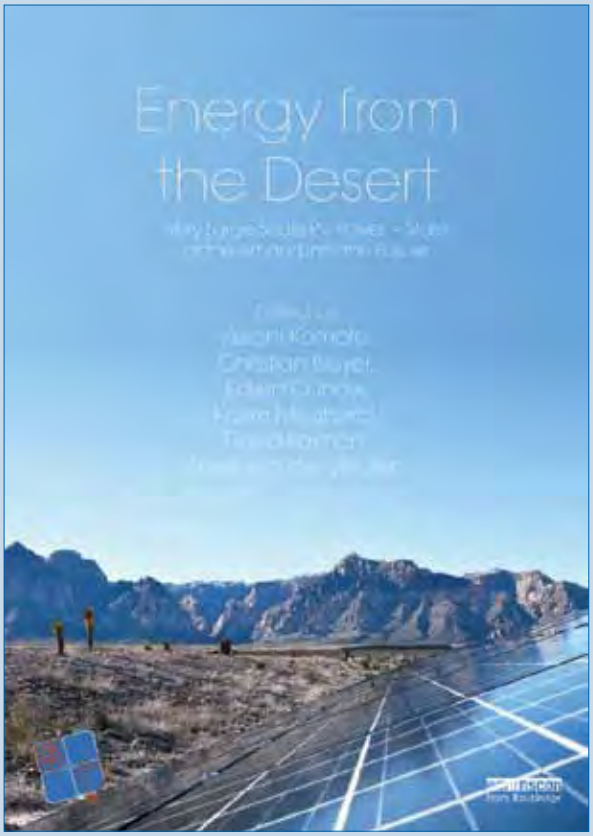


Fig. 4 – Task 8's recently published book, "Energy from the Desert: Very Large Scale Photovoltaic Power - State-of-the-Art and into the Future," Earthscan from Routledge, 2012.

OTHER ACTIVITIES

Publication: "Energy from the Desert: Very Large Scale Photovoltaic Power – State-of-the-Art and into the Future"

Based on the results of discussion under the previous Workplan (2009-2011), Task 8 published the latest report entitled, "Energy from the Desert: Very Large Scale Photovoltaic Power – State-of-the-Art and into the Future." The report gives an overview of the potential of very large scale PV, guidelines for these systems as well as technical and strategic options for implementation.

DISSEMINATION ACTIVITIES

Task 8 organised the international symposium entitled, "Very Large Scale PV Systems (VLS-PV) for Sustainability," as a side event of 27th EU-PVSEC in Frankfurt, Germany, in September 2012.

Task 8 made presentations at the following international conferences, as well.

- 38th IEEE-PVSC in Austin, TX, USA (June 2012);
- 27th EU-PVSEC in Frankfurt, Germany (September 2012);
- 22nd PVSEC in Hangzhou, China (November 2012);
- International conference: Renewable energy cooperation and Grid integration in Northeast Asia, in Ulaanbaatar, Mongolia (November 2012).

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2013

Task 8 will continue to discuss working items for accomplishment of the VLS-PV activity, along with the Workplan. Active dissemination at the international conferences and communication with stakeholders, such as workshop with large scale PV installers, shall be carried out, as well.

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)
Report: "Summary - Energy from the Desert: Very Large Scale Photovoltaic Power – State-of-the-Art and into the Future," 2012
Book: "Energy from the Desert: Very Large Scale Photovoltaic Power - State-of-the-Art and into the Future," Earthscan from Routledge, 2012 (ISBN 978-0-415-63982-8(hbk) /978-0-203-08140-2(cbk)))

MEETING SCHEDULE [2012 AND PLANED 2013]

27th Task 8 Meeting was held in Madrid, Spain, 19-20 April 2012.
28th Task 8 Meeting was held in Arnstadt, Germany, 20-21 September 2012.
29th Task 8 Meeting will be held in Arizona, USA, 24-26 June 2013.
30th Task 8 Meeting will be held in Chambery, France, 7-8 October 2013.

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	John S MacDonald	Day4 Energy Group Inc.
China	Xu Honghua	Electrical Engineering Institute, Chinese Academy of Sciences
France	Fabrizio Donini Ferretti	Chora Finance
France	Karim Megherbi	Helios Energie
France	Aurelien Bertin	Helios Energie
Germany	Edwin Cunow	LSPV Consulting
Germany	Kay Herget	Bosch Solar Energy AG
Germany	Christian Breyer	Reiner Lemoine Institut gGmbH
Germany	Christof Koerner	Siemens AG
Israel	David Faiman	Ben-Gurion University of the Negev
Italy	Fabrizio Paletta	RSE
Italy	Francesco De Lia	ENEA
Italy	Gianluca Gigliucci	ENEL
Italy	Michelle Appendino	Solar Ventures
Italy	Roberto Vigotti	RES4Med
Japan	Keiichi Komoto	Mizuho Information & Research Institute (MHIR)
Japan	Kosuke Kurokawa	Tokyo Institute of Technology (Tokyo Tech)
Japan	Tomoki Ehara	E-konzal
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
Mongolia (observer)	Namjil Enebish	National Renewable Energy Center

TASK 9 – DEPLOYING PV SERVICES FOR REGIONAL DEVELOPMENT

Fig. 1 - 26th Experts' Meeting, April, Stockholm, Sweden.

Fig. 2 - 27th Experts' Meeting, September, Frankfurt, Germany.

Fig. 3 - 9th Annual Meeting of the CLUB-ER, thematic session on mini-grids: Erik Lysen, PVPS Task 9 Expert presenting the PV-Diesel Hybrid Document.

RATIONALE AND OBJECTIVES

PV technology and its viable applications offer options to meet the Millennium Development Goals (MDGs) and now stretch far beyond services to remote communities.
With rising fossil fuel prices and declining prices of PV cells and modules, PV applications are competitive in a rising number of situations: Many initiatives in emerging regions are paving the way for broad PV deployment in non-OECD countries.

Beyond the more classical Solar Home Systems for individual (household and "pico" uses) and community uses, addressed during the first 10 years of Task 9, the challenge of the effective deployment of PV services for regional development now lay on a broader range of applications including village mini-grid power systems, in particular through hybrids, PV services for drinking water and health and also other social, productive, and professional applications, PV in the built and urban environment, and large scale PV.

The objective of Task 9 is twofold:

- In order to promote the implementation of appropriate and efficient technical solutions, Task 9 is developing partnerships with selected "megaphones" (financial institutions, regional / professional organizations) which offer dissemination opportunities for the outputs of other technology-focused PVPS Tasks addressing these challenges, adapting the messages and implementation frameworks in areas beyond the borders of OECD countries. These partnerships would enable the sharing of PVPS' knowledge in the area of rural electrification and beyond e.g. highly relevant topics like penetration of PV in the urban environment, PV hybrids, very large scale PV plants and high penetration in grids.
- Produce substantive work on applications meeting the needs of rural communities such as water pumping, 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.

SUBTASK 1: PV for Water Pumping

Water is an increasingly scarce commodity; 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. The scope of this Subtask is to initiate and maintain interdisciplinary expert dialog in the field of PV and water supply. The objective is to provide guidelines to decision makers to ensure PV-powered drinking water supply systems are implemented where they are the most sustainable option, building on past experience.

SUMMARY OF TASK 9 ACTIVITIES

MILLENIUM DEVELOPMENT GOALS RELATED (including business models)	INTEGRATION OF PV IN ENERGY SYSTEMS (including business models)
1 – PV Water pumping 2 – PV and Health, community services 3 – Pico PV Services	4 – PV and hybrid mini grids for rural loads – status Modelling for Rural loads 5 - PV in medium scale fast growing urban cities
6 – Deployment and outreach in Asia • Asian Development Bank • ASEAN Center for Energy 7 – Deployment and outreach in Africa • Club ER • IRENA, AfDB	

Fig. 4 – IEA PVPS Task 9's activities.

The position paper on **"Policy Recommendations to Improve the Sustainability of Rural Water Supply Systems"** has been finalized, approved by the ExCo and published on the PVPS website in June 2012. The Subtask work is completed and the material is currently being used for dissemination activities:

- Thomas Meier has presented this paper at the International Off-grid Renewable Energy Conference (IOREC), organized by the IRENA and ARE in Accra, Ghana on 1-2 November 2012.

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. Fraunhofer ISE has accepted to take the lead of this Subtask. The activities envisaged are:

- a publication capitalizing on the existing experience in this field;
- a Workshop with the Catholic and Evangelic Churches who are active in this field.

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). So far, as illustrated in the comprehensive technical overview and business model produced by GTZ, the literature has approached the deployment of Pico PV services in terms of "donor driven." Nowadays, devices of widely varying quality are already flooding the market and large companies, including multinationals, are disseminating Pico PV products on a purely commercial basis.

- The publication entitled **"Pico Solar PV Systems for Remote Homes – A new generation of small PV systems for lighting and communication"** is under the approval process from the ExCo and will be available on the PVPS website by the end of February 2013.
- This paper will be presented during the workshop with ACE/GIZ on rural electrification in Myanmar, in April 2013.

SUBTASK 4: PV and Hybrid Mini-Grids with Loads

Task 9 has capitalised on the work done by Task 11 for the organisation of two training workshops on PV-Diesel Hybrid systems for rural electrification for the CLUB-ER (Club of over 30 African agencies and structure in charge of rural electrification) in Mali and Nairobi respectively in July and December 2011. Task 11 work has been used as training material. As a result, a publication on the status of the technology, cost, and feedback from CLUB-ER training session entitled: **"Rural Electrification with PV Hybrid Systems – Overview and Recommendations for Further Deployment"** has been produced and it is currently being edited. It will be sent to the ExCo for approval by the end of February 2013.
This document is a joint publication of Task 9 and CLUB-ER and it has been presented to the thematic session on Mini-grids in the framework of the CLUB-ER annual meeting of Abidjan (see outreach activities).

Following the Task 9 Meeting in Frankfurt in September 2012, it has been decided to further work on this subject. In fact, the arrival of Fraunhofer ISE and of several experts from the completed Task 11 has renewed interest in pursuing the work on this subject. This document will be the basis of a new publication on hybrids but focussing on size optimization (PV/battery/fuel), design and modeling issues in the perspectives for wider deployment in developing regions. IRENA is also keen to contribute to this Subtask work; in particular, on the basis of its experience on battery storage in small islands.

A small group on hybrids will meet in Lyon at the beginning of February 2013 to further define the scope of the new publication.

SUBTASK 5: PV in Medium Scale Fast Growing Cities

France and Denmark have expressed the interest in working on a document on PV in urban settings in developing regions. There is a lot of interest on the subject, economics are changing and design issues are evolving.
Denmark has presented a concept paper on PV in urban settings in developing regions. This document is a start, but contribution of other experts is sought. The targets are the cities that are expected to grow very fast in the future.

During the last Task 9 meeting in Frankfurt, IRENA has expressed the interest in contributing to this subtask by sharing their experience in this field.

Innovative Business Models

The aim of this Subtask, led by the Netherlands, was to create a framework to assess and categorize various business models in collaboration with universities in the Netherlands.

Since the Netherlands has left the Task and since business model and financial mechanisms are a rather horizontal issue, in the new 2012-2014 Workplan, this Subtask has become an activity of each Subtask: Business Models for Hybrids, Business Models for Households Systems, etc.

SUBTASK 6 and 7: Deployment and Outreach in Asia and Africa

This Subtask is the operating arm to establish partnerships with regional organizations, countries, development bodies, etc.

The idea of this Subtask is to produce documents, flyers and brochures highlighting the conclusions of other PVPS' Tasks for promotion and presentation to the "megaphones," which can serve as a basis on which, depending on demand, more in depth workshops, training programmes, etc., can be tailored and designed.

During 2011, focus was placed on Asia, with a very positive collaboration the Asian Development Bank (ADB). In 2012, more effort has been put into developing partnerships with selected African Megaphones, in particular with the Club of African Rural Electrification Agencies (Club ER).

The collaboration with the African Development Bank (AfDB) will be explored in 2013. The AfDB has recently showed its interest in renewable energy financing and it is becoming pro-active in this sector in Africa.

TASK 9 PARTICIPANTS

COUNTRY	PARTICIPANT	AFFILIATION
Australia	Geoff Stapleton	GSES
China	Mr. Zu Feng	Beijing Corona Science & Technology Co., Ltd
China	Mr. Li Yutong	Beijing Corona Science & Technology Co., Ltd
Denmark	Peter Ahm	PA Energy Ltd.
France	Anjali Shanker	IED
France	Silvia Puddu	IED
France	Taric de Villers	IED
France	Gregoire Lena	IED
Germany	Georg Bopp	Fraunhofer ISE
Germany	Brisa Ortiz	Fraunhofer ISE
Japan	Takayuki Nakajima	Japan Photovoltaic Energy Association (JPEA)
Japan	Masanori Ishimura	NEDO
Japan	Atsuhiko KIBA	NEDO
Netherlands	Erik Lysen	Lysen Consulting Engineer
Sweden	Frank Fiedler	Dalarna University
Sweden	Caroline Nielsen	Dalarna University
Sweden	Björn Karlsson	Malerdahlen University
Sweden	Fridrik Wallin	Malerdahlen University
Switzerland	Thomas Meier	ENTEC
Switzerland	Alex Arter	ENTEC
ARE	Simon Rolland	Alliance for Rural Electrification

Collaboration with Asia:

- The Collaboration with other "megaphones" such as the Asean Center of Energy (ACE) has been initiated and the Pico PV Paper (see Subtask 3) and possibly other T9 publications will be presented within the Rural Electrification Workshop in collaboration with the Asean Center for Energy (ACE) and GIZ in April 2013, in Yangon, Myanmar.

Collaboration with Africa:

- A T9 expert, Thomas Meier, has presented the paper on PV Water Pumping at the "1st International Off-grid Renewable Energy Conference (IOREC)" organised by the IRENA and ARE in Accra, Ghana on November 1-2, 2012.
- PVPS has been partner of the CLUB-ER in the organization of the thematic session on **"Renewable Energies for Rural Electrification with Mini-grids"** at the CLUB-ER Annual meeting which took place in Abidjan from 10 to 14 of December 2012. In particular Erik Lysen, Task 9 Expert, has given a short presentation of the PVPS and its work to the public. He has been moderator of a session and speaker in a second session with the presentation of the PVPS/CLUB-ER joint publication on PV-Diesel Hybrid systems. The Alliance for Rural Electrification (ARE) also took part in the organization of the meeting with the organization of a Business delegation.

KEY DELIVERABLES FOR 2013

- **Rural Electrification with PV Hybrid Systems – Overview and Recommendations for Further Deployment** (February 2013)
- **Pico Solar PV Systems for Remote Homes – A New Generation of Small PV Systems for Lighting and Communication** (March 2013)
- **Publication on Hybrids Design and Optimization Issues** (November 2013)

CONFERENCES AND WORKSHOPS FOR 2013 (ALREADY CONSIDERED)

- ACE/GIZ Workshop on Rural Electrification in Myanmar in April 2013

TASK 9 MEETING SCHEDULE (2012 AND PLANNED 2013)

2012

26th Experts' Meeting, April, Stockholm, Sweden
27th Experts' Meeting, September, Frankfurt, Germany

2013

28th Experts' Meeting, 6-7 April 2013, Bangkok, Thailand
29th Experts' Meeting, October, Paris, France

Task9/Subtask 4 Meeting

7 February 2013 – Lyon, France - Subtask 4 Hybrid Systems

The Innovation Energie Développement (IED) contract as Operating Agent with the French ExCo ADEME has been renewed until 2014; a new Workplan has been approved and will be in force as of 2013. It takes into account the achievements from 2010 to 2012 and it is an update of the orientations, targets and objectives according to the resources available.

- Germany, Fraunhofer ISE joined in 2012
- Sweden, Dalarna University joined in 2012
- Observers: Thailand (Min. of Energy and EGAT), Malaysia, GIZ, and IRENA
- Observers from Task 11: Greece NSE LTD, The Netherlands Tss4U
- Observer from Task 8 – Japan: E KONZAL and MHIR

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. Without such support the industry cannot grow to levels that would allow PV to reach generation cost competitiveness and become a mainstream source of electricity. Furthermore, continuing diligence on environment, health, and safety issues is necessary to safeguard health and the environment, and as we progress towards larger scales of photovoltaic deployment, improving sustainability and life-cycle impacts becomes increasingly important.

OVERALL OBJECTIVES

The main goals of Task 12 are to foster international collaboration in the area of photovoltaics and the environment and to compile and disseminate reliable environment, health, and safety (EH&S) information associated with the life-cycle of photovoltaic technology to the public and policy-makers. Accurate information regarding the environmental impacts of photovoltaic technology builds consumer confidence, as well as policy-maker support, thus improving demand. On the supply-side, environment, health, and safety initiatives set standards for environmental, economic and social responsibility for manufacturers and suppliers, thus improving the solar supply-chain with regard to all dimensions of sustainability.

The overall objectives of Task 12 are to:

1. Quantify the environmental profile of PV electricity, serving to improve the supply chain and to compare it with the environmental profile of electricity produced with other energy technologies.
2. Help improve waste management of PV by collective action on recycling.
3. Define and address EH&S and technical and perception issues that are important for market growth.
4. Disseminate the results of the EH&S analyses to stakeholders, policy-makers, and the general public.

The first objective is served with Life Cycle Assessment (LCA) that describes energy, material and emission flows in all stages of the life cycle of PV. The 2nd objective is accomplished by proactive research and support of industry-wide activities (e.g., PV CYCLE). The 3rd objective is addressed by advocating best EH&S practices throughout the solar value chain, and assisting the collective action of PV companies in this area. The 4th objective (dissemination) is accomplished by presentations to broad audiences, peer review articles, reports and fact sheets, and assisting industry associations and the media in the dissemination of the information.

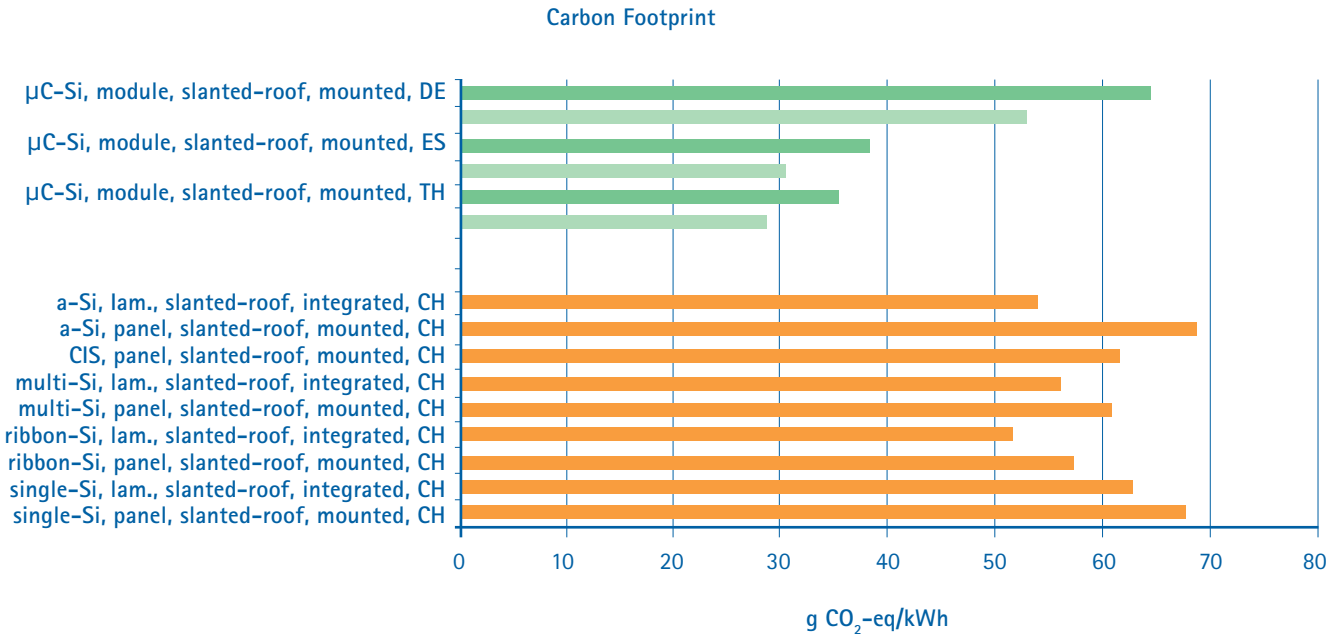


Fig. 1 - Carbon Footprint of electricity from photovoltaic slanted-roof installations using modules produced in the "ThinFab" in China and from photovoltaic slanted roof installations using various different technologies in Switzerland. Green: thin-film modules produced in China; Light green: thin-film modules produced in Europe; Yellow: other module technologies manufactured in Europe; Electricity output: Germany: 809 kWh/kWp; Spain: 1394 kWh/kWp; Thailand: 1481 kWh/kWp; plants with other module technologies: 922 kWh/kWp. Source: Flury K., Frischknecht R. and Itten R. (2012) Life cycle assessment of Oerlikon Solar mC-Si solar modules. treeze Ltd., Uster.

APPROACH

Task 12 is subdivided into four subtasks serving the four objectives above, these are: Recycling, Life Cycle Assessment (LCA), Safety in PV Industry, and Information Dissemination.

ACCOMPLISHMENTS OF IEA-PVPS TASK 12 BY 2012

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

Achievements as Task 12 group:

- Platform for disseminating best-practices on PV end-of-life module recycling.
- Support for the 1st and 2nd International Conference on PV Module Recycling.

Achievements of Task 12 members:

- PV CYCLE
  - Study on the Development of a Take-Back-and Recovery System for Photovoltaic Products.
  - Task 12 activities on recycling have been aligned with those of the PV CYCLE program, which includes 196 industry members, representing more than 90 % of the European market. The Experts of Task 12 assisted EPIA and PV CYCLE to host two International Conferences on PV Module Recycling and plan to contribute to the next Conference in early 2013.
- EPIA/PV CYCLE
  - Organisation of 1st and 2nd International Conference on PV Module Recycling.
- BNL
  - A recycling workshop was organized by Brookhaven National Laboratory (BNL) during the 34th IEEE Photovoltaic Specialists Conference (PVSC) in Philadelphia in June 2009.
  - Developed a cost optimisation model for the collection and recycling of PV modules.
  - Published articles on the technical and cost feasibility of collection and recycling and developed a method for recycling Cd and Te from CdTe photovoltaics.
- NEDO
  - Started PV recycling research supported by the Kitakyushi Foundation for the Advancement of Industry, Science and Technology (FAIS).

SUBTASK 2: Life Cycle Assessment

Achievements as Task 12 group:

- The 2nd and expanded edition of *"Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity"* was published in November 2011.

A report on "LCA and LCI Inventories' with data necessary for conducting LCA was published in October 2011.

Achievements of Task 12 members:

- LCA analyses of PV module technologies: A large number of articles in high-impact journals and papers in International conferences.
- EPIA's sustainability WG factsheets on carbon footprint and EPBT.
- LCI data has been collected from several Task 12 members and were used in view of updating the ecoinvent database. Examples are Life Cycle Assessment of Flexcell Amorphous Silicon Modules and Life cycle assessment of Oerlikon Solar µC-Si solar modules.

SUBTASK 3: Safety in Facilities

- BNL:
  - A seminar on Silane Safety in conjunction with the IEEE PVSC, San Diego, in April 2008.
- EPIA:
  - A workshop on 'PV Fire Safety' in September, 2010.

SUBTASK 4: Information Dissemination

- Individual Task 12 members have published extensively (more than 50 journal articles and 100 conference and workshop presentations) on LCA and recycling issues.
- Also several joint publications from European and American authors have been facilitated via Task 12 interactions.
- 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.

PLANS FOR 2013

Because of a change in leadership in Task 12, activities to date have been delayed. The following are plans for 2013 that will be reviewed at the next Task 12 Experts meeting.

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

- Task 12 is indeed the ideal platform to discuss recycling of EoL modules at the global level.
- The subtask will be expanded to also cover manufacturing waste.
- EPIA continues to represent PV CYCLE and provide updates on the legislative framework in Europe (WEEE) and promotion of best practices.
- Expand the platform for the international cooperation on PV end-of-life module recycling.
- Support International Conferences and Workshops advising recycling options and capabilities.
- Promote the creation of industry recycling programs in the U.S. and Asia.

SUBTASK 2: Life Cycle Assessment

- Task 12 considers to extend the methodology guidelines to issues such as "water use", "recycling materials" and possibly "avoided electricity mix".
- Task 12 will continue gathering LCI data and plan to publish such in IEA reports.
- The following technology specific LCAs are planned by task members and will be cross-referenced among task members: global (cristalline silicon) supply chains FBR polysilicon production; LCA of future (2050) PV supply chains.

TABLE 1 - TASK 12 PARTICIPANTS

COUNTRY/ASSOCIATION	PARTICIPANT	ORGANISATION
Austria	Werner Polz	Umweltbundesamt GmbH
Canada	Maxime Cossette Marc Suys	5N Plus Inc
EPIA EPIA	Ioannis-Thomas Logothetis Gaetan Masson	European Photovoltaic Industry Association
France	Didier Beloin-Saint-Pierre	Centre Energetique et Procédés, MINES ParisTech
Germany	Michael Held	LBP Stuttgart University
	Karsten Wambach Sylke Schlenker	Sunicon (Solar Materials)
	Wiltraud Wischmann	ZSW
Japan	Mitsutoshi Hino	Kyocera Corporation
	Atsuyuki Yamamoto	NEDO (Technology Development Organisation)
Norway	Ronny Glockner Jan Ove Odden	ELKEM solar
PV CYCLE	Jan Clyncke	PV Cycle Association
	Virginia Gomez	
Spain	Marco Raugei	ESCi (Escola Superior de Comerc Internacional)
Switzerland	Rolf Frischknecht	treeze Ltd., fair life cycle thinking
The Netherlands	Mariska de Wild-Scholten	SmartGreenScans
	Carol Olson Ton Veltkamp	ECN
	N.J. Mohr	Nijmegen University
USA	Kevin Lynn	U.S. Department of Energy (DOE)
	Garvin Heath	National Renewable Energy Laboratory (NREL)
	John Smirnow	SEIA
	Parikit Sinha	First Solar

- Contribution by Task members to the UNEP International Resources Panel report on "THE BENEFITS, RISKS, AND TRADE-OFFS OF LOW-CARBON TECHNOLOGIES FOR ELECTRICITY PRODUCTION" which considers all environmental impact categories including mineral demands and stock depletion, GHG emissions, water and land use, etc.
- Studies on PV biodiversity impacts (monitoring program of Chinese PV power plants).
- Information and dissemination concept.

SUBTASK 3: Safety in PV Industry

- This task will be expanded to include not only safety in facilities through the manufacturing process, but also safety throughout the life-cycle of a PV product, including the safety of solar installers and decommissioning agents.
- Fire Safety – review of current practices/codes/standards in member countries and promotion of best practices
- Installer Safety – review of current practices, training, projects, and certifications adopted by member countries, and promotion of best practices.

SUBTASK 4: Information Dissemination

- Dissemination of Information – improved Task 12 website and distribution of materials by folding the separate Task 12 website into the overall PVPS website.

PROPOSED NEW PROJECTS

Many Task 12 Experts have initiated valuable projects through their own organizations, and building upon these efforts through Task 12 is an important step in expanding the reach of EHS and sustainability efforts in the industry. Task 12 Experts will be encouraged to use Task 12 as a vehicle to promote their work, and to build upon this work through the input of other Experts.

For example, through Task 12, SEIA has proposed to expand the Solar Industry Commitment to Environmental & Social Responsibility, a standard of environmental and social responsibility practices developed by the SEIA Environment, Health & Safety Committee. Through Task 12, this work can be expanded and improved by leveraging the expertise of Task 12 members, and utilizing the PVPS communication channels to include PVPS and Task 12 in further efforts.

These projects will be added to the Workplan as they are approved by the Task 12 members.

PUBLICATIONS

- Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity, 2nd edition, IEA PVPS Task 12, International Energy Agency Photovoltaic Power Systems Programme.
  Report T12-03:2011. ISBN: 978-3-90642-01-5

- Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, International Energy Agency Photovoltaic Power Systems Programme.
  Task 12, Report T12-02:2011. ISBN: 978-3-906042-00-8.

- Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity,1st edition, IEA PVPS Task 12, International Energy Agency Photovoltaic Power Systems Programme.
  Report T12-01:2009.

In addition to the collectively published IEA reports, task 12 members published extensively in peer-reviewed journals and presented at international conferences.

For more information, contact the Task 12 Operating Agent:
Garvin Heath, National Renewable Energy Laboratory (NREL), USA

MEETING SCHEDULE (2012 AND PLANNED 2013)

The Task 12 Experts Meeting was held in Frankfurt, Germany, September 2012.

The Task 12 Experts meeting will be held in Golden, CO, USA, in June 2013.

The following Task 12 Experts meeting will be held September 2013 in a location to be determined in consultation with Task 12 Experts at the meeting in Golden, CO, USA.

TASK 13 – PERFORMANCE AND RELIABILITY OF PY SYSTEMS

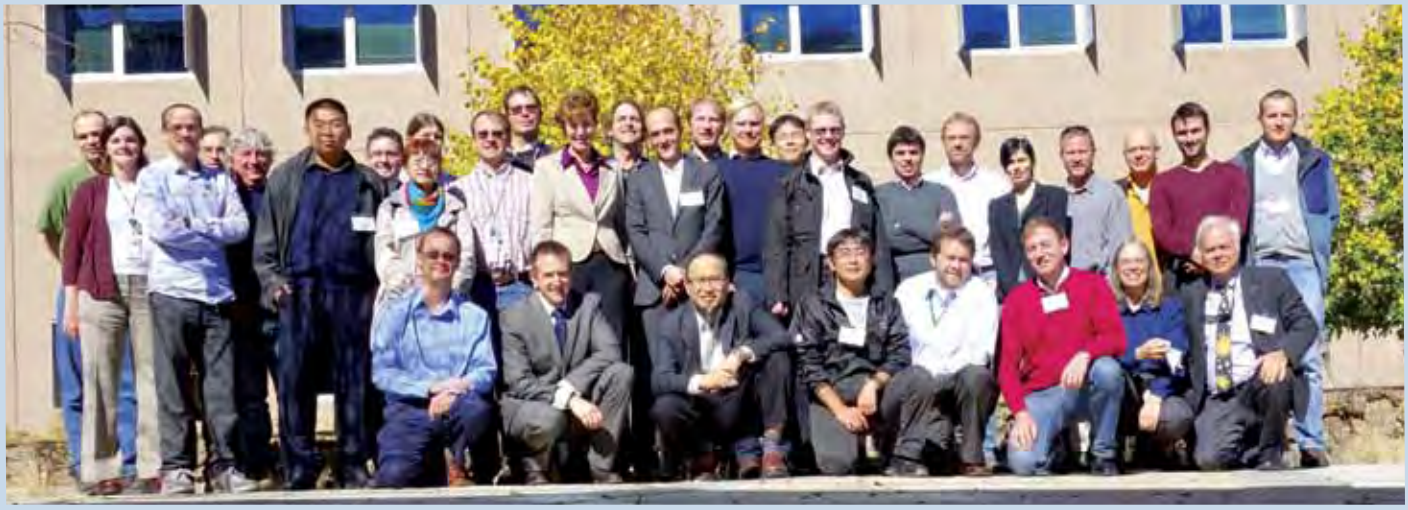


Fig. 1 - Task 13 Expert Meeting at NREL, Golden, Colorado, USA, 23-25 October 2012 (Photo: Thomas Nordmann).

INTRODUCTION

Given the favourable political framework in many countries world-wide, 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 quality of PV systems 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. Presently, there are seventeen countries and 30 institutions collaborating in this project, which had 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 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.

The following 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 organized into the following subtasks:

SUBTASK 1: Statistical PV System Performance Analysis

Subtask 1 addresses the statistical analysis of PV system performance. Participants will collect operational data of PV systems in their countries in a standardized format on a monthly basis. The information gathered will be accessible for interested market actors via an online Performance Database. 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. The database will also be useful as a benchmark for new PV installations.

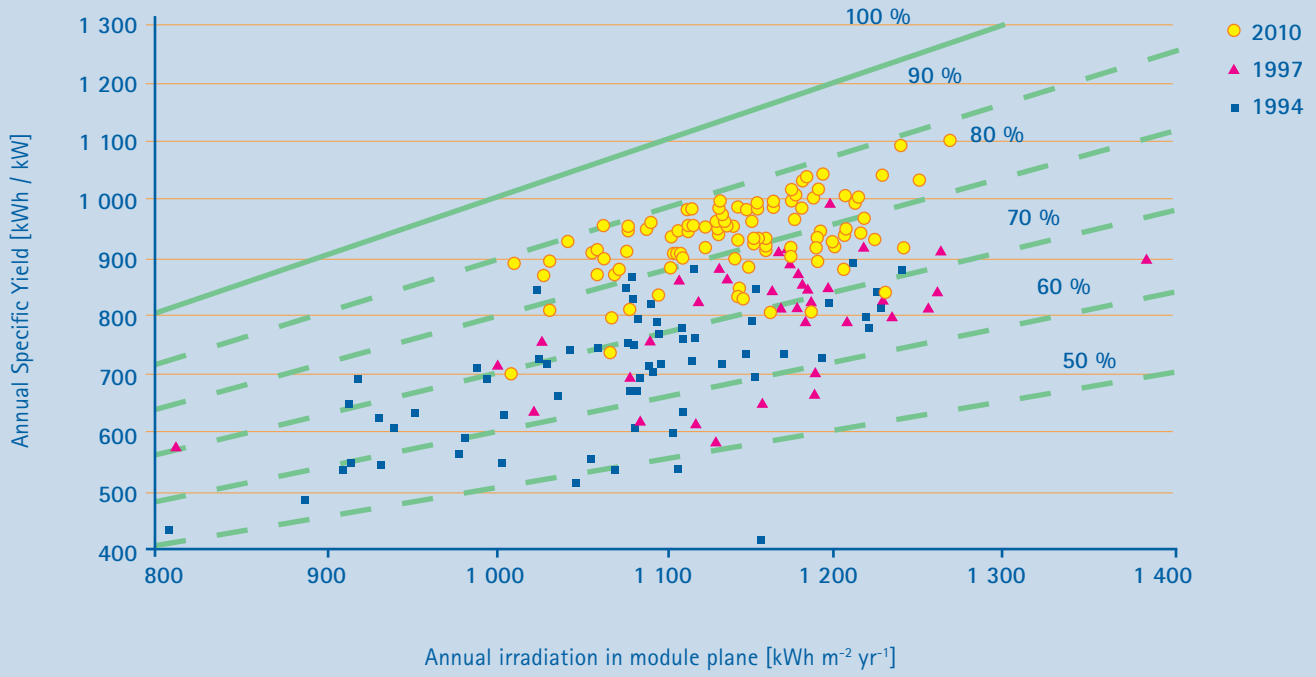


Fig. 2 - Monitored specific energy yields as a function of total plane-of-array irradiations of PV systems installed in Germany during the years 1994, 1997, and 2010. Clearly, specific energy yields have been improved during the past 17 years (from: Reich et al. Prog. Photovolt. 20 (2012) 717-726).

The existing data from the 500 grid-connected PV systems from the Task 2 database were also imported into the new IEA PVPS Performance Database. Task 13 members are now able to access the online-database and view the received 56 datasets and operational data on the Internet. The online-database entries can be selected individually or as a group and the operational data can be displayed or exported in graphic or table form. This will allow the user to create reports on selected grid-connected PV systems. During the year 2013 the NEW IEA PVPS Online Performance Database will be made publicly accessible.

A team has been set-up to collaborate on Subtask 1.2 Statistics on the Operation of PV Systems. The motivation for this is to answer the question: "How well is PV serving the world?" The aim is to provide only three figures for ease of communication to PV customers: Annual AC yield, performance ratio, and degradation rate. A guideline wil be drawn up that would allow all Task13 members to gather national data in the same format. The team will collect all national data and will show the global distribution of annual AC yield in kilowatt hour per year per installed kW. A global distribution of performance ratio values can be determined using either measured irradiance or satellite data. Degradation rates can be inferred from a series of annual data. As the focus will be on annual data, the aim is to provide the customers/owners of PV systems with a benchmark value of performance.

In cooperation with the industry and national programmes, participants aim to 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 system operation. Initially, a set of standardised graphical representations was developed as a first step and used for discussions during previous Expert Meetings. It was shown that deficiencies in system component operation and in overall system performance may be detected, understood and explained better than by a simple comparison of monthly yields or PR values (Figure 2).

Based on this experience, in the next step further refinements and new graphs were identified to be added to the set of standardized plots. In this way, operational data of a larger number of PV systems can be evaluated in great detail. This again may lead to further improvements in overall system design. It was also noted, however, that the increase in the amount of graphs hampered the preparation of system performance analysis reports, with tailored graphs becoming too complex to be directly implemented by non-experts. In addition, it was found that for the identification of typical errors a limited subset of plots is sufficient. To this end, user guidelines are being developed that lead to rules of which plots to prepare, in order to identify particular system errors.

In consecutive steps, 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. Here, it has been shown in a recent publication (Müller et. al, reference in dissemination list below)

TASK 13 PARTICIPANTS IN 2012 AND THEIR ORGANISATIONS

COUNTRY	ORGANISATION
Australia	CAT Projects, Desert Knowledge Precinct, Alice Springs The University of New South Wales, Sydney
Austria	Austrian Institute of Technology (AIT) Polymer Competence Center Leoben (PCCL) GmbH Institute of Polymeric Materials and Testing (IPMT), Johannes Kepler Universität Linz
Belgium	3E nv/sa, Brussels
China	Institute of Electrical Engineering, Chinese Academy of Sciences (CAS)
EPIA	European Photovoltaic Industry Association (EPIA)
France	Commissariat à l'Énergie Atomique et Énergies Alternatives/ Institut National de l'Énergie Solaire (CEA / INES) Electricité de France (EDF R&D)
Germany	Fraunhofer-Institut für Solare Energiesysteme ISE Institute for Solar Energy Research Hamelin (ISFH) TÜV Rheinland Energie und Umwelt GmbH
Israel	M.G.Lightning Electrical Engineering Unirom Electronics Ltd.
Italy	European Academy Bozen/Bolzano (EURAC) Gestore dei Servizi Energetici - GSE S.p.A. Ricerca sul Sistema Energetico – RSE S.p.A.
Japan	National Institute of Advanced Industrial Science and Technology (AIST)
Malaysia	Universiti Teknologi Malaysia (UTM) Universiti Teknologi MARA (UiTM)
Netherlands	Utrecht University, Copernicus Institute
Norway	University of Agder
Spain	Centro Nacional de Energías Renovables (CENER) Universidad Carlos III de Madrid
Sweden	ABB AB, Corporate Research Energibanken i Jättendal AB SP Technical Research Institute of Sweden
Switzerland	Scuola Universitaria Professionale della Svizerra Italiana (SUPSI) TNC Consulting AG
Turkey	ANELES AS
USA	National Renewable Energy Laboratory (NREL) Sandia National Laboratories (SNL)

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

that energy loss due to inverter power limitation can be adequately determined the way described here. In addition, it has been shown that the use of the so-called profile angle can be used to better determine and analyze row shading loss characteristics.

Innovative technologies and system concepts – such as thin-film and bifacial PV 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 international 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.

In 2012, Task experts focused on writing the internal report "Review on failures of PV modules." Approximately 45 % of the document is finished by now. Information on the number and statistical distribution of micro cracks in silicon wafer-based PV modules which have been installed outdoors has been collected and published. This information will enable PV module manufacturers and experts to

Fig. 3 - The Task 13 workshop on PV module reliability was held as a parallel event of the European PVSEC's programme in Frankfurt, Germany, in September 2012. The workshop entitled "Characterizing and Classifying Failures of PV Modules" attracted more than 150 interested participants from industry and research.

judge how many micro cracks are normal in a PV module and which amount or distribution is not acceptable. Participants have started to collect module degradation data from different sources. Furthermore, information on the actual knowledge on snail tracks and cell cracks has been updated and presented during the Task 13 workshop on PV module reliability (Figure 3).

Research results of the degradation behaviour of PV modules, of the comparison of degradation under accelerated stress conditions in the laboratory versus real time 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 technical reports.

The following technical papers were published in 2012:

B. Müller, Th. Reis, A. Driesse, Ch. Reise, Maximizing the Yield of Large PV Power Plants: What can We Learn from Monitoring and Simulation? 27th European Photovoltaic Solar Energy Conference, Frankfurt, Germany, 24-28 September 2012, 5CO.6.5

W.G.J.H.M. van Sark, N.H. Reich, B. Mueller, A. Armbruster, K. Kiefer, Ch. Reise, Review of PV performance ratio development, in Proceedings of the World Renewable Energy Forum (Ed. C. Fellows), American Solar Energy Society SES, Boulder, CO, USA, 2012, pp. 4795-4800.

N.H. Reich, B. Mueller, A. Armbruster, W.G.J.H.M. van Sark, K. Kiefer, Ch. Reise, Performance Ratio Revisited: AR PR > 90 % Realistic? Progress in Photovoltaics 20 (2012) 717-726

H.G. Beyer, G.H.Yordanov, Stability of the Performance of Thin Film Modules during One Year of Operation, 38th PVSC, 3-8 June 2012, Austin, USA (2012)

U. Jahn, M. Schweiger, W. Herrmann, Final Results of High Precision Indoor and Outdoor Performance Characterization of Various Thin-Film PV Module Technologies, 27th European Photovoltaic Solar Energy Conference, Frankfurt, Germany, 24-28 September 2012, 4BV.2.8

M. Köntges, S. Kajari-Schröder, I. Kunze, Cell Cracks Measured by UV Fluorescence in the Field, 27th European Photovoltaic Solar Energy Conference, Frankfurt, Germany, 24-28 September 2012, 4CO.11.4

M. Köntges, S. Kajari-Schröder, I. Kunze, Crack Statistic for Wafer-Based Silicon Solar Cell Modules in the Field Measured by UV Fluorescence, IEEE Journal of Photovoltaics, Volume: PP, Issue: 99, DOI: 10.1109/JPHOTOV.2012.2208941 (2012)

Task 13 organized a workshop on PV module reliability issues during the 27th European PV Solar Energy Conference in Frankfurt in September 2012. The Workshop "Characterizing and Classifying Failures of PV Modules" was held as a parallel event as part of the EUPVSEC's programme. Leading specialists from Europe, America and Asia informed the audience about new developments in testing and certification of PV modules, cracking of crystalline silicon modules, the results of field investigations and typical modules failures in the field (Figure 3).

The workshop attracted more than 150 participants from over seventy countries who are interested in scientific and technical developments in PV module reliability. Task 13 and the speakers received many positive responses to their presentations.

MEETING SCHEDULE (2012 AND PLANNED 2013)

The 5th **Task 13 Meeting** was held in Brussels, Belgium, 19 - 21 March 2012.
The 6th **Task 13 Meeting** took place in Denver, Colorado, USA, 23-25 October 2012.
The 7th **Task 13 Meeting** will take place in Rotterdam, Netherlands, 18-20 March 2013.
The 8th **Task 13 Meeting** will be held in Malaysia, 21-24 October 2013.

TASK 14 – HIGH PENETRATION PV IN ELECTRICITY GRIDS

Fig. 1 - Task 14 Experts at Meeting in Kassel, Germany (Photo: IEA-PVPS Task 14).

INTRODUCTION

With PV becoming an increasingly visible part of the electricity mix in a number of countries, proper understanding of the key technical challenges facing high penetrations of PV is crucial to ensure further smooth deployment of PV. Key issues include the variable and somewhat unpredictable nature of PV generation, the power electronics interconnection to the grid and its location within distribution grids 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 regards only limited lessons can be learned from more established intermittent renewable technologies such as wind generation.

Overcoming the technical challenges will be critical to 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, it is important to discuss these cases in a collaborative manner. With further growth of distributed as well as centralized PV generation, 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

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.

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 optimum manner. The aim of these efforts is to reduce the technical barriers to achieve high penetration levels of distributed renewable systems on the electric power system. Due to the fact that a number of distribution system integration-related issues are emerging first for PV systems, Task 14 will focus on working with utilities, industry, and other stakeholders to develop the technologies and methods enabling the widespread deployment of distributed PV technologies into the electricity grids.

SUBTASKS AND ACTIVITIES

Task 14 addresses predominantly technical issues of high penetration of PV in electricity networks, including energy management aspects, grid interaction and penetration aspects related to local distribution grids as well as 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. The work programme is organized into four main Subtasks and one cross-cutting Subtask, which will be the link between the main Subtasks.

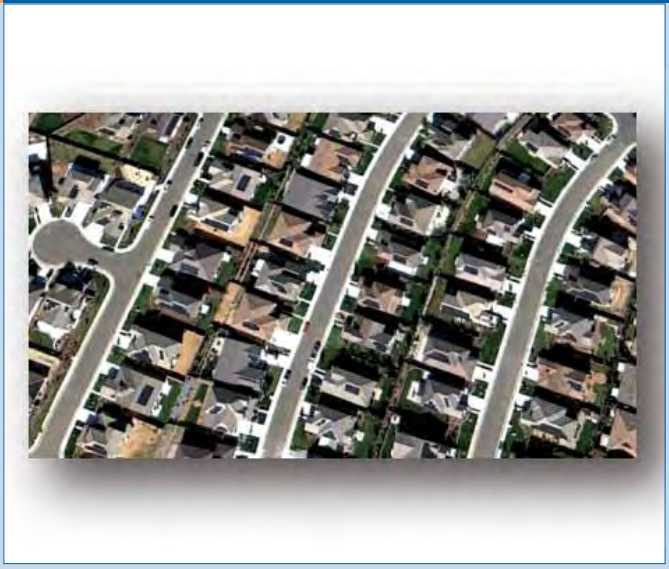


Fig. 2 - High Penetration PV Community in Sacramento, CA, USA, (Photo: SMUD, NREL).

Fig. 3 - IEA PVPS Task 14 organisation.

CROSS-CUTTING SUBTASK: Information Gathering, Analysis and Outreach

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

SUBTASK 1: PV Generation in Correlation to Energy Demand

This subtask shows how with better prediction tools, an optimized local energy management (including Demand Side Management DSM) and a better understanding of temporal fluctuation PV penetration levels can be improved. In addition to the basic analyses, the feasibility of local high PV penetration in grid will be demonstrated by case studies on different penetration and urban scales.

In addition monitoring and prediction tools are being reviewed and adapted to anticipate the shift in local grid to answer to the prediction need of utilities (interaction on solar resource prediction with Task 46 of IEA SHC).

SUBTASK 2: High PV Penetration in Local Distribution Grids

Subtask 2 addresses the Role of PV in Distribution Grids and includes an Impact Analyses of High PV Penetration in Distribution Grids and concludes with recommendations on grid codes, incentives and regulation.

Information provided by distribution system operators are used to review the current state of distribution grids with high PV penetration in a number of case studies. By comparing the selected cases from different countries, best practice examples that may be a reference for challenges and solutions will be identified. Possible optimization approaches for active and reactive power control, such as central coordinated control and local unit parameterization, are reviewed to assess the technical effectiveness and economic efficiency of the analyzed approaches of active and reactive power balancing for country-specific distribution grids in an international benchmark.

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 is laid on grid interaction and penetration related aspects. Gaps in current PV system technology and electric power system operation practices are identified. Furthermore, detailed analyses, how large numbers of PV installations can be successfully integrated into the total power system including the technology of smart grids are made.

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.

By reviewing and analyzing remote control and communication practices for Smart Inverters, the suitability of current standards/ practices for high PV penetration scenarios will be assessed.

PROGRESS AND ACHIEVEMENTS

During 2012, Task 14 continued the successful series of high penetration workshops with two well received events held in Europe and Japan. In May, the *Task 14 High Penetration PV Workshop* was hosted by SMA Solar Technology AG in Niestetal, Germany. With about 50 participants from German electricity sector, manufacturers and research, the Task 14 workshop was a great success and attracted broad interest from all stakeholders. The workshop program included presentations on case studies from Germany, where high penetration PV has already become reality in wide areas of the countries, as well as presentations on international experiences.

The second event was organized in October 2012 in Tokyo, Japan, hosted by NEDO and the University of Tokyo. With more than 40 participants, this event brought together Japanese experts from research and industry, and IEA-PVPS Task 14.

Fig. 4 - Task 14 High Penetration PV Workshop at SMA Solar Technology AG, Germany (Photo: IEA-PVPS Task 14).

Presentations were made on case studies, successful examples of high penetration PV projects and the associated challenges.

Task 14 Workshop presentations of both workshops held in 2012 as well as documents from previous events are publicly available for download at the Workshops section of the IEA-PVPS website: http://www.iea-pvps.org/index.php?id=212

Regarding technical work a collection of case studies of high penetration PV scenarios in the participating countries was performed, which is currently being compiled into a report. The cases include PV penetration scenarios in local distribution grids as well as from the overall power system wide perspective.

In addition, the forecast expert group investigated the suitability of Forecast Tools with respect to high penetration PV, linking together weather forecasts, prediction and monitoring tools. This work item is jointly carried out with IEA-SHC Task 46 on solar resource characterisation.

SUMMARY OF TASK 14 ACTIVITIES PLANNED FOR 2013

Task 14 activities in 2013 will focus on the compilation of the collected case studies of high penetration PV scenarios in the participating countries. The objective of this activity is to provide lessons learned and formulate recommendations for managing grid with high penetration of PV.

Furthermore, a review of optimization approaches for reactive balancing and active power control on a distribution level and for system wide PV generation will be performed.
In addition, further technical research will be made on inverter related requirements for high penetration PV, including interface related issues and communication/control issues.

INDUSTRY INVOLVEMENT

As from the beginning, industry has been directly involved in the development of the concept and Workplan for Task 14. 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.

Besides the country participation, increased interest from industry associations was received. In 2012 also EPIA, the European Photovoltaic Industry Association joined Task 14 and has been actively contributing since then.

During its whole period, Task 14 has 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 are designed for use by experts from the electricity sector, specialists for photovoltaic systems and inverters, equipment manufacturers and other specialists concerned with interconnection of distributed energy resources.

During 2012, Task 14 work was presented at some of the key events, including the 27th European PVSEC:

- "Challenges and Solutions of Large-Scale PV Power Integration," Presentation by Task 14 Operating Agent Mr. Christoph Mayr at the 10. Swiss National PV Conference, 23. March 2012;
- "Solar Forecast Survey Results," Review published by Jan Remund and Stefan C. Müller (Meteotest, Switzerland) at the 27th European PV Solar Energy Conference and Exhibition (PVSEC 2012) in Frankfurt. Germany, September 2012.

For 2013, the publication plans include:

- 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.

TABLE 1 – CURRENT LIST OF TASK 14 PARTICIPANTS (NOT INCLUDING OBSERVERS)

COUNTRY	PARTICIPANT	ORGANISATION
Australia	Ian McGill	University of NSW
Australia	Glenn Platt	CSIRO Energy Technology, Australia
Austria	Roland Bründlinger	Austrian Institute of Technology
Austria	Christoph Mayr	Austrian Institute of Technology
Belgium	Karel Debrabandere	3E
Belgium	Achim Woyte	3E
Canada	Andrew Swingler	Schneider Electric
Canada	Dave Turcotte	Natural Resources Canada
Switzerland	Lionel Perret	Planair SA, Switzerland
Switzerland	Jan Remund	Meteotest
Switzerland	Christof Bucher	Basler Hofmann
China	Yibo Wang	Chinese Academy of Science, IEE
Germany	Martin Braun	Fraunhofer IWES
Germany	Thomas Stetz	Fraunhofer IWES
Germany	Gunther Arnold	Fraunhofer IWES
Germany	Daniel Premm	SMA Solar Technology
Denmark	Kenn H.B. Frederiksen	EnergiMidt A/S
Spain	Vicente Salas	Universidad Carlos III de Madrid
Israel	Moshe Ohayon	Israel Electrical Company
Italy	Giorgio Graditi	ENEA
Italy	Ilaria Adriano	RSE - Ricerca sul Sistema Energetico.
Japan	Koji Washihara	NEDO
Japan	Kazuhiko Ogimoto	The University of Tokyo
Portugal	Catarina Calhau	EDP Inovação, S.A.
Portugal	Joao Maciel	EDP - Energias de Portugal
Sweden	Antonis Marinopoulos	ABB Corporate Research
United States	Barry Mather	National Renewable Energy Laboratory
United States	Benjamin Kroposki	National Renewable Energy Laboratory
EPIA	Ioannis-Thomas Theologitis	European Photovoltaic Industry Association
EPIA	Manoel Rekinger	European Photovoltaic Industry Association

In addition, the successful series of utility workshops related to high PV penetration scenarios in electricity grids will be continued in 2013, in order to involve industry, network utilities and other experts in the field of PV integration to the Task 14 work.

At the moment, 3 workshops are tentatively planned for 2013:

- May 6, 2013: Joint workshop organized by Task 14 and the consortium of the European High Penetration PV demonstration project MetaPV in Brussels, Belgium;
- September 2013: Joint Solar Forecasting and high penetration workshop, organized by IEA SHC Task 46 and IEA-PVPS Task 14 at the European PV Conference (EU PVSEC) in Paris, France;
- November 2013: Australian High Penetration PV Workshop, jointly organized by UNSW and Task 14, Sydney, Australia.

Presentations of all Task 14 events organised so far are publicly available for download at the Workshops section of the IEA-PVPS website: http://www.iea-pvps.org/index.php?id=212

MEETING SCHEDULE

2012 Meetings:

- May 11-13, 2012: 5th Experts Meeting, hosted by Fraunhofer IWES, Kassel, Germany
- October 31-November 1, 2012: 6th Experts Meeting, hosted by NEDO, Tokyo, Japan

2013 Meetings (tentative):

- May 6-8, 2013: 7th Experts Meeting, hosted by 3e, Brussels, Belgium
- October/November 2013: 8th Experts Meeting, hosted by UNSW, Sydney, Australia

AUSTRALIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DR MURIEL WATT, IT POWER AUSTRALIA

Fig. 1 - Araluen Arts Centre, Alice Springs, 180 kWp solar system using Hanwha Q.Cells QPeak Black modules. Designed by CAT Projects as part of the Alice Solar City and expected to produce 330 MWh per year (Photo: Hanwha Q.Cells).

GENERAL FRAMEWORK AND IMPLEMENTATION

The Australian PV market remained strong in 2012, with installation levels reaching 1 GWp and installed capacity now well over 2 GWp. In response to the continuing high PV uptake rates, State Governments closed most feed-in tariffs to new applicants, replacing them with a voluntary nominal payment for export related to the wholesale price, and the Australian Government reduced the incentives available for small PV systems via the Renewable Energy Target (RET) mechanism. International module price drops and a high Australian dollar exchange rate saw local module prices drop from AUD 2,10/Wp in 2011 to 1,30/Wp and installed system prices drop from an average of around AUD 4 to around 3/Wp. At this price, and with continued increases in grid electricity prices, due largely to network refurbishments and upgrades, PV is a very attractive option for homeowners in many parts of Australia and is of increasing interest to the commercial sector.

Residential penetration levels now average 10 % and are up to 20 % in some areas. Installation restrictions are being imposed by electricity network operators in some areas to cope with potential issues arising from sudden changes in load due to cloud movements and to voltage rises in residential feeders. New grid connect standards are under consideration to assist with high penetration levels and are likely to be introduced in 2013. Changes are also needed to retail electricity market structures to accommodate new supply and demand options now available via PV and other distributed generation technologies, demand management, energy efficiency and storage. This is especially important where increased on-site generation is reducing revenue to pay for networks.

Electricity prices are expected to continue to rise over the next few years, and a carbon price was introduced from mid-2012, starting at 23 AUD/tCO_2-eq. Hence the market for distributed PV will remain strong. For central generation, a 10 MW system was installed in Western Australia by First Solar for Verve Energy and GE Energy Financial Services, with funding support from the State Government, and several larger-scale PV systems are now under construction. However, with wholesale electricity prices still relatively low, larger-scale PV systems continue to require policy support.

NATIONAL PROGRAMME

The main support for PV at a national level remains the Renewable Energy Target (RET). Support for large systems is via the Large-scale RET which increases each year to 41,000 GWh of renewable electricity by 2020. It operates via a market for Large-scale Generation Certificates (LGCs), with 1 LGC created for each MWh of electricity generated. Support for small-scale systems is via an uncapped Small-scale Renewable Energy Scheme. In 2012, systems up to 1.5kWp (20 kWp off-grid) were eligible to create 2 Solar Credits (Small-scale Technology Certificates or STCs) per MWh. This will drop to 1 STC per MWh in 2013. In addition, all PV systems up to 100 kWp were also able to claim STCs up-front for up to 15 years of deemed generation, based on location. This means that the STCs for small systems acted as an up-front capital cost reduction. A review of the RET is currently underway, with a proposal to reduce the eligibility for deeming to 10 kWp. This would impact the commercial sector market.

Fig. 2 - The Townsville RSL Stadium 348 kWp PV system for the Townsville Queensland Solar City Project. The system comprises: main curve roof (173 kWp), 2 x flat skillion roofs (155 kWp) and shade structure (20 kWp) using Kyocera KD135 and KD240W modules. The system is expected to generate 510 MWh a year and will provide about half the energy needs of the stadium in winter and around one third of its needs in summer (Photo: Ergon Energy).

Fig. 3 - 5 Murray Rose Avenue, Olympic Park, Sydney. The 130,5 kWp commercial office rooftop PV system was used to achieve Peak Demand Reduction and Emissions Reduction credits towards a 6 Star Green Star certified office rating. The PV system is also a significant part of the 5 Star NABERS Energy target for building operation (Photo: The GPT Group).

RESEARCH, DEVELOPMENT & DEMONSTRATION

PV research, development and demonstration are supported at the national, as well as the State and Territory level. In 2012, research grants were available through the Australian Research Council and the Australian Solar Institute. The latter invested 46 MAUD in 2012 on PV research ranging from new manufacturing techniques to hybrid system technologies and building integrated PV.

The funding included 15 MAUD towards a new USA-Australia Institute for Advanced Photovoltaics and other collaborative projects with the USA and Germany. The ASI will be absorbed into a new Australian Renewable Energy Agency from 2013. A new Clean Energy Finance Corporation has also been established, with 10 BAUD to finance renewable energy, energy efficiency and low emission technologies.

Industry funding for technology development and demonstration was also available through the Australian Centre for Renewable Energy, which provided 2,2 MAUD to Bluescope Steel for development of BIPV products, and through the Solar Flagships programme. AGL and First Solar were the successful bidder for the Round 1 PV Flagship grant and will construct 106 MWp in Nyngan and 53 MWp in Broken Hill, NSW. The project cost is 450 MAUD, of which 130 MAUD was received from the Federal Government and 65 MAUD from the NSW Government. The systems are expected to be operational from 2014. An associated 3,275 MWp pilot research and storage facility worth 40,7 MAUD will be established as an Education Investment Fund Research Infrastructure Project, to undertake power systems research.

The Australian Capital Territory ran a solar auction process in 2012 for 40 MWp of PV. The first successful project was awarded to FRV Royalla Solar Farm for the installation of 20 MWp. A second stage process is now underway.

INDUSTRY AND MARKET DEVELOPMENT

After two years of rapid growth, the industry consolidated significantly in 2012, as support programs wound back. However, a more sustainable market, with less reliance on subsidies is now being established.

The estimated 1 GWp was installed mainly in small-scale residential systems. The market in 2013 is likely to remain stable, with an increase in commercial system installations at the expense of residential ones. However, development of the commercial market is currently hampered by the lack of standardised procedures or rights to connect.

Larger-scale installations will be more prominent in 2013, with commencement of the Solar Flagships and the ACT Royalla system, as well as other possible installations where planning approval has been given. These include proposals for plants of around 50 MWp near Canberra, Manildra, Nyngan and Moree.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

HUBERT FECHNER, UNIVERSITY OF APPLIED SCIENCES, TECHNIKUM VIENNA

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

The Austrian photovoltaic market is rising significantly. In 2012, for the fourth time in a row, a duplication of the market could be reported. Differently to most other PV supporting countries, Austria has mainly three levels in supporting PV systems. The feed-in-tariff system is designed only for systems larger than 5 kWp and is only responsible for about one part of the supported PV systems in Austria; investment support systems for small, private systems are well established on federal and regional level, as well. Two targets for the national PV market are laid down in the national green-electricity act (GEA), firstly issued in 2002, and meanwhile revised several times. The market should come up to 500 MW in 2015 and a 2020 target of having 1,2 GW installed in Austria. These goals seem to be not very ambitious since at the end of 2011 187 MW were installed and this number seems to be doubled in 2012 to currently end up with numbers close to 400 MW.

- Feed-in Tariff is provided via the national green-electricity act. The "new RES" are supported by this act mainly via up to 13 years guaranteed feed-in tariffs; a cap with an additional 8 MEUR annually limits the installation. The application has to be done via an internet website which was closed after some minutes since the available financial allocation was reached. 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.
- Systems up to 5 kWp 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 up to 5 kWp only for private people and was opened for the first time in August 2008. In 2012, the support given per kWp was 800 EUR for standard systems and an additional financial benefit to building integrated systems (BIPV) in the range of 1 000 per kWp.
- Besides this, some regions provide PV support budgets as well, amongst them very specific support, e.g., only for municipal buildings.

At the end of 2012 about 0,5 % of the total delivery of electricity to end users might have been provided by photovoltaics.

RESEARCH AND DEVELOPMENT

The National PV Technology Platform, founded in September 2008, experienced a very good development in 2012; primarily supported by the Austrian Ministry for Transport, Innovation and Technology, this loose platform was transferred into a legal body in 2012, exclusively financed by the participating industry, research organisations and universities. The PV Technology Platform brings together about 25 partners, active in the production of PV relevant components and the relevant research community in order to create more innovation in the Austrian PV sector. The transfer of latest scientific results to the industry by innovation workshops, trainee programmes and conferences, joint national and international research projects, and other similar activities are part of the work programme beside the needed awareness rising aiming at further improving the frame conditions for manufacturing and innovation in Austria at the relevant decision makers. At the end of 2012, about 5 000 employees were working in the PV industry in Austria. This initiative is coordinated by the University of Applied Sciences Technikum Vienna. Since many years, the Austrian PV research activities are mostly focused on national and international projects: The involved research organisations and companies are participating in various national and European projects as well as in different IEA PVPS Programme Tasks 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, "E!mission" by the Austrian Climate and Energy, as well as "Buildings of Tomorrow Plus," are funded by the Ministry for Transport, Innovation and Technology. The programmes cover quite broad research items on energy technologies including a specific PV focus.

Fig. 1 - PV-glass-glass modules at the Fronius PV inverter factory/Upper Austria (Photo: Ertex-Solartechnik GmbH).

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

PV and the high penetration in some parts of the low voltage network becomes more and more a driver of the comprehensive and internationally orientated "Smart Grid" activities in Austria, which are also coordinated and supported by the Ministry for Transport, Innovation and Technology. In 2012, some demo-sites for effectively integrate high shares of PV (and other renewable, such as small hydro and bioenergy) into the distribution network were started, mainly driven by research institutes and some distribution network operators; most of these activities are supported by national or EU research projects.

Fig. 2 - Flexible CZTS photovoltaic film (for integration into building elements) (Photo: crystalsol).

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 187 MW of PV power had been installed in Austria by the end of 2011; for 2012 there are no final figures available yet, but it is expected that nearly 400 MW were totally installed in Austria at the end of 2012.

The annual growth rate in 2011 was, with a total of 92 MW, more than two times the rate of 2010 and by far the largest rate ever, but will be certainly again surpassed by the 2012 numbers.

Austria has some internationally well positioned manufacturers nearly exclusively involved in foreign trade.

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. Building integration is an important issue and a cornerstone of the public implementation strategy; some more quite remarkable installations were realised in 2012.

Besides on-grid applications, off-grid systems are widely used to provide electricity to technical systems or for domestic use in Alpine shelters or houses lying far away from the grid.

MARKET DEVELOPMENT

The National Photovoltaic Association ("PV Austria") is very active in public relations and works by creating a national network for dissemination of information on PV, 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 on 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.

By the end of 2012, well over 100 companies and persons involved in the PV business were Association members.

The 10th Annual National Photovoltaic Conference (a two day event in 2012, organised by the University of Applied Sciences Technikum Vienna and supported by the Ministry for Transport, Innovation and Technology) is well established as THE annual come 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, aiming at addressing mainly the installation companies as well as the end users. Many specific workshops have been organised by "PVAustria."

The "Certified PV Training" for planners and craftsmen, offered by the Austrian Institute of Technology (AIT), has increased its PV program significantly by performing 8 day-training courses all over the country, with a total of more than 200 participants in 2012. For the year 2013, 16 further courses are planned.

FUTURE OUTLOOK

- The producing Austrian PV industry is strengthening its efforts to compete on the global market, mainly by a close collaboration with the research sector, in order to boost the innovation in specific niches of the PV market.
- In general, the situation of the local PV market is improving but would benefit from more stability in the support system.
- Strategic initiatives to strengthen the potential of the local PV Industry will be further increased.
- Grid integration will become a major issue; the fruitful collaboration between research institutes and some national distribution networks operators will create significant results from their first demo-sites.
- 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 Networks," commenced in 2010 and lead by Austria, is just about to become a focal point of the international research activities. However, the national energy research programmes are more and more also dedicated to PV issues, with many projects just 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 to be mentioned, where PV plays more and more an important role.
- The European Building Directive is moving the building sector towards "active buildings" with PV as its central element of generation is already causing a new momentum in the building sector.
- The level of the public know-how and interest about the potential and perspectives of PV is continuously growing. Several renewable energy education courses are already implemented and some new courses are currently under development. All of them include PV as essential part of the future energy strategy. The importance of proper education for installers and planners of PV systems will increase, depending on the market situation; the training is already available and can be extended easily. Meanwhile, at the University of Applied Science Vienna (Technikum-Wien), about 200 students are studying at the Bachelor and Master courses in "Urban Renewable Energy Technologies" with solar and specifically, PV systems, as one core element of the education.

BELGIUM

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

GREGORY NEUBOURG, APERE ASBL, BRUSSELS

Fig. 1 - Polar Station: the Belgian Queen Elisabeth Station is the first zero emission polar station and was built in 2007-2008. Wind and solar power are the only energy sources.

In 2003, the federal government voted a total nuclear power phase-out for 2015. Since nuclear share is more than 50 % of the electricity production and renewables represented only 6,8 % in 2010, the phasing-out had to be re-planned. 3 of the 7 nuclear reactors will shut down in 2015, the others will be kept in operation until 2025. In order to maintain a good level of self-production, along with the reduction of the energy consumption, the development of renewables is one of the most important objectives for the 3 regional governments in Belgium.

The PV success story started in 2009 with massive subsidies from the different regional governments. These subsidies were progressively adapted in accordance with the international PV module prices' reduction. Before each decrease of the green certificates' support or before the suppression of the tax credit, the amount of installed capacity raised abruptly, making the market quite unstable.

In 2012, the authorities realized that PV has a significant impact on the grid but also on the price of electricity. Discussions have been initiated to review the support mechanisms to reduce these impacts (implementation of a compensatory tax, for example). In three regions, support mechanisms are being revised to early 2013.

NATIONAL PROGRAM

In 2010, the 2009/28/EC European Directive to reach 20 % of renewable energy was translated in Belgium into a national renewable energy action plan with an objective of 20,9 % of renewable electricity. For PV, it foresaw an installed capacity of 426,1 MW for the end of 2011 and 1 340 MW for 2020. At the end of 2008, the total power of all photovoltaic systems installed in Belgium was about 100 MW. By the end of 2012, it reached 2,5 GW (non-consolidated), which is almost the double of the objective for 2020.

The same Directive requires Member States to establish a recognized training for installers of small-scale renewable energy systems. Belgium has incorporated this requirement in a global reflection on the quality of PV systems.

RESEARCH AND DEVELOPMENT

R&D efforts are concentrated on highly efficient crystalline silicon solar-cells, thin film and organic solar-cells. There is also some research on smart PV modules that would embed additional functionalities as micro-inverters (mainly Imec Research Center). High penetration of PV in grid systems is being researched and demonstrated in Belgium, mainly in two projects: the European MetaPV project and the local project of Flobecq.

INDUSTRY

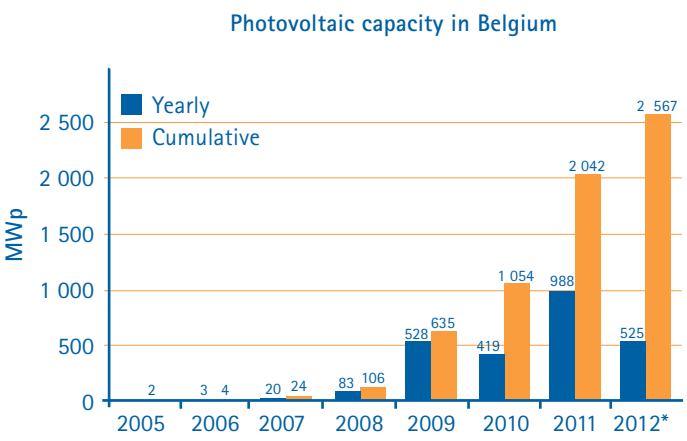
Module production was never a big industry in Belgium. The last factory that produced classical silicium PV modules (Photovoltec) went bankrupt in 2012. The only actors left are specialized in BIPV (Issol, Soltech) or in amorphous silicon (Derbigum). Next to these three big companies, a lot of companies work in all parts of the value chain of PV, making the Belgian PV market a very dynamic sector. (www.pvmapping.be)

Fig. 2 – Brussels Port: The biggest urban PV installation in Belgium has been built in the port of Brussels: 1,2 MWp.

Fig. 4 – European Headquarters: Both the modern and the historical parts of the European Commission's new building, currently in construction, will be covered by an umbrella of photovoltaic panels .

Fig. 5 - Solar Tunnel: The 3,6 kilometer solar tunnel produces enough electricity to power 4 000 trains a year.

MARKET DEVELOPMENT



**Estimation*

Fig. 3 – Photovoltaic capacity in Belgium.

YEAR	YEARLY (MW)	CUMULATIVE (MW)
2005	0	1 616
2006	2 497	4 113
2007	19 661	23 773
2008	82 700	106 473
2009	528 294	634 767
2010	419 122	1 053 889
2011	987 994	2 041 883
2012*	525 423	2 567 148

**Estimation*

In terms of market development, despite the economic crisis, 2012 will probably be comparable to 2009 with more than 500 MW installed, bringing Belgium to an approximate 2,5 GW installed capacity (±230 Wp/inhabitant) .

Small-scales projects (< 10 KW) represent 61 % of the installed capacity with more than 305 000 installations. The other 39 % include 5 300 large-scale projects.

At the regional level, Flanders installed a lot more than the other regions but this is only due to the large-scale projects for which the financial conditions were better than in other regions over the last years. Bureaucratic barriers were also less important. Since the end of 2012, the Brussels region has the best conditions for large and small-scale projects.

Trends for 2013 are quite uncertain. Big changes in the subsidies are planned in Flanders and Wallonia. Flanders has already introduced a compensatory tax (53 EUR/kWp/year) for the use of the electricity network. That will certainly have an impact on new projects.

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

PATRICK BATEMAN, CANADIAN SOLAR INDUSTRIES ASSOCIATION (CANSIA) (HTTP://WWW.CANSIA.CA)
LISA DIGNARD-BAILEY AND YVES POISSANT, CANMETENERGY, NATURAL RESOURCES CANADA

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 Province of Ontario, Canada's most populous and second largest province, leads the country in photovoltaic (PV) investment. In 2012 an additional 267 MWac was installed, for a cumulative PV power capacity of 645 MWac in operation. This is a 70% increase over the 2011 installed capacity.

Fig. 1 - A 260 kilowatt solar PV rooftop system installed at the Okanogan College in British Columbia to meet the ambitious target for the living challenge and help train students in green construction practices (Photo: Skyfire Energy).

The next most notable developing market is that of the province of Alberta (Canada's fourth largest and third most populous) due to its Micro-Generation Regulation [2] and programs such as ENMAX's Generate Choice [3]. In the province of British Columbia several large demonstration projects significantly increased the installed capacity. Figure 1 highlights the most recent 260 kilowatt PV installation at the Okanogan College targeting net-zero energy consumption. In the Northwest Territories a large 61 kWp PV system was installed (Figure 2) to assess the cost and benefits of PV for diesel-powered remote community microgrids.

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 and 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.

The PV Innovation Research Network, funded by the Natural Sciences and Engineering Research Council (NSERC), brings together a core group of 32 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners. The network submitted its midterm report and held its third national scientific conference and first Canadian PV graduate school event. The network focuses its efforts on organic, nanostructure and other innovative PV device approaches that have the potential to leapfrog existing and established technologies.

The NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBSN) performs research that will facilitate widespread adoption in key regions of Canada of optimized net zero energy buildings design and operation concepts by 2030. CanmetENERGY is contributing 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". 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.

Fig. 2 - Fort Simpson is Northwest Territories Power Corporation largest diesel-powered community. This 61 kilowatt system (the largest North of 60 degrees in Canada) will help displace 15 000 litres of fuel annually and provide up to 8,5 % of the village's minimum power requirements during the summer (Photo: Skyfire Energy).

IMPLEMENTATION

Ontario's Feed-In Tariff Program

Ontario's Feed-In-Tariff (FIT) and microFIT programs, managed by the Ontario Power Authority (OPA), are North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuel sources including solar-PV, bio-energy, waterpower and wind. In 2012, the program pricing schedule for PV systems was revised to reflect decreasing equipment costs and other market factors [4].

As of December 2012, the OPA received, under the FIT program, 10 299 applications representing about 21 292 MWAC of PV generating capacity. Of these applications, more than 1 700 projects currently have contracts for roughly 4 500 MWAC of capacity. Under the microFIT program, the OPA has received approximately 56 000 applications representing 514 MWAC of generating capacity, 99 % of which was for solar PV. Roughly 14 800 microFIT projects have been contracted so far, representing 130 MW connected to the grid.

The OPA recently opened an application period for small FIT projects (>10 kWAC up to 500 kWAC), from which it expects to award up to 200 MWAC worth of contracts. Because of delays, some suppliers under the precursor program to FIT, the RESOP program, have been given extensions to complete their projects. The OPA reported that approximately 395 MWAC of solar PV is operational and 80 MWAC is still under development from the RESOP program.

Alberta Microgeneration Program

A new renewable energy micro-generation program from ENMAX Energy Corporation was introduced in the province of Alberta in 2010 [3]. ENMAX Energy is a subsidiary of ENMAX Corporation which is owned by The City of Calgary. As part of the new program partly funded by the Alberta Climate Change and Emissions Management (CCMEC) Corporation, ENMAX will deliver turnkey home generation solutions (including wind and solar) to residential consumers across Alberta. To date ENMAX has installed more than 500 kWp of micro-generation in Alberta under the program. The not-for profit CCMEC Corporation was established in the province of Alberta to "achieve actual and sustainable reductions in greenhouse gas emissions and facilitate climate change adaptation by stimulating transformative change through investments in climate change knowledge, clean technology development and operational deployment."

INDUSTRY STATUS

Canada's solar sector has experienced continued significant investment over the last 4 years. Employment in PV-related areas in Canada has grown with a 2012 labour force estimated at over 5 500 compared to 2700 jobs in 2009.

In 2012, a Sector Profile for Solar Photovoltaics in Canada was published. It reported on the state of the PV market including various incentives in place, describing the PV supply chain, key manufacturers, economic impacts, workforce capability and the state of R&D initiatives in Canada. [5]

MARKET

PV power capacity in Canada grew at an annual rate of 25 % between 1994 and 2008. In recent years this growth was 202 % in 2010 and 49 % in 2011 due to the Ontario incentive programs. 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 as shown in Figure 3, due to 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 84 % of the cumulative PV installed capacity in Canada in 2008. However the off-grid market represented less than 1 % of PV systems installed in Canada in 2011, due to the large growth of grid-connected applications. The national survey completed for 2011 showed a significant decrease in PV module prices (weighted average) to 1,52 CAD per watt, compared to 9,41 CAD in 2001. This represents an average annual price reduction of 20 % over a 10-year period.

FUTURE OUTLOOK

The Feed-In Tariff (FIT) 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. Other Canadian provincial and territorial governments continue to evaluate the potential for accelerating the deployment of solar PV in their energy mixes with significant progress expected in Alberta in 2013. The Canadian Solar Industry Association in their strategic planning process has identified innovation in the solar electricity sector as a key strategic opportunity for Canada. A committee will support an in-depth analysis of opportunities for innovation in solar electricity generation and prepare a Solar Electricity Innovation Roadmap for Canada in 2013.

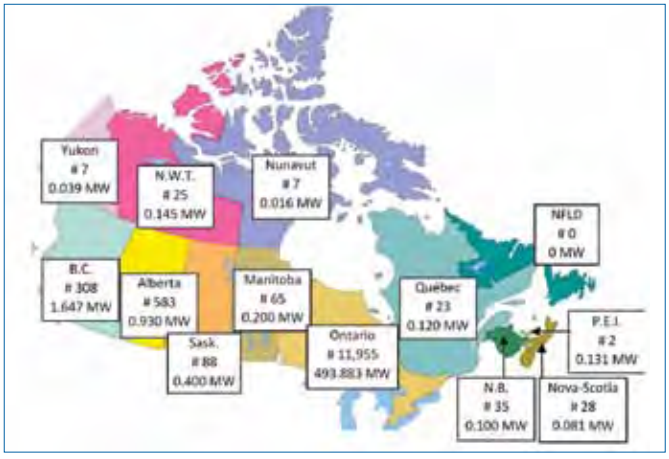


Fig. 3 - Map showing the Canadian provinces, the capacity (megawatt) and the number of utility interconnected PV Systems in 2011.

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CHINA

PV TECHNOLOGY AND PROSPECTS

WANG SICHENG, ENERGY RESEARCH INSTITUTE, CHINA NATIONAL DEVELOPMENT AND REFORM COMMISSION
XU HONGHUA, INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCE
LV FANG, INSTITUTE OF ELECTRICAL ENGINEERING, CHINESE ACADEMY OF SCIENCE

GENERAL FRAMEWORK

China is facing serious pressure on energy supply and GHG emission, China has make efforts to overcome these problems. Renewable energy (RE) development is the basic strategy in China for energy sustainability and GHG reduction. Solar PV will play a key role in renewable energy development in China.

The China RE Law went into effect on January 1, 2006 to support RE and it was updated in 2009. Based on the RE Law, there are two funds which can be used to support RE. One of the funds is the RE Surcharge; collected from all end users of electricity at the rate of 0,8 cents/kWh and about 20-25 BCNY will be collected each year. The other is the special RE Fund; directly controlled by Ministry of Finance, with about 10-20 BCNY available each year. Currently, the RE Surcharge is used to subsidize electricity generated by RE (PV, wind power and biomass power) through the means of a Feed-In Tariff (FIT) and the Special RE Fund is used to support the government sponsored projects: The PV Building Project and the Golden Sun Demonstration. The status of government supported projects is listed in Table 1:

TABLE 1 – GOVERNMENT SPONSORED PV PROJECTS

LARGE SCALE PV		
Phases	**Approved Capacity**	**Feed-in Tariff**
2011 FIT	2 000 MW	FIT = 1,15 CNY/kWh
2012 FIT	2 000 MW	FIT = 1,0 CNY/kWh
Total (2009 - 2012)	4 300 MW	800 MW waiting for grid connection
Financial Source	Renewable Energy Surcharge	
PV BUILDING PROJECT		
Phases	**Approved Capacity**	**Subsidy to Capital (CNY/W)**
3rd phase, 2011	106 projects, 120 MW	BIPV 12 CNY /W
4th phase, 2012	250 MW	BIPV 9 CNY /W, BAPV 7,5 CNY /W
Total (2009 - 2012)	500 MW	
Financial Source	Special Fund for Renewable Energy	
GOLDEN SUN DEMONSTRATION		
Phases	**Approved Capacity**	**Subsidy to Capital (CNY/W)**
3rd phase, 2011	140 projects, 690 M	C-Si 9,0 CNY/W, a-Si 8,5 CNY/W
4th phase, 2012	167 projects, 1709 MW	PV Building 5,5 CNY/W, off-grid >7,0 CNY/W
Total (2009 - 2012)	2870 MW	
Financial Source	Special Fund for Renewable Energy	
ADDITIONAL PV BUILDING PROJECT AND GOLDEN SUN DEMONSTRATION		
Phases	**Approved Capacity**	**Subsidy to Capital (CNY/W)**
November 2012	2830 MW	BIPV 7 CYN/W, BAPV 5,5 CYN/W
Financial Source	Special Fund for Renewable Energy	
Total Installed and Approved PV by the end of 2012 is 10 500MW		

On December 19, 2012, Premier Wen Jiabao chaired the meeting of State Council to approve 5 approaches to support solar PV:

(1) To push forward the shakeout and recombination of the PV industry by market force (to overcome the problem of over-capacity in the PV industry in China);
(2) The government PV market development plan should be agreed upon with the plan of the Grid Company (to avoid the problem of delay of grid-connection and cut-off PV power plants from grid for safety);
(3) Expanding the domestic PV market and focusing on distributed PV (to change the situation of high dependency on the foreign markets and encourage distributed PV instead of LS-PV);
(4) To set up solar resource based Feed-in Tariffs of PV, stop capital subsidy and move to performance based tariff subsidy (originally, only one PV FIT for the whole of China and capital subsidy for the PV Building Project and the Golden Sun Demonstration);
(5) To follow the market mechanisms, reduce government interference and prohibit local protections (to setup a healthy market for PV in China).

NATIONAL PROGRAM

In 2012, the National Energy Administration (NEA) released the 12th 5-Year Plan (2011-2015) for Solar Power Generation. The updated target of cumulative solar power installation for 2015 and 2020 is listed in Table 2:

TABLE 2 - GOVERNMENT TARGET FOR SOLAR POWER (2015, 2020)

TARGETS FOR CUMULATIVE INSTALLATION OF SOLAR POWER (GW)				
Market Sectors		2012	2015	2020
Distributed PV	Rural Electrification	0,102	318,2	6,92
	Communication and Industry	0,058	100,0	2,17
	PV Buildings	2,390	14,0	40,0
LS-PV and Others	PV Products	0,058	1,0	4,0
	Large Scale PV (LS-PV)	4,392	15,0	40,0
	Solar Thermal Power (CSP)	0,000	1,0	2,0
Total		7,0	35,0	100,0
Share of Distributed PV (%)		36,4	51,4	54,0

TABLE 3 - SOLAR POWER TARGET AND ANNUAL PROGRESS FORECAST

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual Inst. (GW)	2,7	3,5	6,0	10,0	12,0	12,0	12,0	12,0	14,0	15,0
Cumul Inst. (GW)	3,5	7,0	13,0	23,0	35,0	47,0	59,0	71,0	85,0	100,0

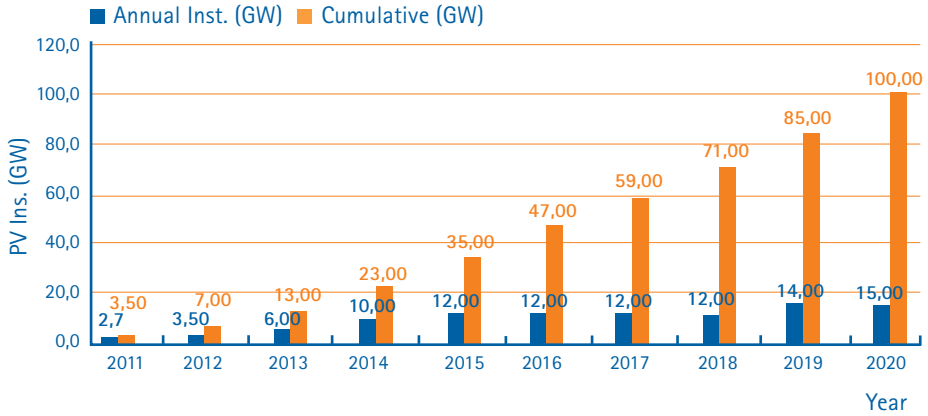

Fig. 1 - Solar Power Target and Annual Progress Forecast.

RESEARCH AND DEVELOPMENT (R&D)

The Ministry of Science and Technology (MOST) government unit is in charge of R&D for PV. The average annual investment for R&D from MOST is about 500 MCNY and the supported fields cover all the manufacturing chain: Poly-Si, wafer, solar cells, PV modules, thin-film technology, CPV, energy storage, BOS components and system engineering.

TABLE 4 – SOLAR POWER TARGET AND MARKET SHARE BY SECTORS

R&D AT BOTH LABORATORY LEVEL AND INDUSTRY LEVEL					
POLY-SILICON INDUSTRY LEVEL			BOS AND PV SYSTEMS		
Hydrogen Reduction	60 kWh/kg		Inverters	Total Capacity	3 GW/Year
				Types	off-grid, centralized, string inverter, micro-inverter
Total Power Consumption	120 kWh/kg			Power Range	100 W - 1 MW
By-products Recycling	100 %				
Capacity/Factory	1 000 - 60 000 Ton/Year		Energy Storage	Lead-Acid	Industrialized
				Lithium Battery	Industrialized
Total Capacity	100 000 Ton/Year				
Cost	$ 15-20 USD/kg			Vanadium Redox Battery	Industrialized
EFFICIENCY OF SOLAR CELLS				Na-S Battery	No
PV Cells	Laboratory (%)	Industry (%)		Flywheel	No
Mono-Si	20,40	19,00		Super-Capacitor	Industrialized
Poly-Si	18,00	17,00		Pumped Storage	Industrialized
D-Junction a-Si	9,20	8,00		Compressed Air Storage	No
u-Si/a-Si M-Junction	11,80	10,00	PV Systems	Off-grid PV	Mature
GaAs	29,25	No		LS-PV	Mature
CIGS	14,30	12,00		PV Buildings	Mature
CdTe	13,38	11,00		Sun Trackers	Mature
DSC	7,40	No		Micro-Grid	Demonstration
HIT	17,27	No		PV Products	Mature
Back-Contact	No	No		Monitoring Sys.	Mature

PV INDUSTRY DEVELOPMENT

China has been the largest producer of PV modules in the world since 2007. In 2012, the total PV module production was about 23GW; a little bit higher than in 2011 (21GW). Even though China is the largest producer in poly-Si in the world, it still needs to import at least 80 000 Tons from other countries, about a 55 % share. The PV industry situation in China is shown in Table 5:

Fig. 2 - Hydro-PV Micro-Grid Demonstration Project in Qinghai Province.

TABLE 5 – POLY-SILICON PRODUCTION IN 2012

COUNTRY	US	EU	Japan	Korea	China	Other	Total
PRODUCTION (TON)	60 000	50 000	13 000	45 000	65 000	7000	240 000

TABLE 6 - DOMESTIC PRODUCTION OF POLY-SI AND SHARE OF IMPORTED POLY-SI

YEAR	2006	2007	2008	2009	2009	2011	2012
Production (Ton)	300	1 100	4 729	20 357	45 000	85 000	65 000
Demand (Ton)	4 000	10 000	25 000	40 000	89 000	145 000	145 000
Shortage (Ton)	3 700	8 900	20 271	19 643	44 000	60 000	80 000
Share of Import (%)	92,5	89	81,1	49,1	49,4	41,4	55,2

TABLE 7 - PV MODULE PRODUCTION IN CHINA (2011, 2012)

NO.	Company	2011	2012
1	SunTech Power	2 090	1 800
2	Yingli Green Energy	1 603	2 100
3	Trina Solar	1 510	1 800
4	Canadian Solar	1 323	1 900
5	Tianwei New Energy	900	1 000
6	Hanwha SolarOne	844	1 000
7	Jinko Solar	760	900
8	LDK Solar	600	750
9	JA Solar	500	900
10	Hareon Solar	428	800
11	Others	10 422	10 050
	Total	21000	23000

PV MARKET DEVELOPMENT

In 2012, total domestic PV installation was about 3,5 GW, much less than the original expectation (4,5 – 5,0 GW), due to the delay of subsidy payment and difficulties in grid connection. The PV installation in China is listed in Table 8:

TABLE 8 - PV MARKET DEVELOPMENT IN CHINA

2012 DOMESTIC PV MARKET BY SECTORS					
No.	Market Sector	Annu.Ins. (MWp)	Share (%)	Cumm. Ins. (MWp)	Share (%)
1	Rural Electrification	20	0,57	102,5	1,5
2	Comm. & Indus.	10	0,29	58,0	0,8
3	PV Products	10	0,29	57,5	0,8
4	Building PV	1 460	41,71	2 390,0	34,1
5	Ground Mounted LS-PV	2 000	57,14	4 392,0	62,7
	Total	3 500	100,00	7 000,0	100,0

In 2012, the management duty of RE surcharge was moved from the Grid Company to the Ministry of Finance (MOF) and MOF will fill the gap of subsidy in case the RE surcharge is not enough. In this case, the problem of shortage of RE surcharge and the delay of payment will be never happen again.
During the last 6 years, the cost of PV has been reduced sharply. It is believed that PV will reach grid parity on the user side or peak power by 2015 and reach grid parity on the generation side by 2020.

It is expected that in 2013, domestic PV installation in China will be 5-10GW, due to the following reasons:

- Subsidy money will not be delayed, the MOF will be in charge of payment;
- Grid connection will become easier since the government plan will be agreed upon with the grid development plan;
- The government sponsored project for Distributed PV will start soon. The announced cap will be 15 GW within next 3 years;
- The new PV tariff will be set, based on local solar resources.

TABLE 9 - PRICE REDUCTION OF PV DURING THE LAST 6 YEARS

YEAR	2007	2008	2009	2010	2011	2012
Cumulative Installation (GWp)	0,10	0,14	0,30	0,80	3,30	7,00
Module Price (CNY/Wp)	36,0	30,0	19,0	13,0	9,0	4,5
System Price (CNY/Wp)	60,0	50,0	35,0	25,0	17,5	10,0
Reasonable Tariff of PV (CNY/kWh)	3,20	3,00	2,50	2,00	1,15	1,00

DENMARK

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

Fig. 1 - Apartments for primarily young students at the harbor of Aarhus. Architect Arkitema. The photographer is architect Thomas Mølvig, who has been kind to let use the photo in this report.

GENERAL FRAMEWORK

The new Danish government launched its energy plan in November 2011, called "Our Energy," with the vision of a fossil free energy supply by 2050 and interim targets for energy efficiency and renewable energy by 2020 and 2035, e.g. by 2020 50 % of the electricity shall come from wind turbines. The energy plan was finally agreed upon in March 2012 by a broad coalition of parties in- and outside the government. The plan, which reaches up to 2020, was further detailed in the government's energy statement of May 2012.

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 only technology specific targets for wind energy and biomass.

Renewable energy is not only a future option, but very much a present and considerable element in the energy supply: By end of 2012 more than 30 % of the national electricity consumption was generated by renewable energy sources, including incineration of waste. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the proposed energy plan, the main objectives being the development of a future environmental benign energy system completely free of fossil fuels. Renewable energy technologies, in particular wind, thus play an important role, but PV is still just seen as one among other emerging renewable energy technologies to be prioritized when found viable.

Key actors have been identified as: Utilities – carrying out small and large R&D and in particular, demonstration projects and general deployment activities; 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 growing interest in and willingness to buy PVs.

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 goals and plans, and these organisations are expected to play a key role in the future deployment of PV in the country.

NATIONAL PROGRAM AND IMPLEMENTATION

Denmark has no unified national PV programme, but does have a number of projects supported mainly by the Danish Energy Authority and via the Public Service Obligation (PSO) of the Danish transmission system operator, Energinet.dk, a fully government owned body. A couple of public funds also support PV related projects, mainly supporting market entrance.

Net-metering for privately owned and institutional PV systems was established in mid-1998 for a pilot-period of four years. The net-metering scheme was extended in late 2002 for 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 was found to prevent it from reaching its full potential. During the political negotiations in the fall of 2005, the net-metering for privately owned PV systems was consequently made permanent, and net-metering, during 2012, at a level of approx. EURcents 0,30/kWh; primarily because of various taxes – combined with dropping PV system prices which proved during 2012 to be able to stimulate PV deployment seriously, as the installed capacity during 2012 grew from about 13 MW to almost 330 MW; a growth rate of about 25 times. For PV systems qualifying to the net-metering scheme, grid-parity has been reached.

This dramatic grow gave rise to political debate towards the end of 2012, and the government announced a revision of the net-metering scheme reducing the net-metering time window from one year to one hour. At the same time the net-metering scheme should also encompass PV systems owned by cooperatives or businesses. In January 2013 the new regulations were still not minted out, and the consequences of the new regulation – besides a general impairment – are not yet fully known, but a tariff of about EURcents 0,17 – 0,19/kWh for PV electricity supplied to the grid outside the new 1 hour net-metering time window appears to be in place.

The potential for large scale deployment of PVs in Denmark in the national PV strategy has been identified as building integrated systems. A few major activities shall be mentioned.

The Skive municipal project had implemented about 1,5 MW by end of 2012 on municipal buildings and is expected to implement in total 1,6 MW at the end of project medio 2013. Other municipalities and regions have taken up the example of Skive.

The PVIB project on the island of Bornholm had implemented more than 2 MW by end of 2012, mostly in the form of roof-tops. The municipality of Bornholm is preparing about 1 MW of PV on its own buildings and a large scale 1,6 MW plant is under preparation. The BIPV project targeting 5 MW or a PV penetration of 10 % in the local grid system is integrated into the EU EcoGrid project investigating the future Smart Grid of Europe.

Energinet.dk started registration of grid connected PV installations in 2010. This effort had proven fully operational for new installations in 2012. With a market growth in 2012 of 25 times, a reliable registration of new installations is found crucial.

RESEARCH AND DEVELOPMENT

R&D efforts are concentrated on silicon processing, crystalline Si cells and modules, polymer cells and modules and power electronics. R&D efforts are beginning to exhibit commercial results in terms of export, in particular inverters.

Penetration and high penetration of PV in grid systems are being researched and demonstrated, and network codes are under revision to accommodate a high penetration of inverter-based decentral generation and to conform to the EU wide harmonisation under development in Entso-E/EC.

INDUSTRY AND MARKET DEVELOPMENT

A Danish PV industrial association (Dansk Solcelle Forening) was established late 2008. With about 50 members, the association has provided the emerging PV industry with a single voice and is introducing ethical guidelines for its members. The association has formulated a strategy aiming at 5 % of the electricity for private household coming from PV by 2020, but is now revising this target due to the high market growth rate in 2012.

Fig. 2 - The town hall of Skive. The photographer is architect Karin Kappel, who has been kind to let use the photo in the report.

The inverter manufacturer Danfoss Solar Inverters has continued its successful expansion during 2012, mainly in terms of export and has increased its staff considerably.
A couple of Danish module manufacturers each with an annual capacity of a few MW per shift are on the market. A few other companies producing tailor-made modules such as window-integrated PV cells can also be found.
There is no PV relevant battery manufacturing in Denmark at present.
A few companies develop and produce power electronics for PVs, mainly for stand-alone systems for the remote-professional market sector such as telecoms, navigational aids, vaccine refrigeration and telemetry.
A number of companies are acting as PV system integrators, designing and supplying PV systems to the home market. With the rapidly expanding market in 2012, the number of market actors is growing fast.
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.

Total PV business volume in 2011 is very difficult to estimate with any degree of accuracy primo 2012, due to the commercial secrecy surrounding the above mentioned business developments. However, the business volume of about 9 MW on the domestic market is estimated at around 30 MEUR and combined with exports, the estimate is around 125 MEUR.

The cumulative installed PV capacity in Denmark (including Greenland) was estimated at about 332 MW by the end of 2012.

FUTURE OUTLOOK

The ongoing annual government funds at 135 MEUR allocated to R&D into energy and renewables are expected to give an ongoing boost to the PV sector, as well, in terms of an increasing share of Danish products.

The future market development for PV in Denmark will strongly depend on the final revision of the net-metering scheme, but as of early 2013, the market has been frozen; while waiting for the new net-metering framework to be finalized.

EUROPEAN COMMISSION

RESEARCH DEVELOPMENT AND DEMONSTRATION ACTIVITIES ON PHOTOVOLTAICS SUPPORTED AT THE EUROPEAN UNION LEVEL

PIETRO MENNA, EUROPEAN COMMISSION, DIRECTORATE-GENERAL FOR ENERGY
FABIO BELLONI, EUROPEAN COMMISSION, DIRECTORATE-GENERAL FOR RESEARCH AND INNOVATION

EUROPEAN ENERGY POLICY FRAMEWORK

Energy Roadmap 2050

The policy drivers established by the 2008 Energy and Climate package – reducing greenhouse gas emissions, increasing security of supply and improving the competitiveness of the energy sector – all remain valid. The need to achieve our objectives in these areas is still strong, despite current economic circumstances. Indeed it is important to recall that delays in climate change mitigation would raise societal costs significantly. Policy development, preparing the right regulatory, industrial and technological framework and the right legal instruments for the post-2020 environment will continue. Given its current position, its potential for further development and cost reduction, mass deployment and increased efficiency, the photovoltaic industry will continue to be an ever more important part of Europe's energy sector.

In 2011 the European Commission published an overall "low carbon economy" roadmap to 2050, a transport sector -specific 2050 White Paper and a Communication outlining a 2050 energy roadmap, presenting different pathways to the decarbonisation of the energy sector. Various studies and contributions from different stakeholders have also flagged up how decarbonisation can begin.

Renewable Energy: a major player in the European energy market

Following up the Energy Roadmap 2050, the Commission published a renewable energy-specific Communication in June 2012. The intent was to give clear signals to industry about the longer term perspectives for renewable energy. The Communication started with the findings of the Energy Roadmap 2050: whatever decarbonisation pathway is followed, however we aim to improve our security of supply; strong growth of renewable energy is therefore a "no regrets" policy. Another clear message from the Roadmap 2050 was that under current policies, we will miss our objectives; so it is clear that a strong new policy regime for post-2020 must be established. The Communication also explored key issues that still need to be addressed on the way to 2020: the single market, renewables support and trading, and renewables in the Mediterranean.

The work on the creation of the single European electricity market is still on-going; and is promised for 2014. A competitive and open market is important for new entrants, namely renewable energy producers. A technology-neutral electricity system management framework – with grid codes and guidelines, infrastructure development which no longer favours incumbents and conventional electricity generation – is an urgent necessity. With such a framework, the transformation of Europe's electricity industry can be accelerated, bringing in new technologies, new market players, greater distributed generation, and demand management. All this will become increasingly possible as the market becomes more competitive and dynamic.

The cost of support to renewables is also an important issue that needs urgent attention. This is, in particular, the case for PV, because it is in PV that the market growth has taken governments by surprise and caused major increases in expenditure on support. The expectation of the Commission is that by creating a competitive market and correcting other market failures, renewable energy will be able to favourably compete with conventional energy sources. As the scale of the industry continues to grow, costs will continue to fall, so that support for renewables can continue to be reduced and eventually phased out.

The reforms to renewable energy support schemes, which have taken place during the last two years, have shown that their cost effectiveness and the incentives for further reducing costs can be much improved, that the market distortions resulting from differences in the national schemes can be reduced, and that the sometimes uncoordinated nature of the reforms can also be improved. This is the reason why the Commission announced plans to produce guidance on support schemes, aiming to ensure that stable predictable frameworks are created, while avoiding that the necessary support results in either huge deficits or unacceptable increases in electricity prices.

Another feature of the market which is helping to ensure that renewables growth occurs in a cost-effective manner is the increase in "trade" in renewables. The Commission points out that it makes sense to exploit renewables where it is more cost- effective, rather than just in the domestic markets of those Member States that are concerned with achieving their 2020 targets. The Renewables Energy Directive created "cooperation mechanisms" to facilitate such trade, but these mechanisms have not yet been extensively used. The Commission therefore plans to produce guidance on their use.

A further element which could help ensure that renewable energy will become a major player in the EU energy market is the improvement of the energy relations and trade between EU and southern Mediterranean countries. The scope for renewable energy growth in North Africa is vast, but new regulatory and infrastructure measures must be developed and put in place, and a market regime created. A number of Commission initiatives are in place to assist with the development of energy market framework conditions in these countries. In addition, the Renewable Energy Directive's "cooperation mechanisms" provide for importing renewable energy from third countries and counting it against a Member State's target. This incentive for renewable energy development and trade could be strengthened, and the Commission is therefore working on guidance on this matter, too.

In addition to these four areas where the Commission will provide more guidance, the 2012 Communication emphasised that, as already indicated in the Energy Roadmap 2050, a strong policy framework will still be needed if renewable energy growth is not to slump after 2020. A range of policy options is highlighted, including emissions reductions, renewables diversification and technology innovation, as well as a broader EU harmonised approach. Work on the future policy framework is recommended to start as early

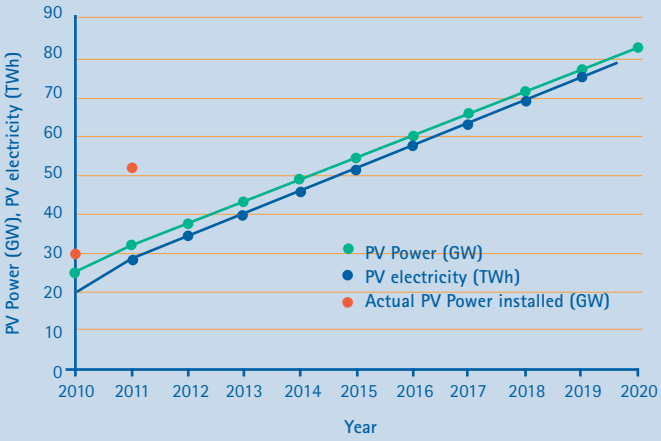

Fig. 1 - PV sectorial targets estimates based on the National Renewable Energy Action Plans (NREAPs) notified to the European Commission by the 27 Member States. Cumulated PV power installed in EU 2010 and 2011 is also indicated (red dots).

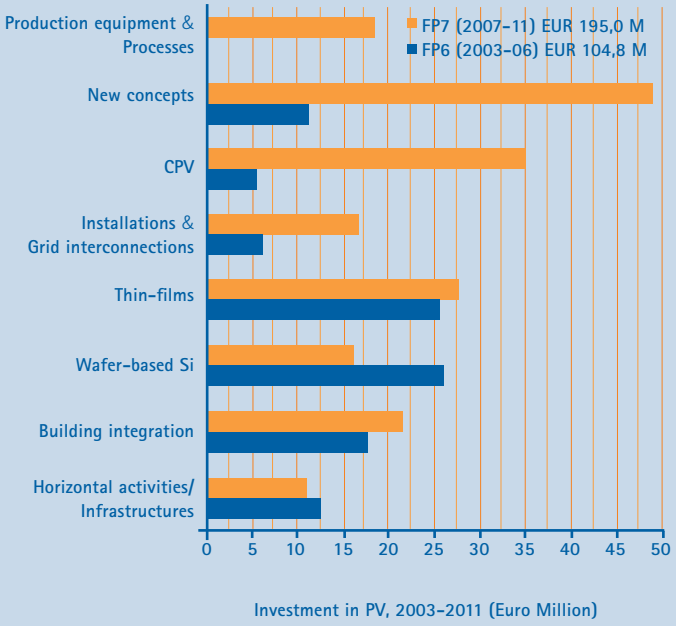

Fig. 2 - Investment in PV, 2003-2011.

as possible. Interactions with other policy areas - in particular international climate change policy - are of course an important issue in this context.

Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)

Following a recast procedure, the new WEEE Directive seeks to increase the amount of waste electrical and electronic equipment that is recycled [1]. The Directive maintains the current collection target of 4 kg/capita/Member State until 2015. From 2016 it introduces a collection target of 45 % of electronic equipment sold and, as a second step from 2019, a target of 65 % of equipment sold, or 85 % of electronic waste generated. These targets apply as a per capita average of all WEEE in each Member State together, in the sense that they do not necessarily have to be achieved by each sector individually.

Photovoltaic panels are within the scope of the Directive, as of its entry-into-force date of 13 Aug 2012. Member States will have to amend their existing legislation on WEEE and align it with the new Directive and the new targets by 14 February 2014, at the latest. Producers are obliged to register their sales of new equipment in national registers, and are obliged to comply with their waste and financing obligations in each Member State.

The Commission will adopt an implementing act as soon as possible, in order to harmonize the details of the registration procedures.

DEPLOYMENT

In 2011, more than 29 GW of PV systems were newly connected to the grid worldwide; up from about 17 GW in 2010. In the same year, Europe was confirmed as the predominant area of global PV demand, hosting 75 % of the new global capacity. Italy was the largest market for the year with 9,3 GW newly connected to the grid, followed by Germany (7,5 GW) and France (1,6 GW). The cumulated photovoltaic capacity installed in Europe by the end of 2011 is estimated at more than 51 GW, from about 30 GW the year before [2]. The significant EU domestic imbalance between demand and supply of photovoltaic modules persisted in 2011, with less than 30 % of the demand satisfied domestically. The imbalance is much lower for inverters of PV systems and essentially negligible for the EPC/installation services, which are supplied almost entirely by EU companies [3]. These considerations are important because, with falling module prices, balance of system costs become increasingly significant. For instance, balance of system costs are currently higher than module costs in some ground-mounted systems.

The feed-in tariff support schemes for photovoltaics, first introduced in Europe, have permitted PV industry to grow up, and PV to step up and become a mainstream power generation technology. During the last few years, we have recorded substantial changes in the industry structure and, especially, an accelerated price reduction of the technology. This has led to continued rush on installations, as investors have tried to make the most of the difference between feed-in tariff and the cost of PV electricity. The growth of the PV market was unanticipated by national authorities, despite the application of a number of complex schemes which were intended to take market dynamics into account. It appears now that the combined effect of reduction of the support schemes, introduction of caps, and restricted access to finance will limit the growth of PV installations in Europe.

Predictability of prices and their consistency with the current scale of the sector justifies further considerations, particularly with regard to whether the center of gravity of the photovoltaic industry has already moved from technology development and demonstration to market deployment. The shaping of future national support instruments might benefit from the conclusions of such considerations.

RESEARCH AND DEMONSTRATION PROGRAMME

The 7th Framework Programme

The 7th Framework Programme for Research of the EU, FP7 (2007-2013), received a higher budget than the previous programme, and ran for seven years. Calls for proposals based on topics identified in the work programme have been published on an annual basis. Seven calls for proposals have been published for the years from 2007 to 2013, including the last 2013 calls. Material development for wafer-based silicon devices, photovoltaics based on solar concentration, and manufacturing process development have attracted relevant European funding. Significant funding has been also made available for thin-film technology and for the development and demonstration of new concepts and approaches for building construction elements based on PV. The EU investments supporting PV R&D and demonstration from 2003 to 2011, broken down by field of activity, are reported in Figure 2.

A more detailed discussion of the research and demonstration topics and of the granted projects is provided elsewhere [4].

Horizon 2020 – The Framework Programme for the 2014-2020 Period

Horizon 2020 is the next framework programme for research and innovation, spanning over the 2014-2020 period. The European Parliament and Council are negotiating the terms for the adoption of the legislative acts, on the basis of the Commission proposals [5]. Horizon 2020 is expected to continue the EU support for the development of efficient, reliable and cost-competitive solar energy systems.

EUROPEAN SOLAR INDUSTRY INITIATIVE OF THE SET-PLAN

Within the frame of the Strategic Energy Technology Plan (SET-Plan) of the European Union [6], the European Industry Initiatives (EIIs) have been conceived as large scale programmes aiming at the rapid development of key energy technologies. The Solar Europe Industry Initiative (SEII), in particular, was launched in June 2010 to contribute to reach ambitious objectives in terms of the solar electricity share of the European electricity consumption by 2020. The SEII deals with both PV and concentrating solar power (CSP).
The SEII-Team is the plenary body, composed of representatives of fifteen countries, industry, EERA-PV and EERA-CSP, and the European Commission.

With regard to the PV sector, in early 2012 the SEII Team has identified seven priority project clusters: I. Solar glass and encapsulation materials; II. Si feedstock, crystallization and wafering; III. High efficiency PV modules based on next generation crystalline silicon solar cells; IV. Innovative processes for inorganic thin-film cells and modules: manufacturing demonstration; V. Dedicated modules for BIPV: design and manufacturing; VI. Concentrator technology: development of components and demonstration of systems; VII. Grid integration and large-scale deployment of PV.

These seven priority thematic areas will be a key part of the joint programming activities of the ERA-NET project which is called "SOLAR-ERA.NET". Eighteen organizations (funding bodies and research programme managers) from fourteen countries participate in the SOLAR-ERA.NET which started operating by the end of 2012.

The SEII 2013-2015 Implementation Plan for PV is currently being drafted in order to replace the previous 2010-2012 Plan.

CONCLUSIONS AND PERSPECTIVES

EU action in the PV sector continues to pursue an increasingly effective mix of policy measures, technological development and demonstration programmes as well as market transformation programmes. The successful deployment of renewable technologies, particularly PV, raised questions about the most cost-effective way of promotion. The policy debate mainly focuses on how national support instruments for RES electricity should be improved and to which extent they can be coordinated at a European level. The Commission wishes renewable energy and PV to be developed as cost-effectively as possible, continues to work with the Member States on the implementation of the RES Directive, and is committed to start the discussion of the post-2020 policy framework. This action is to couple with the tenacious pursuing of innovative technology patterns, if Europe's global leadership in renewable energy is to continue. PV is expected to play a key role in a sustainable, decarbonised and competitive energy system after 2020, as one of the "no-regrets" options.

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S ACTIVITIES

GAËTAN MASSON, EPIA, HEAD OF BUSINESS INTELLIGENCE
CRAIG WINNEKER, HEAD OF POLITICAL COMMUNICATION

Fig. 1 - EPIA's Industry Area at the 27th EU-PVSEC 2012.

EPIA – the European Photovoltaic Industry Association – is **the voice of the photovoltaic industry in the world's largest PV market**, with Members active along the whole solar PV value chain: from silicon, cells and module production to systems development and PV electricity generation as well as marketing and sales. EPIA's mission is to give its global membership **a distinct and effective voice in the European market**. In this framework, the association is responsible for:

POLITICAL ACTIVITIES

EPIA represents its Members by working to influence European policymakers and move the debate on issues related to the PV industry and renewable energy in general. Among other things, we are actively engaged in:

- Monitoring and influencing key legislative developments at EU and national level relevant to PV
- Developing industry positions in order to interact with the decision-making process in Europe
- Providing expertise on PV technology to the EU institutions, as well as at national and international levels
- Building a network of contacts with representatives of the EU institutions and of the energy sector
- Providing appropriate information to Members and gathering their input

PV KNOWLEDGE CENTER

EPIA keeps its Members informed and up-to-date on the PV industry with targeted business intelligence on markets, industry and technologies. We are constantly:

- Monitoring and analysing market trends
- Analysing the impact of policies on market and industry development
- Assessing technological developments and new industry challenges
- Assessing new technological challenges in the electricity sector field
- Delivering accurate information on subjects such as sustainability, employment or certification
- Synthesising and publishing data in EPIA reports
- Representing and carrying EPIA messages in workshops, projects and conferences
- Representing EPIA in IEA PVPS Task 1 (markets and communication), Task 12 (sustainability), Task 13 (performance & reliability, from 2013 onwards) and Task 14 (grid integration)

Fig. 2 - EPIA's Industry Summit at the 27th EU-PVSEC 2012.

COMMUNICATIONS ACTIVITIES

Over the years EPIA has developed strong and well-regarded tools for communicating to key stakeholders – including EU decision-makers and opinion leaders as well as its Members and the sector in general. These include:

- EPIA's publications, which are considered vital reference tools in the photovoltaic world
  - *Connecting the Sun:* grid integration challenges and solutions
  - *Solar Photovoltaics Competing in the Energy Sector* – On the road to competitiveness
  - *PV Observatory:* Policy Recommendations
  - *Solar Generation* (jointly with Greenpeace)
  - *Global Market Outlook for Photovoltaics*
- EPIA's monthly newsletter, SOLARIS, which is distributed to more than 18,000 contacts. It includes news of the latest developments in the PV sector, as well as information for Members on EPIA activities and events.
- EPIA's engagement in the social networking world, including sites such as LinkedIn, Facebook, YouTube and Twitter – help to spread the word about important initiatives and efforts to influence policymakers on PV.
- Events throughout the year, including various conferences, workshops and other knowledge-sharing events for the benefit of its Members.
  - EPIA Annual General Meeting (Members only)
  - EPIA Market Workshop (Members only)
  - European PV Industry Summit during the EU PVSEC
- Political initiatives including advocacy events, meetings at the European Parliament, debates with EU decision makers, press conferences, and other activities aimed at achieving our strategic objectives and increasing our influence with policymakers.

EPIA WORKING GROUPS

In order to support its activities and to better reflect the interests of its Members, EPIA has developed thematic Working Groups:

- The **Policy Working Group** involves Members in EPIA policy activities on EU policy developments and related EPIA activities.
- The **Communications Working Group** develops a major communications campaign – Your Sun Your Energy – to raise awareness of PV among European citizens and politicians.
- The **Sustainable Development Working Group** gathers and communicates knowledge on technical subjects with regard to sustainability or more technical subjects.
- National Associations meet (on ad hoc basis) to gather policy and market data; promote PV policies by means of best practices and workshops; and coordinate on policy and communications activities.

EUROPEAN PROJECTS

EPIA participates in several EU funded projects, with the aim of addressing issues of strategic importance for the growth of the whole PV industry.

EPIA'S INVOLVEMENT IN IEA-PVPS ACTIVITIES

IEA PVPS ExCo Meetings

EPIA regularly participates in the IEA PVPS ExCo meetings.

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

EPIA contributes to the Task 1 activities by bringing its European experience of the most developed markets in the world, its members who are active in the whole value chain and its experience in gathering and exchanging information on PV systems. EPIA contributed to the Trends Report and the discussions on future support schemes.

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

EPIA, together with the Brookhaven National Laboratories (USA), chaired this Task until 2011, which took-off during 2008 after launching in 2007. Task 12 meetings were hosted by EPIA during the 27th EU PVSEC in Frankfurt, Germany.

Task 14: High Penetration of PV Systems in Electricity Grids

EPIA has started to collaborate on Task 14 in 2012, bringing its experience as well as that of its Members in one of the most important fields of expertise necessary for the future worldwide development of grid-tied PV system markets.

GENERAL SUPPORT TO IEA PVPS

The association hosted an IEA PVPS island booth at the EPIA Industry Area during the 27th EU PVSEC in Frankfurt, Germany, in September 2012. Gaëtan Masson, Head of Business Intelligence took part as speaker at three workshops organized by or with IEA PVPS, in Stockholm in April 2012, in Frankfurt, Germany, during the 27th EU PVSEC in September 2012 and in Hangzhou, China, during PVSEC-22 in October 2012. Marie Latour, Senior National Policy Advisor, took part in the EU-PVSEC workshop as a speaker.

FRANCE

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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

GENERAL FRAMEWORK AND IMPLEMENTATION

The French government is committed to increasing the share of renewable energies in total energy consumption to 23 % by 2020. The multi-year energy investment programme sets a target of 5 400 MW of energy production from photovoltaic installations by this date. In order to achieve this target, the government has introduced a series of pricing and tax incentive measures to encourage growth in the photovoltaic sector.

Photovoltaic electricity purchase prices are weighted in favour of building-integrated photovoltaic systems (Table 1). Private individuals with building-integrated systems will receive the T1 rate, in addition to a further tax credit.

The government revised its support policy back in March 2011, in the belief that the "bedding in" phase was complete, with the sector substantially exceeding the targets set in 2008. The three-month suspension of the compulsory purchase scheme for installations exceeding 3 kW had a negative impact on the sector. Despite the fact that this measure did not concern residential installations of less than 3 kW, the government's move raised doubts among manufacturers and users alike about future support for the sector. The pricing policy for 2012 includes quarterly reductions in purchase prices based on the volume of projects submitted in the previous quarter, and a tender process for photovoltaic installations exceeding 100 kW. The total annual volume of new installations is capped at 500 MW. The additional costs associated with the purchase price are funded through the *Contribution au service public de l'électricité* (CSPE - public electricity service contribution). The CSPE is funded by consumers via payment of their electricity bills. At present, only EDF and local distribution companies (ELD) are covered by the compulsory purchase scheme, and are reimbursed by the CSPE.

At the Environment Conference held in September 2012, the new government (which took office in June 2012 following France's presidential and parliamentary elections) proposed a roadmap for transition to environmentally friendly energy production, as part of its preparations for a major public debate on energy transition. The government has set a target of reducing the proportion of electricity produced using nuclear power from 75 % to 50 % by 2025, focusing efforts on two aspects: Energy efficiency and renewable energy. ADEME was involved in producing France's long-term energy plans for 2030-2050.

The new government has recognized that recurring pricing and regulatory changes have had a negative impact on the wind power and photovoltaic sectors. It is committed to supporting growth in these sectors by simplifying administrative procedures, while ensuring that environmental requirements remain strict. In line with the published outcomes of the Environment Conference, the government made the decision, in January 2013, to double its target volume of new installations to 1 000 MW per year. New tenders will be launched in 2013, covering systems of between 100 kW and 250 kW (120 MW in total) and systems exceeding 250 kW (400 MW in total). The pricing schedule will also be simplified (with building usage criteria removed). Some pricing changes came into effect on 1 October 2012: A 5 % rise in the T4 rate and 20 % reduction for the T5 rate for ground-based power plants (these changes are reflected in Table 1). A rate rise of up to 10 % will also be applied to certain projects, depending on the origin of the photovoltaic modules. According to the government, these measures will generate more than 2 billion EUR of investment and will secure existing jobs and create new jobs (approximately 10 000 in total). The annual cost of these changes to the public purse is estimated at a relatively modest 90 to 170 MEUR.

NATIONAL AND REGIONAL PROGRAMMES

France's photovoltaic sector growth policy is managed by the Ministry for Ecology, Sustainable Development and Energy (MEDDE). As well as supporting the sector through its purchase price policy, the government has also introduced a tender-based photovoltaic project funding mechanism. The tender process is managed by the *Commission de régulation de l'énergie* (CRE - French Energy Regulation Commission), France's electricity and gas market regulator.

TABLE 1 – APPLICABLE PV FEED-IN TARIFFS AS AT Q4 2012

CATEGORY	USAGE	POWER	TARIFF* (EUR/kWh)
Building-integrated photovoltaic systems	T1 – Residential use	P ≤ 9 kW 9 kW < P ≤ 36 kW	0,3415 0,2988
	T2 – Building for education or health activities	P ≤ 36 kW	0,2279
	T3 – Other type of building	P ≤ 9 kW	0,1976
Simplified building-integrated	T4 – Any type of building	P ≤ 36 kW 36 kW < P ≤ 100 kW	0,1934 0,1837
Other installation	T5 – Any type of installation (Ground mounted...)	0 kW < P < 12 MW	0,0840

**The new measures announced in early January 2013 are taken into account.*

Fig. 1 – Low-energy building in Paris' 17th arrondissement. 96 kW BIPV designed and installed by Sunvie.

In 2012, two types of tender were launched for photovoltaic installations:

- The first type of tender covers the construction and operation of photovoltaic installations of between 100 kW and 250 kW. These installations must comply with the rules governing simplified building-integrated photovoltaic systems (ISBs). The tender process is divided into seven bidding phases, with a total new production output target of 120 MW for the first phase and 30 MW for the next six phases. The total maximum power output is 300 MW. A total of 218 projects (45 MW) were selected in the first phase, and a further 109 projects (21 MW) in the second. The third, fourth and fifth phases were launched in June, September and December 2012 respectively, with the final two bidding phases scheduled for launch in 2013.
- The second type of tender covers the construction and operation of photovoltaic installations exceeding 250 kW (building-integrated, ground-based and parking shade PV systems, concentrator photovoltaics and thermodynamic solar installations). A total of 105 projects have been selected (520 MW), some 70 MW above the original target of 450 MW. Projects are selected according to the price that the bidder wishes to charge for electricity supplied to the grid over a period of 20 years. The selected projects are located in those areas of France that receive the most sunshine, in order to maximize productivity. The average electricity sale price proposed by the bidders in the first phase of the 100-250 kW tender process is 229 EUR per MWh. Industry professionals have criticized the complexity of the procedures and the high grid connection costs.

Thermal Regulation RT2012 (which aims to divide new building energy consumption by three) should represent a genuine opportunity for the solar power sector (Figure 1 shows an example of a low-energy building constructed in accordance with RT2012). Furthermore, this regulation is an intermediate step towards a future regulation, under which new buildings will be required to become net producers of electricity.

France's local authorities, regional councils and general councils also operate their own PV project support mechanisms, based on targeted tender processes. The Midi-Pyrénées regional council, for example, has launched a programme to install photovoltaic systems on all public sixth form college buildings in the region. The Centre region, meanwhile, has launched a tender process under the title "Innovative and High-performance Buildings". The Languedoc-Roussillon region has provided support to the "Saint-Charles Solaire 2.0" self-consumption project. And in the Poitou-Charentes region, a specialist renewable energy company is working with the regional authority and a local supplier to create local photovoltaic electricity production capacity.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Ministry for Ecology, Sustainable Development and Energy (MEDDE) implements the government's policy through a number of subsidiary agencies such as ADEME (French Agency for Environment and Energy Management), ANR (French National Research Agency) and OSEO (organization which provides support to SMEs and SMIs for innovation projects).

The public photovoltaic research programmes range from fundamental research upstream of the value chain (ANR's PROGELEC programme) to finalized projects and industrial prototypes (ADEME's AMI PV programme, and OSEO's reindustrialization support programme). These R&D projects are run on a public/private partnership basis and involve around 30 research teams and almost all equipment and component manufacturers.

In late 2009, the government initiated a major future investment programme, known as *"Investissements d'avenir"* (IA). Under this programme, ADEME launched two calls for expressions of interest, known as "AMI PV" and "AMI Solaire". Under the AMI PV programme, nine projects were selected. Initial progress reports on these projects were presented at ADEME's photovoltaic research and innovation event *(Journée ADEME, recherche et innovation photovoltaïque)*, held in Sophia Antipolis on 15 November 2012. The agenda also featured five other major ADEME-supported projects launched in the previous year.

ANR is continuing its efforts in the PV sector with the PROGELEC 2011-2013 (renewable electricity production and management) programme. Five photovoltaic projects were selected in 2012, in addition to the five chosen in 2011. OSEO has announced support to develop inkjet printing technology for thin-film organic cells.

The *Institut national de l'énergie solaire* (INES - French National Solar Energy Institute) is currently undergoing rapid growth and is involved in a range of different public/private partnership projects. Public bodies CEA and CNRS and university laboratories are involved in research and innovation programmes. The *Institut Photovoltaïque d'Île-de-France* (IPVF - Ile-de-France Photovoltaic Institute) is focusing its efforts on developing thin-film materials and new concepts.

Fig. 2 – Canopea®. Solar-powered housing project designed by Team Rhône-Alpes, winner of the 2012 Solar Decathlon Europe competition. Top of an apartment building with PV/T hybrid collectors.

The Canopea® urban solar-powered housing project, designed by Team Rhône-Alpes, won the 2012 Solar Decathlon Europe competition. This positive-energy apartment block project includes a communal area under a glass roof fitted with PV/T hybrid collectors (Figure 2). The next international competition will be held at the Palace of Versailles in 2014.

INDUSTRY AND MARKET DEVELOPMENT

The French photovoltaic industry experienced a difficult year in 2012. The worldwide fall in photovoltaic module retail prices, the effects of excessive capacity, the economic slow-down and the French government's decision to revise its public support policy have undermined confidence among users and caused instability for many small businesses. The effects have been particularly severe for those businesses that have failed to adapt, diversify and focus on new segments. Cell and module production lines have been operating below full capacity. Photowatt, an integrated manufacturer (ingots, wafers and crystalline silicon cells) and pioneer in the field, was taken over by EDF at the start of 2012. Tenesol, the other major pioneer in France's PV sector (modules and systems, a subsidiary of Total) was taken over by SunPower, in which Total had acquired a majority stake a few months earlier. Bosch Solar Energy opened a new photovoltaic module production line at a converted industrial site in Vénissieux. Two specialist optical disk manufacturers, SNAsolar and MPO Energy, opened a new module production line and a new c-Si cell production line respectively. At the end of 2012, there were 11 active module manufacturers in France. Solar tracker and concentrator systems have continued to grow, with a number of new projects and additional investment in 2012.

Small installation companies, which once saw the photovoltaic sector as a promising area for growth, have either seen a fall in business or filed for bankruptcy.

Major energy companies, component manufacturers and process specialists have created dedicated renewable energy subsidiaries, and have been involved in various projects, both in France and abroad.

The renewable energy trade shows in Paris (April 2012) and Montpellier (December 2012) both saw exhibitor numbers down on previous years. This year saw growth in the downstream sector, including new offers from design, development, operating and funding companies, as well as supervision, maintenance, monitoring and security companies.

The first three quarters of 2012 saw a total of around 1 000 MW of additional capacity connected to the grid. As of 30 September 2012, the cumulative grid-connected photovoltaic capacity stood at 3 923 MW, a 34 % increase since the end of 2011, according to figures published by the Observation and Statistics Office (SOeS) of the *Commissariat général au développement durable* (the French General Commission for Sustainable Development). New grid connection figures for the first three quarters of 2012 show a downturn compared with the same period in 2011, in terms of both the number of installations (down 65 %) and total power output (down 24 %). This slowdown applies to all segments of power, except for installations exceeding 250 kW. This is primarily due to the completion of projects which had been placed on a waiting list before the suspension of the compulsory purchase scheme in December 2010. New installations are due to be connected during Q4 2012. This allows to estimate the volume of grid-connected installations during the year 2012 to be about 1 100 MW. Thus, the cumulative grid-connected PV capacity at the end of 2012 would reach 4 000 MW.

There is growing support for the concept of self-consumption of electricity produced by photovoltaic systems installed on the roofs of manufacturing and commercial premises. Often these buildings have a large roof surface area capable of producing sufficient electricity to allow companies to run off their own electricity production during daylight hours. These systems are designed to allow businesses to use more than 95 % of their production for their own purposes.

There have also been significant developments in terms of energy in rural areas.

Throughout 2012, professional unions have continued to lobby the French government on the need for a clear message to improve the visibility of the industry – a key factor in securing the long-term success of the sector. In response to these demands, the government launched a series of urgent measures in January 2013 to boost the French photovoltaic sector, including a doubling of the target volume to 1 000 MW per year, simplification of the pricing schedule, the introduction of pricing bonuses under certain conditions and the launch of new tender processes.

In terms of long-term goals, the industry has set a target of 20 GW of total power output by 2020. ADEME, meanwhile, has conducted an outlook study to assess the potential of the photovoltaic sector, with estimated capacity of 33 GW by 2030, under reasonable technical and economic conditions.

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY- STATUS AND PROSPECTS

CHRISTOPH HÜNNEKES AND KLAUS PRUME, PROJEKTTRÄGER JÜLICH (PTJ), FORSCHUNGSZENTRUM JÜLICH GMBH

Fig. 1 - Example of a building integrated PV system demonstrating the beneficial combination of CIGS solar modules and modern architecture (Photo: T. Ott).

GENERAL FRAMEWORK AND IMPLEMENTATION

The transformation of the energy system is a core task for Germany's environmental and economic policy. The overall objective is an environmental friendly, reliable and economical feasible energy supply. The German Federal Government paved the way for this target when announcing the German Energy Concept in autumn 2010 [1]. Moreover, it was decided in 2011 to terminate the production of nuclear power until 2022.

The goals are to be reached firstly by efficient energy use and secondly by the use of renewable energies. The German Energy Concept states that this energy source will contribute the major share to the energy mix of the future. With respect to the electricity supply, the share for renewable energies has reached approx. 22 % already in 2012. It is expected to reach 35 % in 2020 and 80 % in 2050. It can be expected that the medium term goal of 35 % renewables by 2020 will be exceeded.

Photovoltaic (PV) is a major part of this development driven by the Renewable Energy Sources Act (EEG) [2] on the one hand and a noticeable decrease of system prices on the other hand. A capacity of 7,6 GW PV power has been newly installed in Germany in 2012, see Figure 1. As a result, PV contributed 28,4 TWh (approx. 4,6 %) to the annual gross electricity generation.

At the end of 2012, a total installed PV capacity of 32,4 GW was connected to the grid and this puts Germany on top of the list of countries with the highest annual and the highest total PV installations worldwide. For PV, the Feed-in-Tariff (FiT) 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. All rates are guaranteed for an operation period of 20 years. Details on the development of the FiT can be found in [3]. Table 1 shows the development of the FiT for small rooftop systems (< 10 kW) since 2001 [4]. Meanwhile, the EEG contains measures for the integration of PV systems into the grid management.

TABLE 1 – DEVELOPMENT OF THE FEED-IN TARIFF (FIT) FOR SMALL ROOFTP SYSTEM (< 10 KW)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
EURcents/kWh	50,6	48,1	45,7	57,4	54,5	51,8	49,2	46,75	43,01	39,14*	28,74	24,43	17,02

YEAR	2012	Jan	Apr	Jul	Oct	2013	Jan
EURcents/kWh		24,43	19,50	18,92	18,36		17,02
MONTHLY DEGRESSION			1,0 %	1,0 %	2,5 %		2,5 %

** 33,03 EURcents / kWh from October until December 2010*

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 2012) [2]. In terms of achieving expansion targets for renewable energies in the electricity sector, the EEG is the most effective funding instrument at the German government's disposal. It determines the procedure of grid access for renewable energies and guarantees favourable Feed-in-Tariffs for them. But, due to the successful but very fast increase in PV energy generation, the EEG has been amended. The last amendment has been in force since April 1st 2012. A monthly adapted degression rate of the FiT has been introduced, which depends on the previously installed PV capacity, and the FiT scheme is now limited to 52 GW of total installed PV capacity.

RESEARCH AND DEVELOPMENT

Research and Development (R&D) is conducted under the 6th Programme on Energy Research "Research for an environmental friendly, reliable and economical feasible energy supply" [5] which came into force in August 2011. Within this framework, the BMU as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. The main parts of the programme are administrated by the Project Management Organisation (PtJ) in Jülich.

BMU Funding Activities

In December 2011, the BMU released a new call for tender which reflects the targets of the new energy research program. Concerning PV, the call addresses five focal points which are all connected to applied research:

- Silicon wafer technology,
- Thin-film technologies, especially based on Silicon and Chalcopyrites (CIS/CIGS),
- System technology for both, decentralised grid-connection and island systems,
- Concentrated Solar Power and other alternative concepts and
- Cross-cutting issues such as Building Integrated PV (BIPV), recycling or research on the ecological impact of PV systems.

In 2012 the BMU support for R&D projects on PV amounted to about 51,7 MEUR shared by 238 projects in total. That year, 85 (2011: 96) new grants were contracted. The funding for these projects amounts to 68,3 (74,3) MEUR in total. These numbers comprise the BMU funding under the "Innovation Alliance PV" as well, see below.

Details on running R&D projects can be found in the BMU "Annual Report on Research Funding in the Renewable Energies Sector" [6] or via a web-based database owned by PtJ [7]. The German contributions to the PVPS Tasks 11, 12, 13 and 14 are part of the programme.

BMBF Funding Activities

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 two focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells.
- 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 from 2009 until 2013.

Innovation Alliance PV – A Joint BMU and BMBF Initiative

In summer 2010, BMU and BMBF initiated the Innovation Alliance PV. Under this scheme, R&D projects are 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 were selected. In particular, cooperation between PV industry and PV equipment suppliers is of importance. Together, BMU and BMBF allocated 100 MEUR to support this initiative. The German PV industry agreed to raise an additional 500 MEUR to accompany the Innovation Alliance.

The approval procedure took place in 2011 and 2012. Currently, 19 R&D projects are in progress:

- BMU: 13 co-operative projects with a total amount of funds of 39,5 MEUR.
- BMBF – Basic Research: 8 co-operative projects, total amount of funds: 28,6 MEUR.
- BMBF – Optical Technologies: 7 co-operative projects, total amount of funds: 26,0 MEUR.

INDUSTRY AND MARKET DEVELOPMENT

The German PV industry faces difficult situations. Today, burdens resulting from the world economic crises and further falling prices result in a tough situation. Nevertheless, the Foreign Trade and Inward Investment Agency of the Federal Republic of Germany "Germany Trade & Invest" lists an impressive number of companies involved in PV:

- 23 inverter manufacturers,
- 67 companies with PV productions (ingots, wafer, cells, modules),
- 46 PV equipment manufacturers,

and additional manufacturers of materials for PV modules and PV system components [8].

This list shows that the German PV industry is positioned along the whole value chain. During the last years, equipment and production companies became the most experienced ones worldwide. In September 2012, around 110 000 workers were employed in the PV industry, in handcraft and trade companies [9].

The EEG accelerated the installation of grid-connected PV-systems in Germany significantly. In addition, the decrease of system prices

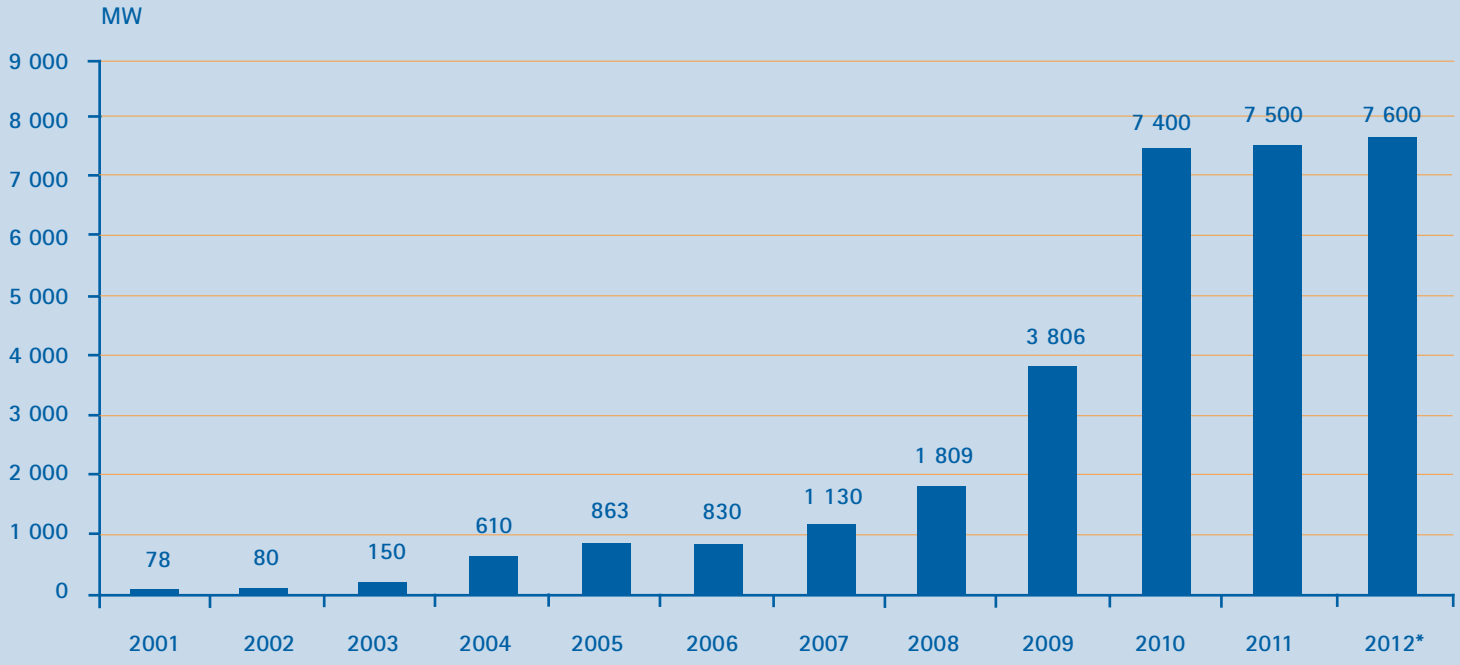

*Fig. 2 - Development of grid connected PV capacity in Germany, *first estimate as of January 2013.*

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 10 kW arrived at around 1 750 EUR/kW in the last quarter of 2012 [9]. This means, system prices are reduced by 64 % in the last six years. The Levelized Costs of Energy (LCOE) for a small rooftop PV system in Germany are around 0,15 – 0,18 EURcents/kWh whereas the electricity price for private households is around 0,25 EURcents/kWh. Investments in PV installations get attractive even without financial support by a FiT.

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[3] *Feed-in Tariffs for 2013 can be found at www.bundesnetzagentur.de*

[4] *The newly reduced Feed-in Tariff (FiT) program went into effect and will be retroactively effective from April 1, 2012. For installs up to 10 kW capacity, the new FiT from January 1st, 2013 will be 17,02 € ct / kWh. For roof top installs up to 40 kW capacity, the new FiT will be 16.14 € ct / kWh, up to 1 MW the FiT is 14,40 € ct / kWh and for installs up to 10 MW on roof tops or ground installed the FiT amounts to 11,78 € ct / kWh. No reimbursement is paid for installs greater than 10 MW. A monthly degression will also retroactively take effect from May 1, 2012. Germany will subsidize its solar program up to 52 GW.*

[5] *The 6th Energy Research Programme of the Federal Government, see http://www.bmwi.de/English/Redaktion/Pdf/6th-energy-research-programme-of-the-federal-government,property=pdf,bereich=bmwi,sprache=en,rwb=true.pdf*

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

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ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE

DR YOEL COHEN, R&D PROGRAMS MANAGER, DIVISION OF THE CHIEF SCIENTIST, MINISTRY OF ENERGY AND WATER RESOURCES

GENERAL FRAMEWORK

The momentum of PV systems installation is continuing. Considerable progress has been made recently as a result of intensive Government activity during the last years.

The Ministry of Energy and Water Resources has set a target of 10 % of electricity supply from renewable energy by 2020, with an interim target of 5 % by 2014.

By the end of 2012, 238MW were installed and connected to the grid. This is roughly equivalent to 2 % of grid electricity. Many more installations are underway; however, it may happen that the target for 2014 will not be fulfilled. The tariffs during the last months of 2012 were 1,22 NIS for up to 15 kWp residential systems and it was reduced to 0,70 NIS for small quota of 10MW in 2013. For the commercial systems the tariff of 0,90 NIS was reduced to 0,45 NIS for quota of 20MW. If the quota will not be finished after 3 months there will be an automatic increase in the price by 0,04 NIS every 3 months. For large systems (above 12MW) the tariff was reduced from 0,98 to 0,66 NIS. These reductions of 1/3 in the tariff reflect the current trend of decline in PV panel price. The tariff is guaranteed for 20 years and is subject to updates. Among the commercial PV systems there are few types of tariffs with minor price differences:

- for power plants between 51 kWp and the largest size that can be connected to the distribution grid;
- for systems connected to the transmission grid (larger than 20 MWp);
- for land tenders (issued by the government) - the connection is to the distribution grid; few tenders have recently been awarded, for a total of 72 MWp.

Most of the installed PV systems by the end of 2012 were small size. 4 700 domestic small size systems with overall 50MW; an additional 3 700 commercial PV systems with overall 175MW; as well as 4 medium size PV systems with 7 MW.

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 2008 was decided in 2012, after a number of postponements. A site for this power plant (0,75 km^2) has been allocated at the Ashalim Junction, in the Negev desert. Four international consortia have put in an offer. The winning bidder gave a "grid parity" tariff of 0,51 NIS which is lower the current electricity tariff of 0,58 NIS per KWh.

INDUSTRY INVOLVEMENT

The number of firms active in the PV field has risen more than tenfold over the last three years. Most companies are small and deal mainly with system integration. Presently there is no local production of PV cells. One company, Bsolar, is active in the bi-facial modules production. A few start-up companies are active in the field of capital equipment and consumables, mainly for the metallization process step.

Another company from Israel, SolarEdge, produces inverters that are based on a patent that can overcome partial shading. SolarEdge is growing very quickly and became one of the top 5 leaders in the inverters segment during 2012. Over 1,8 million power optimizers and 70 thousand inverters were sold by the end of 2012.

Net Metering Regulation

The net metering regulation enables every consumer who has a time dependent meter to install their own PV system. In this way, the consumer can reduce the grid load during high priority hours. In the case of production above the consumption, a base price of 0,35 NIS is offered, while production for self consumption gets the higher time dependent electricity price. An initial quota of 200 MW was offered, and there is a tendency to enlarge this quota in the future.

Grid Reserves and PV

Grid reserves above the maximum annual demand peak were less than 5 % in 2012. This was a result due to the blocking of the gas from Egypt and some slower installations in the private sector. The situation led the network management into problems during the high summer demand. This critical situation made it urgent for the first time to release an additional PV quota of 30 MW before the summer peak. It was the first time that PV was recognized as a generation resource that can help the national needs.

Energy Mix in the Network

The current quota for wind was reduced from 800 MW to 500 MW. The transfer of 300 MW to solar was done in order to accelerate the integration of RNE to the grid. The current PV installations are progressing much faster compared to wind farm installations. This decision will help to achieve the government target for 2014 of 5 % RNE.

Grid Parity – What is the Real PV Value for the Grid?

The Kandel Committee, from the Prime Minister's Office, set guidelines for calculation of the gap between the production of energy by renewable energies and the benefit from not using fossil based production. In this way, the price for roof based PV of 0,476 NIS was demonstrated. The importance of this work is that it gives some options to clarify the actual level of subsidies that are needed for network operation while insertion of more and more RNE into the grid. A specific price dependence on the penetration levels was introduced.

RESEARCH AND DEVELOPMENT

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

- new research was initiated in TAU. This research will investigate the option to combine photo thermionic emissions with PV junction generation and combined with residual heat usage.
- The Negev radiation maps are finally at the printers; two entire-Negev maps on a scale of 1:250 000 (one DNI and one GHI), and for each, a set of twelve local sheets on a scale of 1:100,000. Nothing on such a fine scale, based on so many years of detailed ground measurements, has been produced anywhere in the world.

GOVERNMENT ACTIONS 2012

It is expected that the Government activity described above (feed-in tariffs for distributed PV and solar power plant tender) will continue to influence the PV market favorably. 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, pilot and demonstration projects. Direct expenditures in PV R&D by the Ministry of Energy and Water Resources.
- A new quota of 50 MW with a tariff for pilot and demonstration projects was announced.

ITALY

PV TECHNOLOGY STATUS AND PERSPECTIVES
SALVATORE CASTELLO, ENEA
SALVATORE GUASTELLA, FABRIZIO PALETTA, RSE

Fig. 1 – 3,0 MW Orsomarso PV Plant on a greenhouse at Cosenza (Photo: Hfv spa).

Fig. 2 – 3,5 MW Montenero PV Plant at Campobasso (Photo: Hfv spa).

GENERAL FRAMEWORK

The year 2012 has been characterized by a series of institutional measures that introduced tariff reduction and above all uncertainty and discontinuity for the entire market. As a consequence, the resulting total power that was installed during 2012 (3 227 MW) was lower, with respect to the power installed during the year 2011 (9 454 MW). Moreover, a major reduction of the installed power is related to the annual cost for the incentive tariff that is quickly approaching the limit of 6 700 MEUR fixed by the fifth phase of the "Conto Energia" programme. It is foreseen that when this limit will be reached, photovoltaics won't be incentivate any more in Italy.

In this situation, a preliminary evaluation of PV technology in Italy gives a cumulative installed and operating photovoltaic power of 16,15 GW and an overall photovoltaic electricity production of 18 300 GWh, corresponding to about 6 % of the national electricity consumption, with a peak of 8,5 % in August.

The national market stimulation initiative (the Conto Energia Programme) has represented a long-standing sustained approach to stimulation of the market, but at present two main barriers have emerged that could adversely affect the growth of the photovoltaic market in Italy: Firstly, the electricity grid's adequacy in some regions of southern Italy, where the installed power of wind turbines and PV is almost the same order of magnitude as the peak load and secondly, the annual cost of the incentive tariffs that is rapidly approaching the budget limits fixed by the Conto Energia Programme.

NATIONAL PROGRAMME

The national market stimulation initiative in operation since 2005 is the "Conto Energia" Programme.

The first phase was defined through two governmental decrees issued in 2005 and in 2006. The first significant installations were made towards the end of 2006 but this phase was completed toward the end of 2009; with 5 726 PV plants, corresponding to about 163 MWp.

The second phase was defined through a governmental decree issued in February 2007. This phase was characterized by the issue of the "Salva Alcoa" decree which had extended the validity of the related tariffs from the end of 2010 to June 2011 for sworn declarations of construction completion recorded until 31 December 2010. In this framework, a further 54 106 installed plants, corresponding to a declared capacity of 3 771 MW were admitted to benefit from the second Conto Energia tariffs. This phase was completed and resulted in setting 203 787 plants in operation, corresponding to a total capacity installed over 6 812 MW.

In July 2010 a new edition, the third one of the "Conto Energia" decree, established an increase of the national objective from 3 GW by 2016 to 8 GW by 2020 and a reduction of the incentive tariffs in the period 2011-2013. During the period of validity of this phase (from January to June 2011) almost 38 590 plants have been realized, corresponding to a total power of about 1 562 MW. In fact, during this period excellent investment conditions due to the availability of

low price photovoltaic components on the market caused a surge in installations, as a way for high rate income.

The decree regulating the fourth Conto Energia was issued in May 2011. The most important aspects regard a total spending limit corresponding to 6 000 MEUR that has been reached toward the end of August 2012. In this framework, 199 427 plants have been installed, corresponding to a total power of about 7 245 MW.

The decree regulating the fifth Conto Energia was issued on the 5th of July 2012. Following this decree, the Italian Government has foreseen the end of incentives within the first months of 2013.

In the framework of the fifth phase, until December 2012, about 24 673 plants corresponding to 457 MW have been installed and put in operation while another 1 098 plants corresponding to about 369 MW have been installed but have not yet been put into operation.

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 (a research company owned by GSE - Gestore dei Servizi Elettrici - the Italian publicly-owned company managing the renewable energy source incentives and regulations). Additional contributions have been supplied by some universities, CNR (the National Council for Scientific Research) and a few private laboratories.

ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest are: Crystalline silicon, Cu2O solar cells, microcrystalline Si devices, micromorph tandem solar cells, 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 the Italian electric system research programme RdS (Ricerca di Sistema) and in the European projects "APOLLON," SOPHIA and SUN on CLEAN. 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 public and private budget 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.

IMPLEMENTATION OF SYSTEMS

According to a preliminary evaluation, a resulting total cumulative capacity of about 16 150 MWp was installed and operating in Italy at the end of 2012.

Fig. 3 – 3,0 MW Scalea1 PV Plant on a greenhouse at Cosenza (Photo: Hfv spa)

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

Off-grid systems:	amounting to	11 MWp;
On-grid centralized systems (>200 kWp):	reaching about	10 232 MWp (*)
On-grid distributed systems:	amounting to	5 908 MWp (*)

(*) preliminary evaluation

INDUSTRY STATUS AND MARKET DEVELOPMENT

In the year 2012, about 14 main producers of crystalline silicon cells and finished PV products have been identified in Italy. On the whole, a total capacity production around 800 MW has been estimated. As far as power conversion system, 7 companies in Italy manufacture inverters for on-grid and off-grid applications. During 2012, their production capacity was around 8 000 MW.

FUTURE OUTLOOK

Even if the national market stimulation initiative, Conto Energia Programme, is expected to be ending in a few months and the recent institutional measures are restraining the entire PV market, it is expected that PV installations will not be stopped, although they shall be considerably reduced, if suitable measures will be taken into account by the Italian government. In fact, it is widely recognized that the simplification of the authorization process and specific measures at no cost for the public finances (i.e., tax breaks) accompanied by the good solar radiation values, especially in the southern region of Italy, will be able to support the achievement of grid parity. In particular, the Italian Government has been formally asked by representatives of the Italian PV operators to insert such proposals in the new National energetic strategy, which is presently under definition.

At the same time, it is expected that the barrier to the diffusion of PV plants represented by the electric grid, which is not adequate in some regions of Italy, should be partly removed by the grid managers and partially solved by the recent Italian regulations which require that PV plants have to provide services to the LV and MV grids in order to improve their management.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

HIROYUKI YAMADA, NEW ENERGY AND INDUSTRIAL TECHNOLOGY DEVELOPMENT ORGANIZATION (NEDO)
OSAMU IKKI, RTS CORPORATION

Fig. 1 - Environmental Energy Innovation Building of Tokyo Institute of Technology (TIT) (Ookayama, Meguro-ku, Tokyo), 653 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 legislation, measures and strategies of the Ministry of Economy, Trade and Industry (METI).

1) Energy policy: Basic Law on Energy Policy Making (enacted in 2002)
Japan's energy policy is based on the following three principles; i) securing stable energy supply; ii) adaptability to the environment; and iii) utilizing market principles. Promotion of the use of PV power generation is clearly stated in ii) adaptability to the environment.

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 the 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 has been decided.

4) Fundamentals of the national energy strategy: Basic Energy Plan (formulated in 2010)
The above-mentioned Basic Law on Energy Policy Making aims to set a basic plan regarding energy demand and supply (Basic Energy Plan) in order to promote measures on the energy demand and supply on a long-term basis, comprehensively and systematically. The Basic Law on Energy Policy Making also requires the deliberation on the necessity to change the Basic Energy Plan every three years at minimum. The current Basic Energy Plan, revised in 2010, stipulates direction of Japan's energy policy toward 2030. The plan sets the goals of drastically enhancing dissemination of renewable energy and increasing the ratio of renewable energy to 10 % of the primary energy supply by 2020. In the aftermath of the nuclear power plant failures in Fukushima Prefecture following the Great East Japan Earthquake in March 2011, discussions to revise the Basic Energy Plan were held, but the revision was not completed in 2012.

5) Short- to mid-term strategy for PV: "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/ modules and systems were set from a mid-term perspective for the period up to 2025 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 FY 2007 (March 2008))
"Innovative PV power generation" was selected as one of the 21 themes of innovative technology development which should be emphasized. The goal was set to increase the conversion efficiency of solar cells from the current levels of 10 - 15 % to over 40 % and to reduce the cost of PV power generation from the current level of 46 JPY/kWh to 7 JPY/kWh.

7) Target of PV installed capacity: Action Plan for Achieving a Low-carbon Society (approved by the Cabinet in 2008) and the J-Recovery Plan (formulated in 2009)
It has a goal of increasing PV installed capacity to 28 GW by 2020 and 53 GW by 2030.

8) Obligation to purchase surplus electricity 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" (enacted in 2009, effective until June 2012)
Basic purchase price of surplus electricity generated by PV systems for FY 2009 and FY 2010 was set at 48 JPY/kWh. The figure for FY 2011 and FY 2012 was reviewed and reduced to 42 JPY/kWh.

9) Obligations to purchase the electricity generated by renewable energy at fixed rates for the Feed-in Tariff (FIT) program: Renewable Energy Law (enacted in 2011)
The new Feed-in Tariff (FIT) program took effect on July 1, 2012. Details of the FIT program are described in the National Program section below.

10) Cultivation of the PV industry: the Green Growth Strategy (enacted in 2012)
Dissemination of renewable energy installation has been promoted under the "Green Growth Strategy", which was formulated as one of the pillars of "Strategy for the Rebirth of Japan", Japan's economic growth strategy toward 2020. PV industry is positioned as one of the industries which support the renewable energy sector.

11) Support programs for dissemination: METI, the Ministry of the Environment (MoE), the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT), etc.
These ministries are implementing various measures to introduce PV systems such as a program to support dissemination of residential PV systems, technology development of PV power generation, projects to support introduction of new and renewable energy by local governments, projects to promote introduction of renewable energy in agricultural, forestry and fishing villages and a project to establish Eco Schools.

With the start of the FIT program in July 2012, the Japanese PV market has entered a new phase for the growth. Previously, the nation's framework for PV dissemination was based on the subsidy program and the program to purchase surplus PV electricity. Accordingly, there were limits in speeding up the price reduction and dissemination of PV systems. Now that the FIT program started with a guaranteed purchase period of as long as 20 years (for non-residential application), it has become possible to calculate profitability. Users now can actively introduce PV systems as part of business operations. A structure for PV dissemination has drastically shifted from the one led by the supply side to the one driven by end users. Financial institutions have been actively supporting the PV power generation business. Through activities by PV system integrators, industries introducing PV systems and end users, downstream PV sectors have emerged, expanding the scope of the PV industry. Installation of PV systems for a wide variety of applications, such as public, industrial and commercial applications, PV systems for roads and railroads as well as agricultural applications has become more popular, though these applications had previously lagged behind residential applications. They are becoming new core market segments next to the residential market. As for the price of PV systems, cost has been reducing through competition, led by an increasing number of overseas manufacturers entering the Japanese PV market as well as the Japanese manufacturers. In 2013, the second year of the FIT program, PV systems approved in 2012 (> 3 GW) will be installed one after another and the subsidy program for residential PV systems will continue. The Japanese PV market is expected to grow to the level of 3 GW/year installed capacity.

NATIONAL PROGRAM

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

METI is leading dissemination of PV systems for residential and public/ industrial applications by the following support measures.

1) Subsidy for measures to support introduction of residential PV systems (budget: 119,4 BJPY for multiple-years)

METI implements subsidy programs for the individuals and companies who install residential PV systems. The amount of subsidy for the FY 2012 is 35 000 JPY/kW or 30 000 JPY/kW. PV systems priced between 35 000 JPY/kW and 475 000 JPY/kW are eligible for 35 000 JPY/kW subsidy. PV systems priced between 475 000 JPY/kW and 550 000 JPY/kW are eligible for 30 000 JPY/kW subsidy. There are requirements for PV systems eligible for the subsidy, such as maximum output capacity must be less than 10 kW and the PV module efficiency must be above a certain level.

2) Feed-in Tariff (FIT) program for renewable energy power generation facilities

The feed-in Tariff (FIT) program for renewable energy power generation facilities took effect on July 1, 2012. In FY 2012, the tariffs and periods of purchase are set as follows: 1) 42 JPY/kWh (incl. tax) for PV systems with the capacity of 10 kW or more for the period of 20 years; and 2) 42 JPY/kWh (incl. tax) for PV systems with the capacity below 10 kW for the period of 10 years. All electricity users share the purchase costs evenly.
Under the FIT program, total capacity of approved PV systems with the capacity below 10 kW was 727 127 kW as of November 30, 2012. Total capacity of approved PV systems with the capacity between 10 kW and below 1 MW was 1 111 393 kW. Total capacity of approved PV systems of 1 MW or above was 1 423 763 kW, making the total capacity of approved PV systems with the capacity of 10 kW or above 2 535 156 kW.

3) Subsidy for introducing renewable energy power generation systems as part of restoration measures (budget: 31,6 BJPY)

In order to create employment in the renewable energy industry and stimulate its related industry in the areas damaged by the Great East Japan Earthquake, subsidy programs for introducing renewable energy power generation facilities such as PV systems in the damaged areas have been implemented. For PV systems, either

Fig. 2 - SoftBank Kyoto Solar Park (Fushimi-ku, Kyoto City, Kyoto Prefecture), 4,2 MW, Multicrystalline Silicon PV module by Kyocera.

10 % or less of the eligible cost, or 80 000 JPY/kW, whichever the lower, is subsidized. To be eligible for the subsidy, it is required that the system should have the output capacity of not less than 10 kW, or the combined output capacity of not less than 10 kW from more than one site. (The average output capacity per one site must be more than or equal to 4 kW.)

(2) The Ministry of the Environment (MoE)

MoE is promoting projects to reduce CO_2 emissions by the use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming." In FY 2012, "Model project to establish communities introducing independent and distributed energy utilizing renewable energy," a project which supports installation of independent and distributed energy systems by industrial, academic and governmental circles utilizing renewable energy and unused energy, was started. The amount subsidized is up to the half of the total project cost. Four projects were selected in FY 2012.
The budget of 6,0 BJPY was allocated in FY 2012 for the"Project for developing technology to prevent global warming (competitive funds)" to support private companies, public research institutes, and universities which conduct technology development of leading low carbon transportation and of leading low carbon houses and offices utilizing new and renewable energy including PV.

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

Construction of green government buildings for central ministries and agencies and government offices in local regions equipped with PV systems and other new and renewable energy systems has been promoted. For the private sector, MLIT called for proposals of the projects which reduce CO_2 emissions at houses and buildings such as office buildings, and also implemented the subsidy program to aid a fixed amount or a part of the maintenance cost. Furthermore, MLIT supports the efforts to realize zero energy homes by upgrading the energy-saving performance of the building frame and equipment of the houses, or by utilizing renewable energy 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 the introduction of renewable energy into these industries. In FY 2012, MAFF started the "Project for early establishment of renewable energy supply model in rural areas" which aims at realization of independent and distributed energy supply systems and revitalization of the villages dependent on the primary industries. It supports the efforts which serve as a model for the renewable energy, such as PV power generation business utilizing the resources in the rural areas.

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

In FY 2012, MEXT started the"Super eco school demonstration project" to promote the realization of zero energy at the public school facilities. This demonstration project subsidizes 50 % of the renovation cost for introducing renewable energy power generation systems such as PV systems for the project period of 3 years. In FY 2012, 3 municipalities including Kyoto City, Kyoto Prefecture, Yabuki Town, Fukushima Prefecture, Ikoma City and Nara Prefecture were selected. Moreover, MEXT supports the improvement work of the both interior and exterior of the school to build environmentally-friendly facilities in the private schools.

(6) Local governments and municipalities

In addition to the national support measures, efforts by local governments and municipalities play an important role for the dissemination support of PV systems. In 2012, 1 096 local governments and municipalities were offering subsidy programs for residential PV systems. Support projects are undertaken in 69 municipalities in Hokkaido, 62 municipalities in Saitama Prefecture, 55 municipalities in Nagano Prefecture, and 53 municipalities in Aichi Prefecture and Chiba Prefecture, respectively. Most of the programs provide subsidy ranging from 10 000 JPY/kW to 50 000 JPY/kW. Tokyo Metropolitan Government (TMG) continued the subsidy of 100 000 JPY/kW in FY 2011 and FY2012. This subsidy program will expire in March 31, 2013.

R&D, D

R&D Projects named "R&D for High Performance PV Generation System for the Future" and "R&D on Innovative Solar Cells" have been continued by the New Energy and Industrial Technology Development Organization (NEDO) and a mid-term evaluation was conducted in August 2012. In the "R&D for High Performance PV Generation System for the Future" project, academic-industrial consortium-based R&D projects covering crystalline silicon, thin-film silicon, thin-film CIGS, and organic thin-film solar cells have been conducted and will be continued for the next two years. In the mid-term evaluation, acceleration of technological development and prioritization of the R&D themes are required in response to the rapidly changing current PV markets and technology. In the "R&D on Innovative Solar Cells" project, "Development of high efficiency concentrator solar cells, PV modules and systems," started as a new joint research of Japan and the European Union (EU) in addition to the on-going projects as follows: i) post-silicon solar cells for ultra-high efficiencies; ii) novel thin multi-junction solar cells with a highly-ordered structure; and iii) thin-film full spectrum solar cells with low concentration ratios. The total four projects will be continued until the end of FY 2015. Some sub-theme projects were required to be streamlined in the mid-term evaluation conducted in 2010, resulting in the termination of approximately 30 % of the sub-theme projects. The mid-term evaluation conducted in 2012 also called for review of agendas and issues based on prospects of the R&D. As for organic PV (OPV) technology, the project named "Development of Organic Photovoltaics toward a Low-Carbon Society" led by the University of Tokyo has been continued. In July 2012, a new NEDO R&D project started under the name of "Development of technologies to lead the practical application for organic photovoltaics" (research term: three years), aiming to identify challenges for commercialization.

Meanwhile, the following two fundamental R&D programs under the control of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) have been continued: i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells (individual proposal-oriented programs with a research term of three to five years, 36 themes) and ii) Creative Research for Clean Energy Generation Using Solar Energy (team proposal-oriented programs with a research term of three to five years, 14 themes). Calls for new proposals were closed in FY 2011.

Furthermore, preparation is underway, led by the National Institute of Advanced Industrial Science and Technology (AIST), for the establishment of a new hub in Koriyama City, Fukushima Prefecture to mainly support renewable energy related industries in relation to the project for restoration from the Great East Japan Earthquake. The building will be established by the end of 2013. As for the PV technology, preparation of the demonstration line for high efficiency crystalline silicon solar cells/ modules and technology development of silicon nanowire solar cells by Japan Science and Technology Agency (JST) are planned at the new hub.

Additionally, demonstration projects on smart communities were also implemented in Japan and overseas and PV systems were installed in the projects in a large volume. Demonstration projects implemented in FY 2012 are listed below.

- Demonstration of Next-generation Energy and Social Systems (FY 2010 ~ FY 2014): Yokohama City of Kanagawa Prefecture, Toyota City of Aichi Prefecture, Keihanna Science City of Kyoto Prefecture and Kitakyushu City of Fukuoka Prefecture
- Demonstration Tests of Next-generation Energy Technologies (FY 2011 ~ FY 2014): Smart City in Hitachi City of Ibaraki Prefecture, Smart Campus of Mie University in Mie Prefecture, Huis Ten Bosch (amusement park) in Sasebo City of Nagasaki Prefecture and Kashiwanoha Campus of the University of Tokyo in Kashiwa City of Chiba Prefecture
- Japan-U.S. Smart Grid Collaborative Demonstration Project (FY 2010 ~ FY 2013): New Mexico, USA
- Japan–U.S. Collaborative Demonstration Project for World–leading Remote Island Smart Grid (FY 2011 ~ FY 2014): Maui Island, Hawaii, USA
- Smart Community Demonstration Project (FY 2011 ~ FY 2015): Lyon, France
- The Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies (FY 2012 ~ FY 2014): India
- Smart Community Demonstration Project (FY 2012 ~): Gongqing City, Jiangxi Province, China
- Smart Community System Demonstration Project (FY 2011 ~ FY 2016): Malaga, Spain
- Smart Community Demonstration Project in an industrial park (FY 2012 ~ FY 2015): Java Island, Indonesia

INDUSTRY STATUS AND MARKET DEVELOPMENT

The annual PV installed capacity in Japan in 2012 is expected to be approximately 2 GW, achieving a significant growth from 1,3 GW in 2011, whereas cumulative installed capacity at the end of 2012 is expected to reach around 7 GW. The installed capacity increased in 2012 in Japan, thanks to a steady growth of the residential PV market and a rapid increase in installation of non-residential PV systems supported by the new FIT program.

Meanwhile, in the manufacturing of PV cells and modules, raw materials, components as well as manufacturing equipment, some Japanese manufacturers were forced to withdraw from the PV business due to continuously decreasing prices of PV cells and modules globally, a large number of entries of overseas PV manufacturers from emerging countries taking advantage of their low-priced products, as well as continued appreciation of yen. Under such circumstances, many Japanese companies have been forced to restructure their business or review their strategies.

Amid the worsening business environment, PV manufacturers including Sharp and Kyocera entered the EPC and power generation business in addition to selling PV, modules and systems. Some companies started PV production overseas (Panasonic) and increased

Fig. 3 - Kyobashi OM Building (Chuo-ku, Tokyo), 42 kW, Multicrystalline Silicon PV module.

their OEM procurement. For differentiation, some launched PV systems high added values such as high output capacity, lightweight and good design. Others enhanced their efforts to heighten reliability of PV modules including addressing PID and other issues. A series of overseas PV manufacturers entered and enhanced their activities in the Japanese PV market, targeting non-residential applications. The market share of foreign-made PV modules exceeded 30 % in Japan. In the area of silicon feedstock, a number of companies decided to withdraw from the PV business, including NS Solar Material, JFE Steel, SUMCO and Space Energy. Other companies are working on business reorganization such as downsizing of their PV business (Ferrotec) and changing business plans (Tokuyama). In the area of PV components, Asahi Glass and Nippon Sheet Glass who manufacture cover glass downsized their PV business, while some manufacturers of wiring units (Onamba) increased their production capacity. In the area of manufacturing equipment, some companies were dissolved. On the other hand, Tokyo Electron acquired an affiliate to enhance their PV business.

In the area of BOS devices, inverter manufacturers are strengthening their production facilities and expanding their product lineups to meet the demand in the residential PV market and the rapidly growing no-residential PV market. This sector of the market is gaining momentum by receiving a large number of newcomers including overseas manufacturers. In the supporting structure manufacturing business, a series of newcomers entered, including those from the steel industry, the concrete industry and the aluminum industry; in expectation of the growth of the market for ground-mounted PV systems.

The PV utilization sector has been very active. In the housing industry, over 300 000 houses were equipped with PV systems annually. PV system installation in houses, which was started by major housing manufacturers, has been expanding and medium- and small-sized housing manufacturers and those in rural areas started installing PV systems in their houses. Consequently, the power generation capacity per PV system increased in parallel with the increase in the installation ratio. With the smart house concept spreading, installation of PV systems in newly-built houses has been increasingly becoming a standard. In apartments and condominiums, more medium-sized PV systems have been installed by taking advantage of the FIT program.

EPC and PV system integration businesses are growing thanks to the overall growth of the PV market covering from medium- to MW-scale PV systems. In addition to PV manufacturers and companies who have been engaged in the PV industry such as those in the heavy electric machinery industry, installers and distributors of PV systems, companies from a wide variety of industries are entering the PV market, including electrical equipment companies, utility-related companies, general contractors, communication companies, project developers and trading companies. Also, new PV-related businesses emerged, such as operation and maintenance (O&M) of PV power plants to secure profitability of PV systems, measurement and monitoring of power generation volume, as well as supporting services for entering the power generation business.

Some financial institutions started to provide loan programs at low interest rates for individual customers for the introduction of residential PV systems and new financing programs to support the PV power generation business. In addition, some of them started to establish investment funds for MW-scale PV projects. Also, some insurance companies started to sell insurance products covering lack of sunshine and indemnification risk which was bothering renewable-energy-related companies.

Electric utilities continue introduction of PV systems in their own facilities, which represents their commitment to taking the initiative in introducing PV systems. Ten utilities also announced a plan to construct a total of 30 PV power plants nationwide with a total capacity of 140 MW by 2020. By the end of 2012, most of these PV power plants started operation and a great number of PV plants have completed across Japan. A total of 73 MW of PV power plants were in operation as of December 2012. In addition, through affiliate companies, some utilities started the installation of PV systems and the on-site PV power generation business utilizing roof and rooftop space of their customers.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DONGGUN LIM, KOREA NATIONAL UNIVERSITY OF TRANSPORTATION

Fig. 1 – 111,2 kW BIPV system located at the Climate Change Research Building of the National Institute of Environmental Research, Incheon, Korea.

Fig. 2 - 13,8 MW PV power plant, Jeollabuk-do, Korea.

GENERAL FRAMEWORK AND IMPLEMENTATION

Korea's energy consumption has increased sharply since the mid-1970s due to rapid economic growth propelled by the heavy and chemical industries. Total primary energy consumption, which stood at 43,9 million TOE in 1980, increased more than five-fold to 263,0 million TOE in 2011, thus ranking Korea as the ninth-largest energy-consuming nation in the world. Energy consumption per capita also increased rapidly from 1,1 TOE in 1980 to 5,5 TOE in 2011. With poor indigenous energy resources, Korea has to rely on almost its entire energy demand from imports. In 2011, the dependency rate on imported energy, including nuclear energy, was 96,4 %. The cost for imported energy amounted to 172,5 BUSD which accounted for 32,9 % of the total inbound shipment. Korea energy resources are limited to low-quality anthracite, which accounted for less than 1% of the total primary energy supply.

Korea's government has been pushing "low carbon and green growth" as a major agenda, holding campaigns to reduce the economy's dependence on oil and gas imports and to tackle greenhouse gas emissions. The total budgets for PV programs amounted to 799,2 BKRW in 2012. Korea's government released its Green Energy Strategy Roadmap 2011 for growth of the green energy industry. It is the second version, following the first in 2009. According to the plan, Korea is aiming to expand its global green energy market share to 18 %, and reaching 328 TKRW in exports by 2030. The strategic directions of the 2011 roadmap newly include the nurturing of world-class small and mid-sized enterprises, more efforts for convergence between technological fields and a strengthened role for the public sector.

In 2012, Korea's government has attempted to adopt two market-based regulations - the renewable portfolio standard (RPS) and the emission trading system (ETS). The RPS will require power producers with a capacity greater than 500 megawatts to generate 2 % of their total power from renewable energy sources and raise it to 10 % by 2022.

NATIONAL PROGRAMME

Korea has been making a strong effort to increase the renewable energy portion of its "national energy mix." The goal was announced in 2008. Korea's renewable energy is aiming at obtaining a 6,1 % share of the total energy consumption by 2020. Currently, the renewable energy is estimated to account for about 2,6 % of the total primary energy consumption.

Korea's national PV programs are categorized into two major sub-programs; Infrastructure-building programs and PV deployment programs. Three main programs are operating under the infrastructure-building programs; certificate of PV system, solar energy test-bed, and overseas business supporting program. And five main programs are operating under the PV deployment programs; PV Subsidy, One Million Green Homes, Regional Dissemination, Public Building Obligation, and the RPS Program.

General Deployment Subsidy Program: The government supports up to 50 % of installation cost for PV systems with a capacity below 50 kW. In addition, the government supports 80 % of the initial cost for special purpose demonstration and pre-planned systems in order to help the developed technologies and systems to advance into the market. This is the "Test-period Deployment Subsidy Program." Until the end 2012, about 16 MW capacity and 690 PV

Fig. 3 – 3 MW PV power plant, Jeollanam-do, Korea.

systems benefited from this program. In 2012, 115 PV systems with a total of 2,3 MW were installed. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities and universities.

One Million Green Homes Program: This program was launched in 2004 and an existing 100 000 solar-roof installations program was merged into this project. The government will support a certain portion of total installation costs. Although the 100 000 Solar-roof Deployment Project was to install PV systems in residential houses, the One Million Green Homes plan focuses on a variety of resources such as PV, solar thermal, geo-thermal, and small wind. In addition, there are several types of homes which range from detached houses to apartment houses. Until the end of 2012, about 122 MW capacity and about 141 000 households benefited from this program. In 2011, the number of households which benefited was 45 530 and the installed capacity was about 37 MW.

Regional Deployment Subsidy Program: The government supports up to 50 % of installation cost for PV systems owned and operated by local authorities. Until the end of 2012, about 60 MW benefited from this program. In 2011, the installed capacity was about 19 MW.

Public Building Obligation Program: The new buildings of public institutions, the floor area of which exceeds 3 000 square meters, are obliged by law to use more than 10 % of their total expected energy use to install renewable energy resource system. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. In 2012, approximately 32 MW was installed under this program.

RPS Program: The RPS is a system that enforces power producers to supply a certain amount of the total power generation by new and renewable energy. The RPS replaced the FIT Scheme from 2012. A total of thirteen companies, including six electricity generation companies, five electricity generation business companies and two other corporations participated in RPS. In 2012, about 162 MW was installed under this program.

TABLE 1 - OBLIGATORILY ALLOCATED CAPACITY FOR PV (RPS PROGRAM IN KOREA)

YEAR	2012	2013	2014	2015
CAPACITY (MW)	220	330	330	320

R&D, D

The government budget in 2010 for PV R&D was 198,8 BKRW, which is a 36,9 % increase over the past five years ('08~'12). The program mostly consists of industry-oriented research works. For the short-term commercialization, many projects have been implemented with the subjects of high efficiency crystalline silicon solar cells, Si thin film solar cells, and CIGS thin film solar cells. For long-term and innovative goals, many projects have been implemented in the area of quantum dot, organic, and dye-sensitized solar cells.

INDUSTRY AND MARKET DEVELOPMENT

The supply chain of crystalline silicon PV in Korea is complete, from feedstock materials to system installation.

TABLE 2 – CAPACITY OF THE PV PRODUCTION CHAIN IN 2012

Poly-Si (ton)	Ingot (GW)	Wafers (GW)	Cells (GW)	Modules (GW)
59 800	3,3	2,9	1,9	2,9

OCI has expanded their annual production capacity of poly-silicon feedstock up to 42 000 tons in 2011. Woongjin Energy expanded their capacity up to 1 GW in 2011 for silicon ingots. Nexolon expanded their capacity up to 1,5 GW in 2011 for silicon wafers.

Hyundai Heavy Industry expanded their capacity up to 600 MW in the c-Si solar cells. Shinsung Solar Energy expanded their capacity up to 350 MW in the c-Si solar cells. STX Solar also expanded their capacity up to 180 MW in the c-Si solar cells. Hanwha acquired Q-Cells (2012) and Solarfun Power Holdings (2010) and expanded their capacity up to 2,4 GW in the c-Si solar cells.

Since the installation of 276 MW in 2008, PV installations continue to decrease; about 79 MW were installed in 2011. This is mainly due to the reduction of government budget, mainly in the FIT programs. However, Korea's PV installation marked a tremendous jump to 252 MW in 2012, which is about 320 % increase over the previous year, and the cumulative installed PV power was about 980 MW. The total capacity of 980 MW corresponds to about 1,2 % of total electricity generation capacity of about 85,6 GW.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS

DATO' HJ BADARUDDIN BIN MAHYUDIN, MINISTRY OF ENERGY, GREEN TECHNOLOGY & WATER, MALAYSIA
MADAM BADRIYAH ABDUL MALEK, SUSTAINABLE ENERGY DEVELOPMENT AUTHORITY, MALAYSIA

GENERAL FRAMEWORK AND IMPLEMENTATION

The year 2012 marks the first anniversary of the feed-in tariff (FiT) programme in Malaysia. The FiT was launched on 1 December 2011 after the Renewable Energy (RE) and the Sustainable Energy Development Authority (SEDA) Bills were passed in Parliament at the end of April 2011. The RE Act 2011 and SEDA Act 2011 were gazetted in June 2011 leading to the establishment of SEDA Malaysia as the agency responsible for administering the FiT programme and spearheading sustainable energy development in the country. The main actors involved in the FiT framework are the Ministry of Energy, Green Technology and Water, SEDA Malaysia, the Energy Commission, electricity utility companies, RE developers and RE service providers.

FiT Programme: In Malaysia, the FiT portfolio covers four types of renewable resources, namely biomass, biogas, small hydro and solar PV. Solar PV has the fastest take-up rate which is attributed largely to the ease of project implementation. As at end of December 2012, SEDA Malaysia had approved a total of 914 applications (168,98 MW) for PV and these applications constituted 95,2 % of the total applications approved under the FiT programme. In terms of installed capacity, solar PV constituted 37,48 % from the total installed capacity approved under the Programme. The FiT Programme is funded by a Renewable Energy Fund (RE Fund) which is contributed by the electricity consumers via the 1 % surcharge levied on the consumers' monthly electricity bills. Domestic users with consumption less than 300 kWh/month are exempted from contributing to the RE Fund. Due to the limited amount of the RE Fund, the FiT is designed with a cap for each renewable resource to ensure efficient management of the cash flow and sustainability of the fund.

Future Outlook: In line with practises in other FiT countries, SEDA Malaysia together with the Ministry of Energy, Green Technology and Water have revised the degression rates for PV. The degression rates are proposed to be increased from the current 8 % to a maximum of 20 % for installed capacities greater than 24 kW. The new degression rates will become effective by the end of Q1 2013.

NATIONAL PROGRAMME & MARKET DEVELOPMENT

The market development for grid-connected PV systems hinges mainly on the FiT programme. Quotas for PV starting from year 2012, 2013 and 2014 were opened for applications on 1 December 2011. As at 31 December 2012, a total of 25,02 MW of PV projects were operational of which 2,21 MW were from individuals and 28,21 MW were from the non-individual PV categories. The market for off-grid PV systems is largely funded by the government to address rural electrification. The PV market will be dominated by the grid-connected PV applications due to the introduction of the FiT programme. Up-to-date information on PV quotas, FiT rates and operational capacity can be accessed via www.seda.gov.my.

INDUSTRY DEVELOPMENT

On the PV manufacturing front, Malaysia is one of the largest PV producers in the world with a total combined production capacity of 3 464 MW for wafers, cells and PV modules with a total number of 7 262 employees in 2012. By 2013, the total combined production capacity is estimated to increase to 4 543 MW for wafers, cells and PV modules, 6 200 tonnes for poly silicon and the total number of employees is estimated to increase to 9 243,95 % of the total production capacity is derived from foreign direct investment (FDI) and only 5 % is from domestic direct investment (DDI). Figure 1 shows the major FDIs in Malaysia and their brief details.

COMPANY	PRODUCT	NAMEPLATE CAPACITY	EMPLOYMENT/ JOBS CREATION	STATE	STATUS
AUO-SunPower	Wafer & cells	505 MW (2012) 724 MW (2013)	1 916 (2012) 2 135 (2013)	Malacca	Up scaling operation
First Solar	CdTe Modules	1 400 MW (2012 & 2013)	3 000 (2012 & 2013)	Kedah	On-going
Flextronics	PV module assembling	282 MW (2012 & 2013)	595 (2012) 445 (2013)	Johor	On-going
MEMC	Wafer	300 MW (2012) 550 MW (2013)	420 (2012) 550 (2013)	Sarawak	Up scaling operation
Panasonic	Wafer, cells & modules	300 MW (2013)	1 500 (2013)	Kedah	Operational 2013
Q-Cells	Cells	800 MW (2012) 917 MW (2013)	700 (2012) 800 (2013)	Selangor	Up scaling operation
Robert Bosch	Wafer & cells	Wafer: 800 MW (2013) Cells: 620 MW (2013)	2 (2012)	Penang	Put on hold
Tokuyama	Polysilicon	6 200 tonnes (2013)	421 (2012) 450 (2013)	Sarawak	Operational 2013

Fig.1 - Major PV FDIs in Malaysia.

Fig. 2 - 685 kW Solar PV at SURIA KLCC (Shopping Mall), Malaysia (Photo: PETRONAS).

In 2012, there were four local PV assembly plants in Malaysia that were producing PV. They were: SolarTIF Sdn Bhd, PV Hi-Tech Sdn Bhd, TS Solartech Sdn Bhd and Malaysian Solar Resources Sdn Bhd; together their combined total production capacity was 177 MW. Their total combined production capacity is expected to increase to 370 MW by 2013. These four plants had 208 employees in 2012 and are expected to increase their workforce to 363 by 2013.

Within the PV industry, there are over 50 PV service providers currently active in the market. The total estimated manpower involved in the PV service industry is between 250 to 300 people. The list of these PV service providers can be found in http://seda.gov.my/go-home.php?omaneg=0001010000000101010100010000100000000000000000000 .

R&D, D

As part of SEDA Malaysia's function to continuously expand the type of renewable resources under its current portfolio, the agency has started two resource assessment studies. In 2012, Universiti Malaysia Terengganu (UMT) was appointed by SEDA Malaysia to undertake wind resource mapping over a period of 12 months. Another study on geothermal resource potential will be carried out jointly with the Department of Mineral and GeoScience Malaysia. In addition, SEDA Malaysia has also endorsed Universiti Malaysia Pahang to conduct research on tidal wave study and University of Malaya on inverter study (for PV capacity > 10 kW).

MEXICO

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

Fig. 1 - 182 kW Grid Connected PV System in Zacatecas, Mexico.

GENERAL FRAMEWORK

Renewable energy as an alternative for power generation has been included in the Mexican Government energy prospective document for the period 2012-2026, although PV participation is considered still marginal. Nonetheless, the number and size of PV projects in Mexico continues growing. Two MW-size facilities came online in 2012 as a pilot project of the national electric utility CFE. A 1 MW unit started commercial operation in the first semester of that year, while a 5 MW capacity plant is still undergoing pre-operational testing. Both plants are located in the Peninsula of Baja California. Interest in PV from the private sector is also growing. Several companies are resorting to PV for the self-supply of electricity. According to CFE statistics, around 1 000 grid interconnection contracts were signed in 2012 by private parties for the installation of roof tops or ground mounted PV plants; totaling 7,7 MW in capacity.

During 2012, domestic power consumers also took advantage of the net-metering scheme previously implemented by the Energy Regulatory Commission, which has resulted in about 4 MW of micro-PV roof tops, around 1 kW each.

Tens of megawatts of large-capacity PV plants are currently at different stages of project development around the country, mostly at the pre-feasibility stage. This is a result of the interest from investors who are exploring the potential for PV business in Mexico.

NATIONAL PROGRAMME

No general policy is currently in place for the promotion and deployment of PV technology. Nonetheless, specific programs are being carried out, such as the one currently under implementation to install PV-powered micro-grids (commonly called "Solar Farms") for the electrification of highly-marginalized, not too-dispersed, remote rural communities far away from the electrical grid. Contrary to previous rural electrification programs in this country, where PV installations were turned over to the community for operation, maintenance and support, which resulted in lack of sustainability and too short useful system lifetime, solar farms will be minded by the national utility itself to assure good plant performance and long service. Four such systems, 50 kW each, were installed in an equal number of communities during 2012. CFE plans to install around 100 more such solar farms in the coming years.

R&DD

The National Science and Technology Council (CONACYT), jointly with the Energy Ministry, issued a call for proposals for the creation of a Mexican Innovation Solar Energy Center. Proposals are still in the evaluation phase and it is expected that results will be published any time soon.

The concept of Smart Grids is quickly gaining momentum in the Mexican energy sector and grid integration of distributed PV and other renewables is in the forefront of the analysis. Specialized working groups are being formed under the leadership of the national electrical utility CFE to move the concept forward. Under contract to

Fig. 2 - 50 kWp solar farm used for rural electrification in Nayarit, Mexico.

CFE, IIE is currently analyzing the impacts of distributed PV systems on distribution lines. One such study that covers the northwestern region of Mexico focused on the large scale deployment of PV roof tops as a peak-shaving alternative during the high demand for air conditioning in the summer season. Further analyses are now under preparation for other regions of the country.

INDUSTRY AND MARKET DEVELOPMENT

The installation of 14,5 MW of PV panels during 2012 (twice the amount installed in the previous year) is cause for optimism of the Mexican PV industry. Almost 40 % of this new capacity is represented by the two CFE units mentioned above. Overall installed capacity in Mexico is estimated at 52 MW.

PV conferences and other related events are becoming more frequent every day, attracting potential investors and large project developers who are convinced of the large potential Mexico has for this technology. Lobbying activities in favor of PV by these and other actors, to gain support from public and private entities, is clearly increasing.

Such promotional activities have resulted in the recent announcement of two funding sources for PV projects, one from a private bank and the other from a public financing institution. This is only a first step of what is expected to be the solution of the financing bottle neck for PV deployment in this country.

Conservative forecasts from the Mexican PV industry indicate that next year PV sales will be at least similar to the ones this year. However, in the onset of a new federal administration and taking into account the fast increase of PV-related activities in this country, one could easily venture to forecast the construction of large-scale multi MW size PV plants in the coming months.

On the other hand, Mexico is not exempt from the ups-and-downs of the international PV industry: a module assembly company that not too long ago had built a factory in this country, decided to close its operations in Mexico as of 2012.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS,
OTTO BERNSEN, NL AGENCY, DIRECTORATE ENERGY AND CLIMATE

Fig. 1 - PV modules on beach tent at Scheveningen (Photo: Lachian Fletcher & Greg Watt, Studio 18a).

GENERAL FRAMEWORK

The policy for the top sector "Energy" in the Netherlands aims at both energy security, with sustainable energy goals of 16 % in 2020, and belonging to the world class in their respective fields. Traditionally, PV research is strong in the Netherlands and now it is focused by the TKI (Top Knowledge Institute) Solar Energy toward industry-led applied research with a new impulse. TKI's are vehicles for research programming within the Top Sectors. In 2012, over 31 MEUR was allocated by the TKI Solar Energy, coming from private contributions, innovation budgets and the general framework for stimulating renewable energy SDE+. There is separate funding for fundamental research which goes to the universities and the FOM (Fundamental Research of Matter) institute. These fundamental research funds are not exclusively allocated to the Top Sector Energy but also span the top sectors Chemistry and HTSM (High Tech Systems and Materials).

The newly formed government continues this existing policy focused on Dutch top sectors of which energy is one. Within the Dutch energy mix solar PV plays a relative minor role in absolute numbers (currently 0,3 % of the total energy production, source CBS statline) but it is an important driver for decentralised and renewable energy production and the so called "energy transition" which includes two way traffic in the electricity grid. The installed capacity of PV has doubled each year from 2009 onwards to 58 MW in 2011 (CBS statline). This acceleration is partly due to sharply falling module prices, and it is expected that this trend will continue in 2012, leading to at least another 120 MW installed capacity. The goal set by the TKI is to reach at least 3 % for solar PV of the total electricity production in 2020. That amounts to roughly 4 GW which is still modest in an international perspective, but it shows a vibrant domestic market. In the spring of 2012, a one off 52 MEUR subsidy deal was negotiated between political parties for individual households to recover some of their installation costs. The amount was divided over 2012 (22 MEUR) and 2013 (30 MEUR). The program of "Green Deals" was also continued, which has the aim of achieving major energy efficiencies, less administrative obstacles and exploring new roles for government and stakeholders. One of these green deals granted targets the market segment of BIPV and setting up test facilities for new products and services. Also the SDE+ was continued for solar installations above 15 kWp. The upper limited however of 100 kWp has been cancelled but there are still very few systems this size in the Netherlands. The national discussion on net metering, currently limited to 5 000 kWh, above which only 0,07 EURcents is paid back, also continues.

The international shake out and consolidation of the PV industry hit home hard in 2011 but in 2012 there was also some uplifting news as Smit Ovens and Tempress who kept attracting new orders and there was still room for newcomers such as SoLayTec and Levitech which also deliver high-tech equipment. The highly innovative SunWeb (formerly part of Solland Solar) was sold to the Finnish Cencorp. The installation branch shows a healthy growth with many new small businesses and collective actions for buying solar panels. The already mentioned lower prices of solar modules played an important role but also the steady rising energy prices and greater awareness in the market of PV being a viable option.

Fig. 2 - PV system on a school roof, Voorburg (Photo: Lachian Fletcher & Greg Watt, Studio 18a).

Fig. 3 - Utrecht CS cold bent solar modules (Photo: Lachian Fletcher & Greg Watt, Studio 18a).

NATIONAL PROGRAMMES

In 2012 the TKI Solar Energy officially kicked off with an "innovation contract" which is a public-private partnership. It covers the entire value chain from materials and devices to large scale deployment of systems and services. Looking beyond PV modules and manufacturing equipment, it targets specifically integration into buildings (BIPV), grid integration and societal integration, safeguarding public support and timely addressing non-technical barriers for large scale deployment. The brunt of the funding goes to industry-led research into wafer-based silicon PV technologies, advanced manufacturing equipment for very high efficiency modules including new applications of nanotechnology, and into thin-film PV advanced manufacturing equipment for low cost/high throughput and new light-weight and flexible applications. Over 31 MEUR was eventually allocated, coming from private funding, innovation budgets and the general framework for stimulating renewable energy SDE+. The public funding amounts to 15,6 MEUR in 2012 within the TKI solar. Apart from that, there is separate funding fundamental research which went to the universities and the FOM-Institute.

The national program for the implementation of renewable energy sources (DEN) continued in 2012 with the activities focused on the quality and ease of installation, permits, certification and public information about the realities of solar PV in the market place. The Foundation "Monitoring Zonnestroom" (Solar Power) joined the IEA PVPS Task 13 concerning performance and reliability of photovoltaic systems. Together, with the solar power branch organisation Holland Solar the yearly "Sunday" event is organised, which spans both science and market information, and the informative "Solar Tours," which covers three different routes by bus through the Netherlands and extends nowadays into Germany.

The SDE incentive for solar modules was replaced in 2011 by the SDE+ scheme which targets larger systems (above 15 kWp), with a maximum of 0,15 EUR cents per kWh but granted in rounds starting at 0,07 EUR cents. Most of the budget went to other renewables. The amount corresponding to around 16 MW installed capacity was granted to larger solar PV projects mainly on public buildings and in the agricultural sector. This scheme is, in addition to the already existing tax incentives, for companies; such as in the energy reduction (EIA) and environmental reduction (MIA/Vamil).

In the national Innovation Program for Solar PV (IPZ) only four consortia made it to the final phase of market introduction without any government support:

1. BalastNedam project modular roof.
2. Femtogrid boosting performance of PV modules in the build environment with "smart" electronics.
3. Dimark developed integrated roofing's using both solar thermal and solar power for traditional prices.
4. Peer+ an university start up producing smart energy glass with flexible settings.

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2012, the 31 MEUR allocated in national tenders went to PV systems and applications, wafer based silicon technologies and, to a smaller extent, to thin-film technologies. The TKI Solar Energy focused on applied research in these three areas. The key research partnerships in these three focus areas are:

- SEAC (Solar Energy Application Centre; an initiative of ECN and TNO) for systems & applications;
- Silicon Competence Centre (ECN, FOM-Amolf, TUD-Dimes) for wafer-based silicon PV technologies;
- Solliance (TNO, ECN, TU/e, Holst Centre, IMEC and FZ Jülich) for thin-film technologies.

Alongside these national initiatives there are several active provinces with extensive applied research activities in solar energy, such as Energy Valley (the three Northern provinces) and Limburg with the BIHTS program on building integrated high tech systems. The total public – private investment (including innovation vouchers) for BIHTS over the coming years amounts to 19 MEUR. This knowledge centre consists of four parts:

- A research facility for BIPV following the approach of "open innovation;"
- A centre of expertise for knowledge exchange between enterprises, government and the education sector;
- A real life lab especially for students;
- An incubator facility for start-ups in the built environment.

Fig. 4 - Solar samples at the TUD research lab (Photo: Lachian Fletcher & Greg Watt, Studio 18a).

A number of other existing national research programs continue or are coming to an end in 2012, such as the Joint Solar Program (JSP), which started in 2004. They include:

- The PV-part of the ADEM (Advanced Dutch Energy Materials Innovation Lab) program focuses on the materials used in solar cells and modules: the active materials for electricity generation from sunlight and the passive materials used in transport of electricity and the protective packaging of the cells. ADEM collaborates with the many institutes in the Netherlands working on solar cells and aims to facilitate in sharing of equipment and expertise.
- The NanoNextNL program for R&D on nanotechnologies includes a subprogram on solar energy.
- The FOM institute Amolf has a program "Light Management in Photovoltaic Materials" which started in 2011.
- On the first of January 2012, FOM started a new research group called DIFFER for fundamental energy research, which will be based in the years to come on the high tech campus in Eindhoven.

INDUSTRY STATUS

The international shake out and consolidation of the PV industry hit home hard in 2011 but there was also some uplifting news as Smit Ovens and Tempress kept attracting new orders and there is still room for newcomers such as SoLayTec and Levitech which also deliver high-tech equipment. The innovative SunWeb (formerly part of Solland Solar) was sold to the Finnish Cencorp. The installation branch shows a healthy growth and many new small businesses including buyer collectives. Also existing organisations, such as the association of home owners, and several energy suppliers offered the purchase of solar modules as part of their services.

The TKI Solar Energy will reinforce the applied research and help consolidate the Dutch international position while looking for new products and services. One of its main goals is to focus applied research and bridge the divide between fundamental research and industry.

DEMONSTRATION PROJECTS

The phase of demonstration projects of PV modules is all but over in the Netherlands. There is a wide interest for solar PV and the demonstration projects now tend to focus on grid and building integration and on new exploitation models. In that sense, solar energy has arrived and is accepted in the Netherlands but still has some distance to go to scale up.

In the 2012 "spring deal" a structural 10 MEUR was reserved as of 2014 for net metering experiments with individual owned modules on public roofs. Two experiments in the municipality of Nijmegen have already started with these "solar parks," with easy access to participate for private stakeholders.

IMPLEMENTATION AND MARKET DEVELOPMENT

A major solar application of 850 kWp was installed in 2012 at the beach resort Klepperstee in Ouddorp aan Zee in the province of Zeeland. It is a remarkable initiative on 1,3 hectare by the seaside. See www.zonneparkouddorp.nl

In the Netherlands there is no obligation to register mounted solar panels and the outroll of smart meters is only at its initial stage. Over the last two years, there also has been an explosive growth in new and old businesses offering the installation of solar modules and the related companies are not necessarily members of the industry organisations or registered as solar power being their core business, at the chambers of commerce. Therefore, exact figures are hard to come by and the best effort is an estimate based on the partial data below.

In 2012 the SDE+ subsidy for larger systems shows an increase in installation size and grants corresponding to 16 MW installed capacity. This is an increase of almost 150 % over the 6,4 MW in 2011. At the same time, the percentage of the SDE+ scheme of the total amount of installed capacity has declined. (source NL Agency, SDE+ January 2013)

The subsidy resulting from the "spring deal" in 2012 received 43 287 requests, which will have to be installed within 6 months, for a total corresponding to 125,7 MW. (source NL Agency, to be published shortly).

Although no exact figures are yet known over 2012, at the time of this publication, and depending on the assumptions, the first indications are that the installed capacity has again doubled in 2012, compared to the previous year, to around 120 MW. This means that the cumulative installed capacity in 2012 in the Netherlands will be 265 MW or over.

This is welcome news for a building sector that has been hard hit by the economic crises. It is one of the few growth markets at this moment.

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

TROND MOENGEN, THE RESEARCH COUNCIL OF NORWAY

Fig. 1 - PV installation at Tyinholmen lodge in the Norwegian mountains. With 22 panels, approx 6 kW, supplied by REC.

GENERAL FRAMEWORK

For decades, hydro power has been the main source of electricity generation, covering roughly more than 95 % of the demand. Since the annual precipitation varies from year to year, and thereby also the power production, the Norwegian electricity system is 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 metal 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.

2012 was the first year of operation of the common Swedish-Norwegian elcertificate market. The elcertificate market is a technology neutral, market-based support scheme for power generation from renewable energy sources. The market is designed to increase power generation from renewable energy sources in the two countries with a total of 26,4 TWh/year before 2020. The total power production in Norway in 2012 was 146 TWh, which is the second highest ever.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001 as an instrument to improve energy system efficiency and increase renewable energy production. Enova offers support schemes in the areas in which the greatest effect in the form of saved, converted, or generated clean energy can be achieved. During some years, Enova has offered households financial support for investments in solar thermal energy. So far, Enova has not offered support to investments in PV systems. In September 2012 however, Enova published a report on how PV may be utilized in Norway in the future, motivating public and private actors to investigate possibilities for PV utilization. The report reflects the decrease in unit costs of PV that has taken place since 2009, and shows that PV in some special instances may be able to compete with other forms of power sources.

Environmental qualities or aspects seem to become an increasingly important market parameter for actors in the Norwegian building and construction sector. There are some signs showing that PV is used to strengthen the environmental performance of buildings. For example, the environmental assessment method for buildings BREEAM (Building Research Establishment's Environmental Assessment Method), that also represents a driving force behind PV, is more widely used.

Without any particular public support schemes for PV systems, however, the main market for PV in Norway continues to be related to off-grid recreational applications and special areas such as lighthouses and telecom. And since PV in most cases represents higher unit costs than wind- and small scale hydro, the new elcertificate market is not expected to result in many new Norwegian PV projects.

NATIONAL PROGRAMME

Currently, Norway has no defined goals when it comes to implementation of PV technology. There are no incentive scheme supporting the installation of PV systems, and consequently the use of PV technology in Norway is limited compared to other countries.

On the other hand, PV seems to continue to be an important topic for government funded research and development.

Fig. 2 - PV installation at Tyinholmen lodge in the Norwegian mountains. With 22 panels, approx 6 kW, supplied by REC.

RESEARCH AND DEVELOPMENT

The Norwegian Research Council (NRC) funds industry oriented research, basic research and socio-economic research within the energy field, including renewable energy sources.

The total NRC-funds for PV-related R&D projects were appr. 144 MNOK (18,5 MEURO) for 2011 and at the same level in 2012. 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. A growing supply business is also filling out the portfolio of projects.

For the first time, a mapping of the total public spending has been conducted, not only on R&D but by different public schemes all along the innovation chain. The mapping has been conducted by the strategic body Energi21 and has covered all governmental projects related to stationary energy production and use. All together the public support was 93 MNOK in 2012, approx 12 MEURO.

The graph below illustrates the profile.

The profiles underline the fact that there has been no introduction of PV in Norway.

The Norwegian Research Centre for Solar Cell Technology has completed it's third year of operation (www.solarunited.no). Leading national research groups and industrial partners in PV 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 solar panel 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 total Centre budget is 374 MNOK over the duration of the Centre (2009–2017).

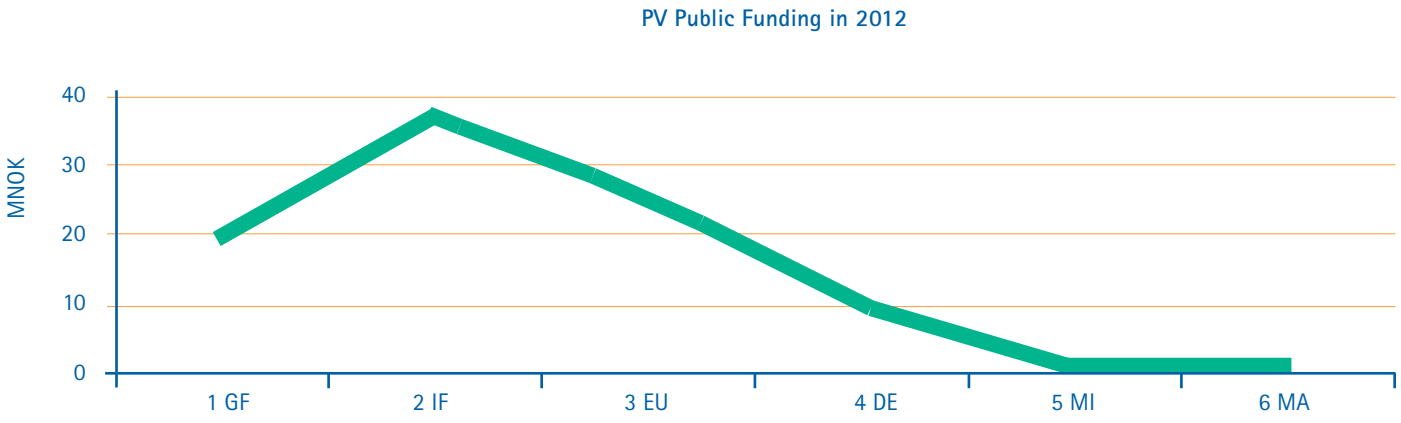


Fig. 3 - 1 GF: Fundamental Research, 2 IF: Industrial Research, 3 EU: Experimantal Development, 4 DE: Demonstration, 5: Market Introduction and 6: Market Stimulation.

There are six main R&D groups in the universities and institute sector of Norway:

- IFE (Institute for Energy Technology): Focus on silicon solar cell design, production and characterization and investigations of the effect of material quality upon solar cell performance. A solar cell laboratory at IFE contains a dedicated line for producing silicon-based solar cells. Additionally, a characterization laboratory has been established.
- University of Oslo (UiO), Faculty of Mathematics and Natural Sciences: The Centre for Materials Science and Nanotechology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.
- NTNU (Norwegian University of Science and Technology) Trondheim: Focuses on production and characterization of solar grade silicon.
- 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.
- Norut (Northern Research Institute Narvik): Development of silicon based solar cells and includes the whole production chain from casting of silicon to solar cell modules. A lab for solar cell characterization was built in cooperation with Innotech Solar AS.

INDUSTRY AND MARKET DEVELOPMENT

The international PV market was further weakened in 2012. Falling unit prices and over-capacity on the supply side has led to corresponding production reductions for the major Norwegian PV actors.

Renewable Energy Corporation (REC). REC – Renewable Energy Corporation, is involved in the whole value chain of solar cells, from raw materials to complete modules.

REC Wafer has so far been the operating division for the mono- and multicrystalline wafers and ingots production in Norway. REC Wafer Norway was operating two processing plants in Glomfjord - one producing of monocrystalline wafers and ingots (300 MW/year), and one plant producing multicrystalline ingots and wafers (275 MW/year), with a total of about 400 employees.

Since 2003, REC Wafer Norway also operated multicrystalline wafer production at Herøya industry park two hours south of Oslo. By 2010, the total production capacity at Herøya was approximately 1,1 GW, employing about 700 people. By June 2102, all of REC's production facilities in Norway were permanently closed down, leaving the head office outside of Oslo as the only activity in Norway. More than one thousand REC employees have lost their jobs. REC Wafer Norway suffered bankruptcy in August 2012.

Elkem Solar. Based on the so called metallurgical route, Elkem Solar has invested in a silicon production plant in Kristiansand in southern Norway. With a design capacity of 6 000 tons of solar grade silicon per year, the plant started ramp up production during 2009. The production technology is now tested and verified, and according to Elkem, it enables the company to produce silicon with just 1/4 of the energy consumption compared with traditional technology.

This first Elkem Solar plant has cost about 600 MUSD to build, making it one of Norway's largest industrial investments on the mainland. In order to adjust to market demand, a number of the 220 plant employees were temporarily laid off for a period in 2012. Since January 2011, Elkem Solar, along with the other parts of Elkem ASA, has been owned by China National Bluestar (Group) Co., Ltd.

NorSun AS Manufactures high performance monocrystalline silicon ingots and wafers at its plant in Årdal on the Norwegian west coast. Annual production capacity at the company's facilities in Norway and Vantaa, Finland exceeds 200 MWp. In order to adjust to market demand, a number of the 220 plant employees were temporarily laid off for a period in 2012. During the second half of 2012, a large number of the approximately 200 employees in Norway were affected by temporary layoffs and some also permanently.

The reduced activity in production of ingots and wafers has also affected a number of other actors such as Metallkraft AS, Innotech Solar AS (ITS) and SIC Processing AS. Other actors like Fesil Sunergy AS and CruSiN AS have been sold to foreign investors.

IMPLEMENTATION

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

PV powered coastal lighthouses represents a significant user category. The Norwegian Coastal Administration (NCA) operates a total of 3083 PV installations. The average is 110 Wp per installation, yielding a total installed PV capacity of 338 kW.

Aside for the leisure market, few new PV installations of significant size were installed in 2012. Exceptions are a small number of household roof-top systems yielding roughly 1-6 kWp each.

There is, however, an increasing interest in environmentally friendly building among architects, developers and other actors in the building sector. During 2012, several large building projects with building integrated PV systems came on the drawing board.

Annual sales of PV capacity in Norway is estimated at 300-400 kWp, mostly as stand-alone systems. The total installed PV capacity is approximately 9-9,5 MWp.

PORTUGAL

PV TECHNOLOGY STATUS AND PROSPECTS

PEDRO SASSETTI PAES AND JOÃO MACIEL, EDP

Fig. 1 - 4 kWp microgeneration project in a public health centre in Portugal.

GENERAL FRAMEWORK AND IMPLEMENTATION

In 2012, following the 2011 political and financial crisis, the Portuguese government continued to deploy the measures agreed with the Troika – the International Monetary Fund (IMF), the European Commission (EC) and the European Central Bank (ECB) – regarding renewable energy generation and co-generation under the special regime.

In April 2012 the DG for Energy and Geology of the Ministry of Economy and Employment released a document containing the guidelines for a review of the Renewable Energy Action Plan (REAP). This document was available for public consultation until June 2012. The major highlight of these guidelines is a reduction of more than 60 % in the solar energy generation goal for 2020. Nonetheless, it will still be possible to achieve the commitments already assumed under the European legislation (20-20-20 climate-energy package). According to this plan, 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.

Several companies showed interest in reviewing these guidelines and submitted their comments on the subject. Taking that into account, the new energy policy framework is currently being prepared by the government, and it is expected to be implemented in 2013.

The mini and micro-generation schemes are not at risk and will prevail in 2013, although with changes in the annual installation cap and in the associated feed-in tariffs.

Fig. 2 - 4 kWp microgeneration project for a domestic house in Portugal.

Fig. 3 - 60 kWp minigeneration project on the rooftop of a company in Portugal.

NATIONAL PROGRAMME

A feed-in tariff mechanism, under the special regime production, is the main instrument for promoting PV, for which there are three different frameworks (see Table 1): the Independent Power Producer (IPP), in force since 1988, the micro-generation scheme (2007, revised in 2010) and the mini-generation scheme (2011).

The mini and micro-generation schemes have suffered modifications through the years, since they were created. The mini-generation scheme's annual tariff reduction increased from 7 % to 14 % in 2011, thus the premium tariff value in 2012 was equal to 215 EUR. Also, the capacity cap was reduced to 30 MW per year. In 2012, another change in the annual tariff was in place, increasing from 14 % to 30 %, which will significantly decrease the reference tariff in 2013.

The micro-generation scheme suffered its first modification in 2011, when the annual tariff reduction increased from 20 EUR/MWh to 54 EUR/MWh for the first 8 years after installation, and from 20 EUR/MWh to 35 EUR/MWh for the next 7 years of operation. The reference tariff value in 2012 was equal to 326 EUR/MWh for the first 8 years after installation, and 185 EUR/MWh for the next 7 years of operation. Like the mini-generation scheme, the capacity cap was also reduced, in this case to 10 MW per year. In 2012, the annual tariff reduction for the first 8 years after installation increased to 130 EUR/MWh, whereas for the next 7 years of operation it decreased to the initial value, 20 EUR/MWh.

TABLE 1 – 2012 PV FRAMEWORK

LEGAL FRAMEWORK	INDEPENDENT POWER PRODUCER (DECREE-LAW 312/2001 AND 225/2007)	MINI-GENERATION (DECREE-LAW 34/2011)	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	250 kW	5,75 kW single or 3-phase; 11,04 kW 3-phase in condominiums
Starting Tariff	**Building integrated** • Less than 5 kW – 0,469 EUR/kWh • 5 kW to 150 kW – 0,354 EUR/kWh **Ground based** • Less than 5 kW – 0,447 EUR/kWh • More than 5 kW – 0,317 EUR/kWh	**Premium tariff** – 0,25 EUR/kWh • From 5,75 to 20 kW – full premium tariff • From 20 kW to 100 kW and from 100 kW to 250 kW – bidding process based on the premium tariff (two separated bidding processes)	**Premium tariff** – 326 EUR/MWh (in 2012 applicable to • Up to 3,68 kW production capacity or 11,04 kW (condominiums) and • Up to 2,4 MWh sold per year and **Regular tariff** – Annual Low Voltage (LV) regulated tariff
Starting tariff revision	Constant value based on formula incorporating technology and operation mode	Premium tariff revised down – 7 %/year	• Premium tariff revised down 130 EUR/MWh/year • Regular tariff revised annually
On-going update	Monthly updated at inflation rate	Fixed tariff for 15 years without inflation correction	**Special regime (Premium tariff)** • Fixed for the first 8 years after installation. Starting tariff in 2012: 326 EUR/MWh (- 130 EUR/MWh/year for subsequent years) • Fixed for the next 7 years of operation. Starting tariff in 2012: 185 EUR/MWh (- 20 EUR/MWh/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)	Premium tariff secured for the first 15 years, after which will equal the market tariff	Premium tariff secured for the first 15 years, after which will equal the market tariff
Capacity cap	Building integrated – 50 MW Ground based – 150 MW (shared with CSP)	30 MW per year	10 MW per year
Other restrictions		• Up to 50 % of contracted consumption capacity can be injected to the grid • Design PV electricity production up to twice the electricity consumed in year prior to licensing • Establishment and implementation of an Energy Efficiency Plan	• Up to 50 % of contracted consumption capacity can be injected to the grid, 100 % for condominiums • At least 2 m^2 solar water heating system installed or equivalent biomass boiler • 30 % CAPEX deductible on income tax up to 800 EUR

Fig. 4 - 20 kWp minigeneration project on an agricultural farm in Portugal.

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), private research institutes (INESC Porto - Institute for Systems and Computers Engineering) and private companies such as EFACEC.

Associations such as SPES (National Solar Energy Society) and APISOLAR (solar manufacturers and installers association), LNEG, IPES (Instituto Português de Energia Solar) 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).

The most significant R&D projects underway, involving universities, national laboratories industry and utility consortiums, are:

- "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.
- Sunlab: Demonstration, by EDP, of the correlation between climatic variables, module position and energy production in different sites and for different PV technologies, in Portugal.
- "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.
- CZTS / Crystalsol Project: Joint development of CZTS technology. Consortium: LNEG, Crystalsol and EDP.

INDUSTRY AND MARKET DEVELOPMENT

In 2012, there were five PV module manufacturers in Portugal (c-Si and a-Si) and two CPV assemblers, as shown in Table 2, with a total production capacity of about 200 MW.

TABLE 2 – PV MODULE MANUFACTURERS AND CPV ASSEMBLERS IN 2012

COMPANY	MAXIMUM CAPACITY (MW)	CURRENT CAPACITY (MW)	PRODUCTION 2012 (MW)	TECHNOLOGY
Open Renewables*	65	65	34	c-Si (77 % mono, 23 % poly)
Martifer Solar	50	50	15	c-Si (poly)
SolarPlus	10	10	n.a.	a-Si (double junction)
Goosun*	10	10	n.a.	c-Si (poly)
Fluitecnik	50	45	15	c-Si (17 % mono, 83 % poly)
WS Energia*	40 MW (one-axis tracker) and 15 MW (two-axis tracker)	n.a.	n.a.	CPV (1,93x, mono c-Si, flat-plate and curve reflectors)
MagPower*	54	n.a.	n.a.	CPV (800x, III-V triple junction cells and Fresnel concentrating optics)

** Data from 2012 was unavailable. The presented figures are from 2011.*

Despite the financial crisis, the Portuguese PV market grew 41 % in 2012, achieving a total cumulative PV capacity of about 223 MW (see Table 3 and graph), 99 % of which are grid-connected.

TRENDS

Present financial and economic difficulties in Portugal increase pressure on governmental support to renewable energy projects. While the government is still preparing a new energy policy framework, it will certainly follow the Troika recommendation as far as RES are concerned:

- Reviewing the efficiency of support schemes for renewables;
- Revising downward the feed-in tariffs for new contracts in renewables;
- Decisions on future investments, in particular in less mature technologies, will be based on a rigorous analysis in terms of its costs and consequences for energy prices.

The maintenance of the micro and mini-generation regimes was ensured for 2013 with an aggregated cap of 41 MW (11 MW micro and 30 MW mini). Expectations exist that this capacity will be realized, especially if flexibility of the cap among regimes is allowed, reflecting adjustments to the effective demand observed.

For micro-generation, the reference tariff in 2013 will be 196 EUR/MWh for the first 8 years after installation and 165 EUR/MWh for the next 7 years of operation. For mini-generation, the reference tariff in 2013 will be 151 EUR/MWh.

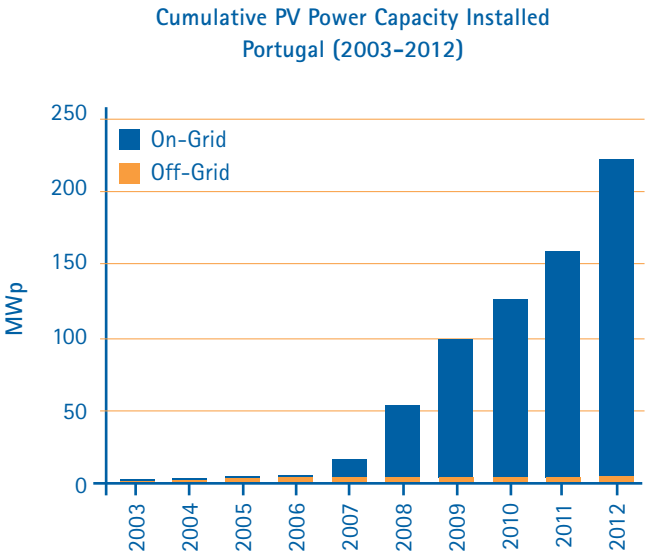


FIG. 5 – Cumulative PV power capacity installed in Portugal (2003-2013).

TABLE 3 – CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (2003-2012)

YEAR	OFF-GRID (MWp)	ON-GRID (MWp)	TOTAL POWER (MWp)
2003	1,67	0,01	1,68
2004	2,23	0,01	2,24
2005	2,44	0,06	2,50
2006	2,64	1,00	3,64
2007	2,84	13,0	15,8
2008	2,94	50,0	52,9
2009	3,04	95,0	98,0
2010	3,14	123	126
2011	3,24	155	158
2012	**3,34**	**220**	**223**

Rem.: Data for off-grid installation are estimated since 2006

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

ANA ROSA LAGUNAS ALONSO, CENTRO NACIONAL DE ENERGIAS RENOVABLES, CENER

GENERAL FRAMEWORK

In 2012, renewable energies have covered 32 % of the electrical demand in Spain. That number is 1 point less than in 2011 and the reduction is related to the lower electricity produced by hydroelectric generation. Again, as in previous years, the leader among renewables is wind energy, which covers the 18 % of the total electricity demand in the country, with frequent peaks of higher values. In fact, there was a record of 64 % instant demand coverage in September 2012. In this context, wind represents the third global position after nuclear (22 %), and coal (20 %). Figure 1 shows the evolution of percentage of demand coverage from renewable energies during last five years.

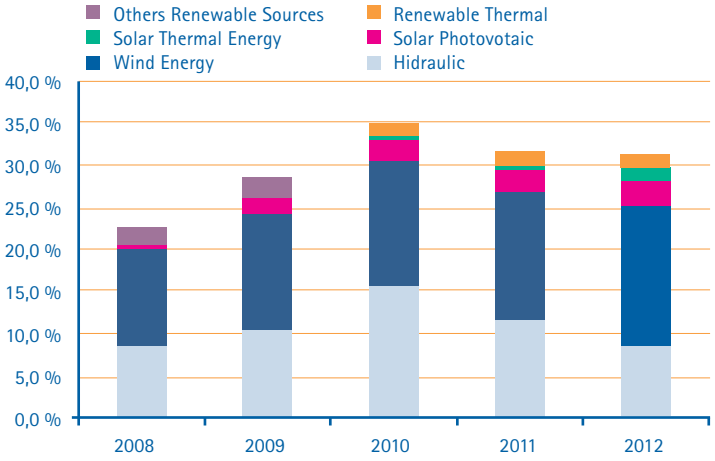


Fig. 1 – Spain's evolution of percentage of demand coverage from renewable energies during the last five years.

In the case of solar photovoltaic electricity production, 3,1 % of total country demand has been covered during 2012 (provisional data out of grid operator REE), with the maximum close to 4 % in the July/August 2012 time frame.

These numbers have not changed so much with respect to previous year; mostly because there have not been many new installations. The regulation as of January 2012 (RD 1/2012) with the total elimination of feed-in-tariff for the electricity produced by PV means, has been the origin of a big slow down in the activity; less than 200 MW were installed in the whole country this year. The panorama did not improve during the rest of the year; as of the summer of 2012, a new tax was added to renewable energies in order to contribute to the reduction of existing deficits in electricity generation costs.

Finally, the expected regulation of auto consumption and net metering, already announced in 2011, did not appear during 2012, being postponed this time until first quarter of 2013. Nevertheless, activity for small PV plants installation has continued and alternatives for using the energy produced in an instantaneous form until a net metering regulation exists are becoming more frequent. In that sense, some of the autonomous communities have started proposing local regulations, due to the delay of the appearance of the central government regulation.

NATIONAL PROGRAMME

The National Programme for PV is aligned with consigns of the European Parliament concerning 20 % of primary energy supply coming out of RREE by 2020 (and 10 % for transportation). The main lines are described in "Plan de Energías Renovables (PER) 2011-2020" issued by the IDAE (Instituto para la Diversificación y el Ahorro de la Energía), and approved by the Council of Ministers on November the 11th, 2011. The achievement of goals proposed considers energetic efficiency and the 2 % annual reduction of the final energetic intensity in the period between 2010 and 2020 (for a moderate economic growth).

In those circumstances, the objective of gross electricity generation out of RREE for 2020 is 38,1 %. That challenging number should only be achieved through an intensive control of performance indicators and technological developments. Nevertheless, the plan must be realistic with the evolution of RREE and for that reason should be reviewed and modified, if necessary.

R&D, D

Among the most relevant initiatives concerning the R&D aspects during 2012 has been the start-up of the Spanish Photovoltaic Technology Platform (FOTOPLAT) during the month of March 2012. This group, led by a research institute (ISFOC) and a PV module manufacturing company (SOLIKER), is financed by MINECO (Ministry of Economy and Competitiveness), responsible of policies for scientific and technical activities in R&D. The executive committee of the association is formed by companies and R&D centres that have as main interest to activate the links among research, technology and innovation players, in order to foster new developments in PV. The other members of the executive committee are IES-UPM, ATERSA, IREC, TECNALIA, CENER, ABENGOA, RENOVALIA and ISOFOTÓN. All of these are institutions covering aspects from the basic research, passing through device development, equipment manufacturing activities and PV plant installations. The participants from the administration are present in the platform meetings, but they do not have the right to vote. Based on the constitution, the FOTOPLAT is open to any entity active in PV in the country.

R&D in Spain is also linked to the rest of Europe because of the presence of Spanish research centres in European forums where the research lines are being decided. Among them is the Joint Programme on Photovoltaic Solar Energy, part of the EERA (European Energy Research Alliance), launched in a Set-Plan meeting held in Madrid (2010) and that is now consolidating its activities.

An important effort is being dedicated in the country to the development of high efficiency technologies, such as CPV. At least 4 projects, involving the most relevant players in this field are financed by the Spanish Ministry of Economy and Competitiveness inside of the INNPACTO frame. Also being part of that call, the other area of activity concerning PV is the energy efficiency in

buildings and specifically the BIPV developments (materials, BIPV modules, another components and control). Aspects concerning control of different electricity generation fed into the electrical grid are considered basic for small generation activities. Related to this point, the iGreenGrid project should be mentioned. iGreenGrid is financed by the 7th FP of European Community and led by Iberdrola with the participation of 12 partners, who are all electrical utilities and technological centres throughout Europe and whose goal is to warranty the reliability, stability and quality of supply in electricity distribution networks after the massive penetration of renewable energies.

Another important area of development that is being carried out in Spain and that will help in fostering large size PV plants has to do with real operating conditions. Improvements in technology must also be made through the knowledge of the lessons learnt on previous steps. At this moment, and after having an important quantity of PV Megawatts installed in Spain for more than 7 years in the field (some more than 10 years), the investigations on real performance and durability of components are being driven by the study of results and problems that appear in the day to day real work of the PV plants. With that starting point, an important development activity being done affects all aspects; from materials, individual components and design and operation aspects.

That knowledge should also be applied to the next generation on use of PV that will be more related with distributed electricity generation, even with microgeneration working in the form of microgrids, but also with the nanogeneration (much less power) if we consider the big options of products that might exist using the potentiality of PV integrated in consumer products.

IMPLEMENTATION

The total installed PV capacity in Spain at the end of 2012 was 4,393 GW. This is 4,2 % higher than the previous year. The absolute number of MW installed in 2012 was 179. The total electricity produced has been 7,950 GWh, almost 12 % more than previous year, and the demand coverage due to PV has gone up to 3,1 % (data out of green operator REE). Figure 2 presents the evolution of installed PV in Spain.

The rate of installation of PV power in Spain has been driven originally by the feed-in-tariff conditions. The recent higher reduction of the installation rate during last year is related to the elimination of the feed-in-tariff from January 2012. Figure 3 shows the evolution of feed-in-tariff for the different types of PV plants during the last 6 years, versus the price centsEUR/kWh paid for electricity generated.

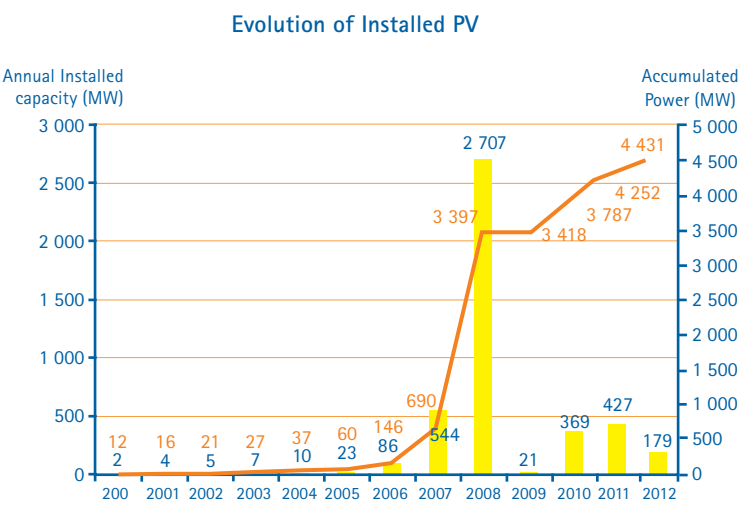


Fig. 2 – Evolution of installed photovoltaics in Spain, 2012 up to November (Source: CNE).

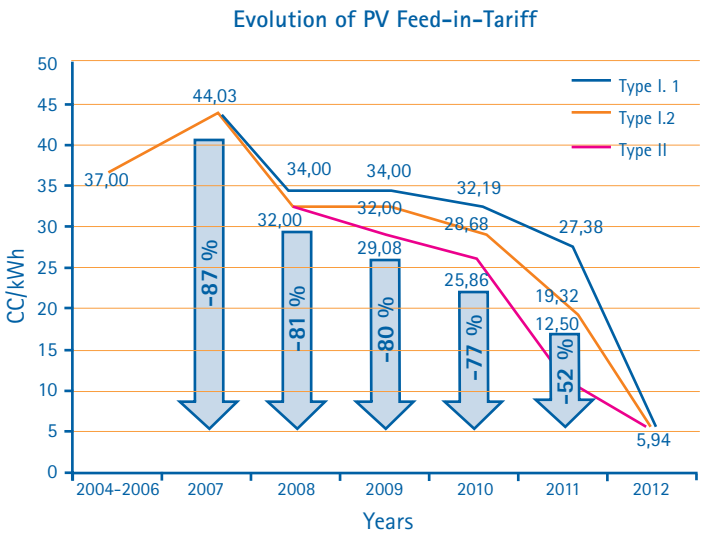


Fig. 3 – PV feed-in-tariff evolution in Spain (Source: UNEF).

In this scenario, it is not clear if the capacity installed in 2013 will be even lower or if the newly announced large plants, already planned with no feed-in-tariff at all, will change the tendency.

Figure 4 shows the capacity installed per autonomous community, as of November 2012. Castilla la Mancha (897 MW) and Andalucía (821 MW) are the ones having the highest number of MW, what might be expected as they also are among the ones with the highest levels of irradiation.

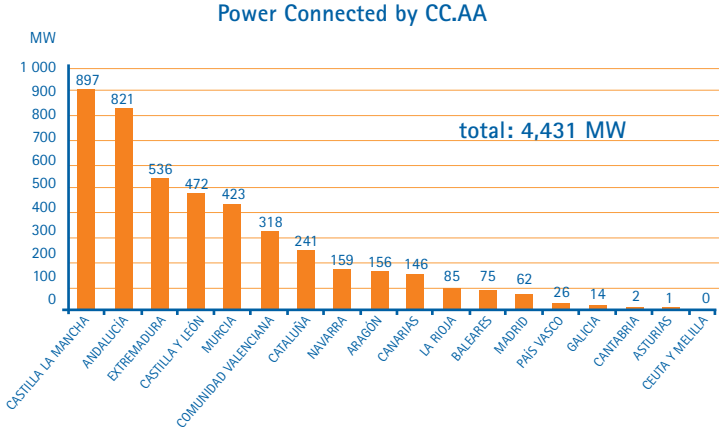


Fig. 4 - PV capacity installed per autonomous communities in Spain, November 2012 (Source: CNE-UNEF).

Fig. 6 – A real instantaneous auto-consumption building in Spain.

INDUSTRY STATUS

The photovoltaic industry in Spain, has suffered an important reduction during 2012, as is the case in most of the European countries. With respect to the employment, the consequent reduction for this reason is estimated close to 40 % (from 12 000 in January 2012 to 7 000 at the end of December 2012) on direct activities directly related to PV but can be higher if derivate activities are considered.

In the case of manufacturing, companies that are also installers are developing their activities and using their own produced PV modules in promotions outside of Spain. Companies with only manufacturing activities are having more difficulties, as they cannot compete in price with products from the Far East. In this circumstance, some of them have announced the closure of operations (SILIKEN, SOLIKER, YOHKON), while some others are under partial work conditions (ISOFOTÓN, T-SOLAR). There are small companies that have found a niche on producing specific PV modules that could be used for BIPV or specific applications, and also small CPV start-ups.

Finally, companies who are only installers have moved projects mainly to Central and South America, South Africa and Middle East, in the case of large plants; and to local developments in the case of plants with size of only a few kW.

Nevertheless, inside of the not so optimistic panorama, the good news of 2012 has been the merger of the 3 different associations representing the industrial PV activities in Spain. AEF (Asociación Empresarial Fotovoltaica), APPA-FV (Asociación de Productores de Energías Renovables FV) and ASIF (Asociación de la Industria Fotovoltaica) have now formed UNEF (Unión Española Fotovoltaica) that will represent the entire photovoltaic community in Spain, in front of institutions.

MARKET DEVELOPMENT

Although there was a new regulation in January last year (RD 1/2012) eliminating all feed-in-tariffs for PV, the scenario concerning price reduction for most of the components (especially PV modules), the costs of electricity in the country and the good levels of irradiation have allowed for the appearance of initiatives in the regions with most irradiation, for construction of large PV plants (on the order of 200 MW) for massive electricity production without feed-in-tariffs.

At the same time, small industries and private entities who have enough space to install their own PV plants are doing so; first, using them in an isolated mode, or as instantaneous auto consumption, while waiting for the announced net metering regulation, due to appear in first quarter 2013.

Both aspects can be the drivers of market development in the future. The extent up to the use of locally manufactured components will depend on prices available at the moment of execution of PV plants.

Nevertheless, when looking at the projections from IDAE (Figure 5) for capacity that should be installed to achieve 2020 goals, the existence of one (larger plants) or the other (auto-consumption) tendency could change the evolution of the increase capacity planned, dramatically.

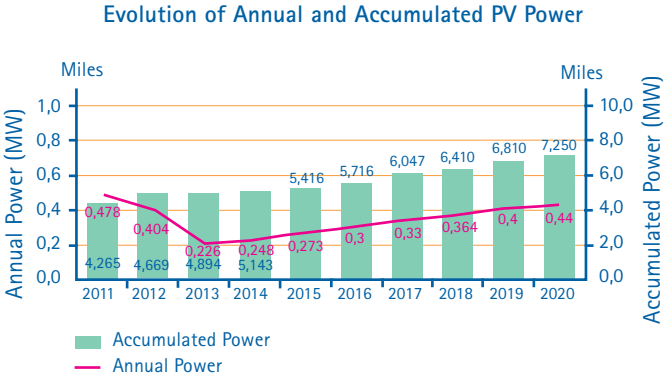


Fig. 5 – Annual and accumulated PV power evolution in Spain (Source: IDAE).

FUTURE OUTLOOK

The future outlook for the PV technology in Spain has various approaches. On one hand, the announced large PV plants for massive electricity generation at no feed-in-tariff and on the other hand, the PV installations which are driven by energy efficiency aspects and which are much smaller in size.

To the second category correspond the concepts of energy efficiency in buildings, beyond that of just PV on the roof. In that case, the ability to handle small microgrids is going to be a key point for development. In this scenario, the use of real BIPV goes necessarily together with the development of new PV products specific for that application. However, the final point affecting achievement of that new opportunity for PV is going to come together with reasonable enough auto-consumption and net-metering policies, that should be issued in 2013.

Therefore, the view as to how the PV development in Spain is going to be could be changed in the next years, and 2012 might have been the inflection point.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

SARA BARGI, SWEDISH ENERGY AGENCY

Fig. 1 - In December 2012, the largest PV installation in Sweden to-date, began to operate: 440 kW outside of Simrishamn (Photo: Solect Power).

Fig. 2 - Swedish Transport Agency in the city of Örebro (Photo: Direct Energy).

GENERAL FRAMEWORK AND IMPLEMENTATION

The vision of Swedish energy policy is social, economic and ecological long-term sustainability of the energy system, while maintaining security of supply. This is to be achieved via an active energy policy, incentives and research funding. Already today CO2-emissions related to electricity production are relatively low, since hydro, nuclear, bio and wind energy are the main contributors.

About half of the PV installations in place in Sweden are small off-grid systems in remote locations, mainly recreational houses on the countryside. PV remains a competitive option without subsidies for use in such locations.

Since a capital subsidy was introduced in 2009, the number of grid-connected installations has increased rapidly. The original subsidy covered up to 60 % of the costs of a PV system, but following decreasing prices this level has been lowered and will amount to 35 % in 2013. The subsidy has been successful and the volume of applications is much greater than the available funds. The cumulative installed grid-connected power has grown from only 250 kW in 2005 to 9300 kW in 2011. However, PV still accounts for a mere 0,01 % of the Swedish electricity production.

There is strong support among stakeholders for net metering, and the government has announced the intention of introducing such a system. A commission is on-going and will present its results in June 2013. A net-metering scheme can thus be in place in 2014 at the earliest and awaiting progress in this question, several utilities are now voluntarily offering their customers to buy any surplus electricity generated by their PV systems.
There is solid public support for PV technology in Sweden, and about 80 % of the population think that efforts towards implementation should increase.

NATIONAL PROGRAMME

The Swedish Energy Agency is the governmental authority responsible for most energy-related issues. In 2012, a new strategy for energy research was formulated. It states that PV research in Sweden should continue to cover several different subjects. It has been suggested that 2 TWh should be produced from PV in Sweden in 2020; however this figure is not a confirmed national target.

The Swedish Energy Agency is responsible for the national energy research programme. In 2012 a new research programme was launched, covering PV, concentrated solar power, and solar fuels. The budget is 3 MEUR for 2013 and will be raised from 2014 and onwards. Six projects were selected in the first call, which was held in 2012. Objectives of the program are both towards maintaining outstanding research, and towards more applied research. The latter will be the focus of the next call, to be held in 2013.

The Swedish Energy Agency also funds solar cell research via its main energy research program, and yearly a total of about 5,5 MEUR are channelled to PV related research. Additional resources to PV research come from several research councils, universities and private institutions. Sweden has also joined the newly formed Solar ERA-NET, where a first call will be held in 2013.

R&D

There are strong academic environments doing research on new types of solar cells, such as CIGS thin film, dye sensitized and polymer solar cells, nanowire solar cells and more. There is also research on enhancement techniques for conventional silicon cells.

Comprehensive research in CIGS and CZTS thin film solar cells is performed at the Ångström Solar Center at Uppsala University. The objectives of the group are to achieve high performing cells while

utilizing processes and materials that minimize the production cost and the impact on the environment. The Center collaborates with the spin-off company Solibro Research AB, and Midsummer AB.

At Lund University, the division of Energy & Building Design study energy-efficient buildings and how to integrate PV and solar thermal into those buildings. At the same university there is research on multi-junction nanowire solar cells. The research is performed in collaboration with the company Sol Voltaics.

An ongoing collaboration between Linköping University, Chalmers University of Technology and Lund University, under the name Center of Organic Electronics, carries out research on organic and polymer solar cells. Different areas of use are being investigated, such as sunshade curtains with integrated solar cell.

Research on dye-sensitized solar cells is carried out at the Center of Molecular Devices, which is collaboration between Uppsala University, the Royal Institute of Technology (KTH) in Stockholm and the industrial research institute Swerea IVF. A scientific highlight is the discovery and development of a new effective electrolyte based on cobalt.

Others which are involved in PV research are the universities of Chalmers, Dalarna, Karlstad and Mälardalen.

INDUSTRY AND MARKET DEVELOPMENT

The installed capacity in Sweden in 2011 was 16 MW, almost equally distributed between grid-connected and off-grid installations. These 16 MW can produce about 15 GWh in a year, which leaves a large potential for growth: it has been estimated that the potential for electricity produced by roof-mounted solar cells in Sweden amounts to several tens of TWh per year.

2012 saw several module producers in Sweden file for bankruptcy, leaving only one module producer, SweModule, still active.

There are two companies exploring newer types of solar cells. Midsummer AB inaugurated their factory in 2011, where they produce thin-film CIGS cells to develop their manufacturing equipment, which is their main product. NLAB Solar AB is developing transparent dye sensitised solar cells for integration in glass windows, and are presently building a pilot plant. A few innovative companies exist that develop balance-of-system equipment, e.g. inverters.

A growing number of small to medium-sized enterprises exist, that design, market and sell PV products and systems. Many of these companies depend almost exclusively on the Swedish market. The capital subsidy programme 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 market products specified for this market segment. Recently several utilities have begun selling turn-key PV systems, often working together with companies installing the systems.

Fig. 3 - Façade mounted PV in the city of Göteborg (Photo: Energibanken).

Fig. 4 - Flexible DSC solar cell from NLAB (Photo: NLAB).

Fig. 5 - Fully automated final assembly of PV modules at the SweModule factory in Glava, Sweden (Photo: SweModule).

SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS

STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.
AND STEFAN OBERHOLZER, SWISS FEDERAL OFFICE OF ENERGY (SFOE)

Fig. 1 - PV façade with micromorphous silicon (left, 10,8 kW)) and multicrystalline silicon PV modules (right, 11,3 kW) (system development and photo: Jansen).

GENERAL FRAMEWORK AND IMPLEMENTATION

Recent national energy scenarios and studies have confirmed an important contribution expected from photovoltaics in the medium and long term. According to the present scenarios, in absolute terms, some 10 – 12 TWh could come from photovoltaics by 2050, representing some 20 % of the present national electricity consumption. The size of the potential contribution from photovoltaics is less debated than the speed at which this may occur: The Swiss solar industry claims such contributions to be achievable much sooner than 2050.

In 2012, on the levels of Swiss policy and administration, work continued extensively regarding the preparation of the various measures in conjunction with Switzerland's phase-out of nuclear energy decided the year before in the framework of the new energy strategy 2050. These measures will have impacts on all levels from research to implementation and use as well as regarding legislative and normative issues. Before coming into force, there will likely be a public vote on the new energy strategy, expected for 2015.

The development of the photovoltaic sector in Switzerland builds on a strong research and technology 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. 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.energy-research.ch).

Market deployment continues to grow at moderate but increasing levels, thanks to the feed-in-tariff scheme now available for a few years and additional efforts of regional governments as well as utilities. Within the feed-in-tariff scheme, the size of the Swiss photovoltaic market is 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 0,009 CHF 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. In respect of PV, these maximum contributions started with 5 % of the available financial envelope and increase over time, as the photovoltaic generation costs come down, up to a maximum of 30 %. Thus photovoltaics and the entire support scheme are subject to a cap. This cap is presently under discussion in the Swiss parliament, particularly related to the new energy strategy for 2050. Besides the regular reductions of the feed-in tariffs applied, increases of the total PV capacity allowed under the feed-in-tariff scheme may come into force by 2014.

Concerning market implementation, the photovoltaic sector in Switzerland further developed in the year 2012 whereas the industrial activities suffered from the capacity and competition issues affecting the global PV industry. Nevertheless, activities in the Swiss PV supply industry remain high with an increasing emphasis on technology development and innovation. R&D activities in the public sector confirm this increasing trend. On the technology front, the

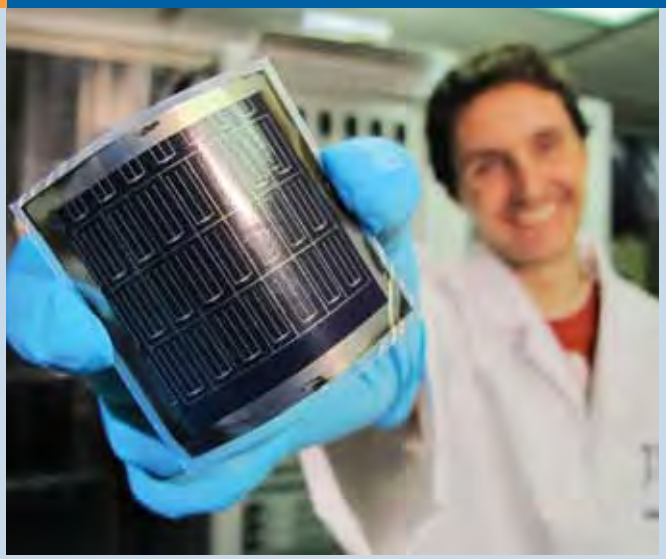


Fig. 2 - A new world record efficiency for flexible CIGS solar cells of 20,4 % was achieved at EMPA (photo: EMPA).

Fig. 3 - Coloured thin film BIPV modules are developed at the PV-Lab of EPFL (photo: EPFL).

key competence centres continued their efforts in their respective domains (solar cells, modules and systems) while increasing their cooperation with industry and on the international level.

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. Due the strong Swiss currency, global competition for the heavily export oriented industry remains an issue. Nevertheless, the efforts to bring Swiss technology to the market place continue. Efforts in the technology development will concentrate on short to medium term market oriented approaches and continuous quality assurance.

The strategy to promote international co-operation on all levels will continue, related to activities in the 7th Framework Programme of the European Union, the European PV Technology Platform, the IEA PVPS programme and in technology co-operation projects.

While costs of photovoltaics are rapidly coming down, the policy debate in the new energy strategy for 2050 continues, in particular concerning possible adaptations to the regulatory framework. In parallel, increased interest and market activities can be observed on the utility side.

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach (www.photovoltaic.ch). This national photovoltaic programme focuses on R&D,D in a system and market oriented approach, from basic research, over applied research, product development, pilot and demonstration projects all the way to accompanying measures for market stimulation. On the technical level, thin film solar cells, their variations 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. Thorough component and system analysis, as well as testing, 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.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In 2012, more than 75 projects, supported by various national and regional government agencies, the European Commission 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. A new photovoltaic technology centre will be built up at the laboratories of CSEM (Centre Suisse d'électronique et microtechnique) in Neuchâtel.

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 20,4 % was announced for CIGS solar cells on plastic substrates (Fig. 2), thus representing a substantial increase of the last record of 18,7 % achieved the year before. This efficiency record is slightly higher than that for CIGS cells on glass and in the range of best multicrystalline silicon solar cells. For dye-sensitised solar cells, work continued at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. An increasing interest for photovoltaic technology can be observed at 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 (Fig. 3).

Fig. 4 - Arrival of the boat PlanetSolar in Monaco after completion of the first world tour by solar energy (photo: NET).

A dedicated website deals with the topic of BIPV (www.bipv.ch) and includes information about available products. Various other PV applications on built infrastructure, e.g. ski lifts or snow avalanche protections, have recently been proposed and realised in pilot installations.

As a recent topic, grid integration has continued to generate interest and recent projects have extensively analysed the implications of PV on the distribution grid. 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 Lugano and Burgdorf carefully evaluate products such as PV modules, inverters and new systems. The test infrastructure is continuously expanding and includes the accredited test centre for IEC module certification (Lugano, http://www.supsi.ch/isaac/swiss_pv_module_test_centre.html) as well as the largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf, www.pvtest.ch). Long term experience with the operation of photovoltaic power systems is carefully tracked for a number of grid-connected systems, ranging between 10 and more than 30 years of operation. Continuous development of system solutions has resulted in a number of industrial products well positioned in the export market.

Work continues on the first prototype of the solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard which has meanwhile demonstrated various flights under specific conditions. Based on this experience, a second airplane will be built. As a particular highlight of such visionary projects, the solar powered boat PlanetSolar (www.planetsolar.org) has completed the first tour around the world by solar energy in May 2012 in Monaco (Fig. 4). On its way, the boat has stopped in many prestigious places to convey the message of the possibilities of solar photovoltaic energy.

International co-operation continues to form a strong pillar of the R&D activities with more than 20 projects running in the 7th framework RTD programmes of the European Union during 2012. The co-operation within the IEA PVPS programme has remained a further strategic activity.

Regarding international co-operation on the programme level, a new European ERA-NET project (www.solar-era.net) started in November 2012, covering both PV and concentrated solar power (CSP). The collaboration with the European Photovoltaic Technology Platform (www.eupvplatform.org) continued throughout the year.

INDUSTRY AND MARKET DEVELOPMENT

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 wire-sawing 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.

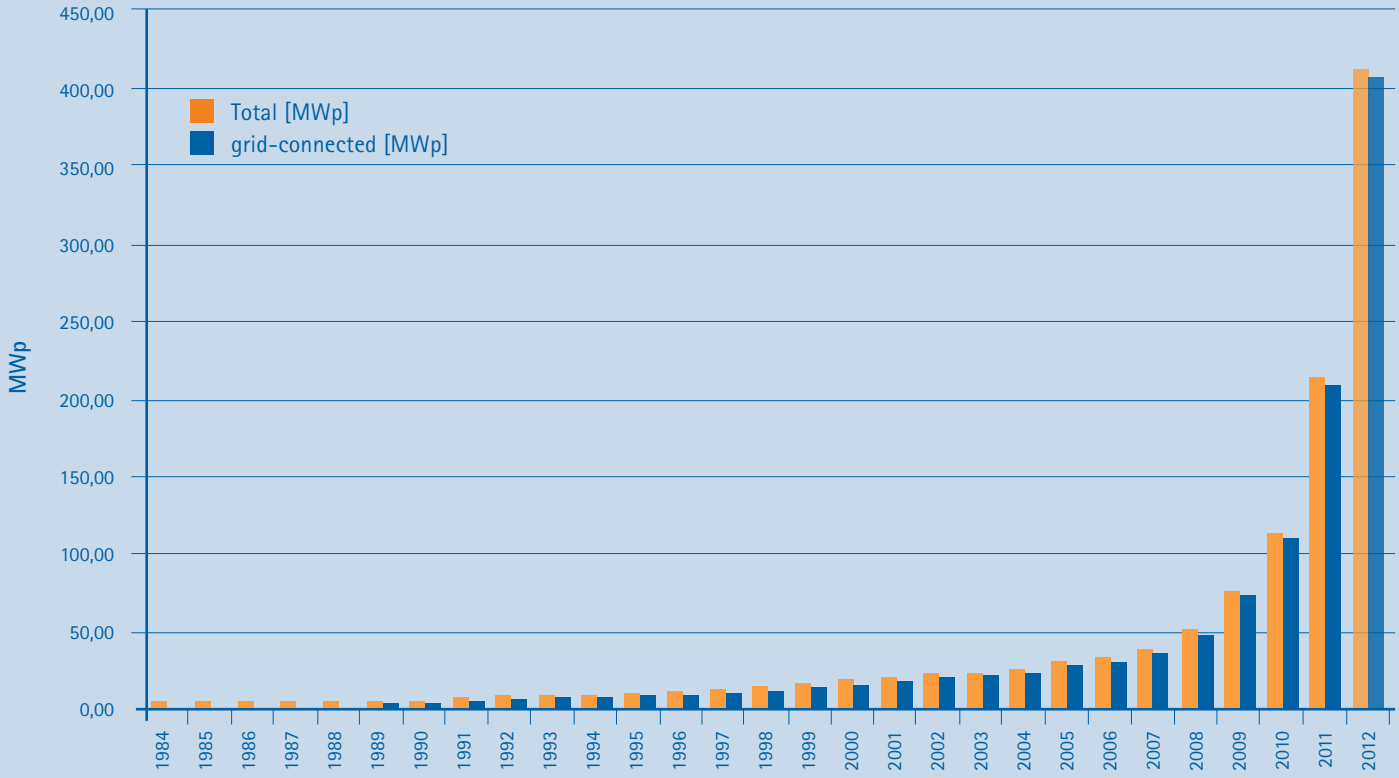


Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2012 (total and grid-connected, estimated values for 2012).

Industrial activities evolve in the field of process equipment (TEL Solar, formerly oc oerlikon) and products based on thin-film technology. Swiss Solar Systems (3S), also part of the Meyer Burger Group, is building some of the world's largest PV module laminators. Roth & Rau, largely acquired by Meyer Burger, has intensified its Swiss R&D activities into heterojunction silicon solar cells. Komax is active in various steps of the module manufacturing chain.

Inverters have proved to be an export success. Sputnik Engineering produces grid-connected inverters with a capacity of 700 MW per year. Studer Innotec has had comparable success with their stand-alone inverters. More recently, ABB has entered the inverter market.

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. In spite of the pressure on the PV industry, the export volume of Swiss photovoltaic products continues to be high, with more than 80 % of the annual turnover.

Besides an increased interest from the manufacturing industry, the finance sector continues to promote financial services directed towards renewable energy. This trend is manifested by the regular investment analysis reports published by the Bank Sarasin (www.sarasin.ch).

Formerly mostly driven by utilities own green power marketing schemes, there has been a strong development in the framework of the new feed-in tariff support scheme. This PV feed-in tariff 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 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.

The 2012 annual market volume for grid-connected systems is estimated to a value around 200 MWp, thus doubling the market of 2011. The total installed capacity has thus risen to about 410 MW (Fig. 5), corresponding to more than 50 W/capita.

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS

DR. METE ÇUBUKÇU, EGE UNIVERSITY SOLAR INSTITUTE, IZMIR, TURKEY

Fig. 1 - 13 kW grid-connected PV system in Özyeğin University, Istanbul, Turkey.

Fig. 2 - 420 kW grid-connected PV system in Ankara, Turkey.

GENERAL FRAMEWORK

With a population reaching 75 million, Turkey's electricity production and consumption based on primary energy resources continue to increase. Gross electric energy consumption of Turkey was 241,9 TWh in 2012 and increased by 5,0 % in reference to 2011. Total installed capacity of electricity was 57 071 MW at the end of 2012 and can be broken down by resources as 34 % hydro, 4 % wind and geothermal, and 62 % thermic (natural gas, coals, liquid fuels etc.).

Cumulative installed PV power in Turkey by the end of 2012 was estimated to be about 8,5 MW.

NATIONAL PROGRAM

According to the Law 6094: "Utilization of Renewable Energy Resources for Electrical Energy Production," a purchase guarantee of 13,3 USD/kWh is given for solar electric energy production for ten years. Some supplementary subsidies for domestic products are as follows:

- PV module installation and mechanical construction, (+0,8 USD/kWh)
- PV modules, (+1,3 USD/kWh)
- PV cells, (+3,5 USD/kWh)
- Inverter, (+0,6 USD/kWh)
- Material focusing solar energy on PV modules, (+0,5 USD/kWh)

All the expected regulations prescribing the technical and financial procedures and principles for supplying energy to the grid were released in 2012.

A total capacity of 600 MW solar power plants will be licensed by the end of 2013. It is expected that these MW-scaled plants will be put into operation by 2015. The Ministry of Council will determine the new capacity after 2013.

As a tangible target, the Energy and Natural Resources Ministry Strategic Plan aims to reach a 30 % share of renewables (incl. hydro) in electric energy production by 2023. Although the share of the photovoltaic power systems is not clarified in this target, a rapidly growing market in the near future in Turkey will not be surprising.

R&D

The following R&D activities were maintained in 2012.

- Ege University Solar Energy Institute's (EÜ-GEE) PV activities are mainly maintained in the following fields: (eusolar.ege.edu.tr):
  - New generation/ dye synthesized/ organic PV cell production studies.
  - Design, modeling, test and comparative performance analyses of PV electricity generators.
  - Management of the Turkish PV Technology Platform (UFTP).
- The research activities of Middle East Technical University - Solar Energy Research Center (ODTÜ-GÜNAM, www.gunam.metu.edu.tr) continue to:
  - Develop 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 PV cells,
  - Third generation PV cells based on semiconductor nanocrystals.
- Gazi University's R&D activities are focused mainly on "Photonics Research Center" targeting epitaxial crystal growth and improvement of the fabrication of electro-optic devices in the field of semiconductor technologies. R&D activities are being conducted for the development of different types of solar cells, sensors, photodetectors, LED and LD materials. (www.gazi.edu.tr).
- Bilkent University – National Nanotechnology Research Center (UNAM) continues its R&D activities on developing PV materials and devices (www.nano.org.tr).
- Solar Energy Application & Research Center (HÜGEM) of Harran University has been established for renewable energy studies, particularly for solar energy. The center's major aim is to develop solar energy systems to utilize high solar radiation potential of the region. HÜGEM has done extensive research on solar energy thermal system design to be used in agricultural and industrial applications; including solar irrigation, solar drying, solar cooling and solar steam production (http://hugem.harran.edu.tr).
- TÜBITAK-UME's (The Scientific and Technical Research Council of Turkey- National Metrology Institute, www.ume.tubitak.gov.tr) interests are:
  - Silicon Heterojunction Solar Cell,
  - New generation TCO coatings,
  - Organic photovoltaics,
  - Testing and characterization of PV modules (Photovoltaic Performance Test Center, TÜBITAK-UME, 2,6 MEUR, 2013-2015).

Fig. 3 - 200 kW grid-connected PV system in Konya, Turkey.

- YETAM (Hacettepe University – Renewable Energy Research Center & Application Center) continues its research and application activities on renewable energy since 1993 (www.yetam.hacettepe.edu.tr).
- Mugla University Clean Energy Research and Development Centre has been focusing on subjects related to photovoltaic materials, devices, and systems, such as fundamental studies on electrical, optical and structural properties of bulk and thin film semiconductor materials for photovoltaic applications, as well as photovoltaic cells based on crystalline, amorphous silicon and thin film compound semiconductors (mutek.mu.edu.tr).
- Kocaeli University focuses on power electronics and grid characterization/ management. Especially, grid-connected PV power production experimental research studies are maintained (www.kocaeli.edu.tr).
- Gebze Institute of Technology's Nanotechnology Research Group and Renewable Energy Group have been operating within the Materials Science and Engineering Department in Gebze/ Kocaeli (www.gyte.edu.tr).
- Özyeğin University Centre for Energy, Environment and Economy was established in 2009 with the objective of studying energy related issues, environment and economy in a coherent way. In 2012, a 13 kW grid-connected fixed mounted PV system was installed on the roof top of the Engineering Faculty Building (see Figure 1). PV activities of the Centre are focusing on development of novel thermo-photovoltaic (TPV) and hybrid TPV-PV cells, based on nano-scale engineering and nano-science. (http://ozyegin.edu.tr/energy).
- Pamukkale University Energy Research & Application Center focuses on PV power systems and DC/AC power distribution issues (pau.edu.tr/tee).
- İstanbul Technical University Energy Institute focuses on signal and data processing for renewable energy systems and on site performance measurement of PV modules and systems (www.enerji.itu.edu.tr).

IMPLEMENTATION

Since it is required that the licenses of the MW-scaled projects are approved by the Electricity Market Regulatory Authority (EPDK), there are still a few kW PV pilot projects in Turkey. Some attractive PV applications which were installed in 2012 are explained below:

Fig. 4 - 105 kW grid-connected PV system in Muğla, Turkey.

- 420 kW grid-connected PV system by Halk Enerji Ltd. in Ankara (see Figure 2). (Customer: Hacettepe Technocity).
- 200 kW grid-connected PV system installed by IBC Solar Ltd. in Konya (see Figure 3). (Customer: MEDAŞ Distribution Company).
- 105 kW grid-connected PV system installed by AnelEnerji Ltd. in Muğla (see Figure 4). (Customer: Muğla Municipality).
- 96 kW grid-connected PV system installed by Gehrlicher Merk Solar Ltd. in Bursa (see Figure 5). (Customer: Gürsu Municipality).
- 95 kW grid-connected PV system installed by Halk Enerji Ltd. in Eskişehir (see Figure 6). (Customer: Tepebaşı Municipality).
- 91 kW rooftop grid-connected PV system installed by Cleanglobe Ltd. in Adana. (Customer: Saint-Gobain Weber Adana).
- 35 kW grid-connected PV system installed by Halk Enerji Ltd. in Bursa. (Customer: U.O.E.İ.B. Technical and industrial Vocational High School).

INDUSTRY STATUS

Currently there is not any manufacturer for feedstock, ingots and wafers in Turkey. China Sunergy Co. Ltd. (CSUN) which is a specialized solar cell and module manufacturer, announced that the company has set up a new manufacturing facility in İstanbul, Turkey with local partner Seul Energy Investment Corp. (SEUL Energy). The new plant covering more than 22 000 square meters has been set up in facilities in the Trade Free Zone in Istanbul, Turkey. CSUN announced its 300 MW/y capacities for both of the cell and module production line. The company aims to reach to 600 MW/y production capacity and 1 200 employee in 2015 (http://www.chinasunergy.com/en/).

Fig. 5 - 96 kW grid-connected PV system in Bursa, Turkey.

Fig. 6 - 95 kW grid-connected PV system in Eskişehir, Turkey.

There are also a few PV module and PV module constituents (glass, frame etc.) manufacturers in Turkey. Some leading companies and their main activities are briefly noted below:

- ANEL Group is the first full-automated PV module manufacturer in Turkey since 2009. ANEL Group, has IEC 61215 certification for their PV modules and produces various goods for known European brands with TÜV, IEC, CE, ISO 9001 and ISO 4001 certifications. (www.anelenerji.com.tr).
- Trakya Cam Co., a leading flat glass supplier in the region and one of the largest glass producers in Europe is increasing solar glass sales. The mother company, Şişecam Group, is in a leading position in business lines covering all basic fields of glass such as float glass, glass household articles, glass packaging and glass fiber as well as soda and chromium compounds. Trakya Cam producing two types of tempered, patterned solar glass in both 3,2 mm and 4 mm thickness named DURASOLAR P+. Durasolar P+ are tested and certified by the SPF Institute and are certified as U1 class (www.trakyacam.com.tr).
- İnci Akü Co. manufactures VRLA AGM and VRLA Gel batteries for renewable energy and UPS applications. İnci Akü's R&D Center is the first and the only R&D Center in the battery sector accepted by the Republic of the Turkey Ministry of Industry and Trade since 2009 (www.inciaku.com).
- SOLARTURK Co. initiated a 60 MW capacity PV module production in Gaziantep (www.solarturk.com.tr).
- Clean World Energy Co. (www.cwenergy.com.tr) and ANTAK Ltd. (www.an-tak.com/) have PV module manufacturing activities.
- 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 in Bursa (www.tera-solar.com).
- Alfa Machinery Industry Co. is scheduled to begin PV module manufacturing (www.alfakazan.com.tr).
- Mavisis Co. produces on-grid and off-grid solar and wind inverters, load banks, grid connected power shifting devices, multifunctional inverters and laboratory equipment such as photovoltaic simulators (www.mavisis.com).
- RA Alternative Energy Technology supported by KOSGEB and established in İzmir is an innovative R&D company working on renewable energy and focusing on software development. Optimization and simulation software for hybrid renewable systems was completed in 2012 (www.raenerji.com).

MARKET DEVELOPMENT

Turkish PV Technology Platform (UFTP) continues its endeavors to bring related bodies together on a common platform and facilitate information flow for healthy market development (More details: www.uftp.org.tr). UFTP hosted the SolarTR-2: Solar Electricity Conference & Exhibition" on 7-9th November 2012 in Antalya-Turkey. SolarTR conference series have already been a major event on solar energy technologies in Turkey. SolarTR-3 will be organized in İzmir, Turkey at the last quarter of 2014. Special events will be organized for photovoltaic research and investments in Middle East and North African countries (www.solartr.org).

Other significant efforts to enable a well-structured market are as follows:

- The PV Mirror Committee – MTC116 established under the Turkish Standards Institute maintained its studies on PV technology standards –translating, harmonizing and annexing as to national requirements.
- The vocational qualification standards of basic renewable energy (wind, PV, solar thermal, biomass) were prepared by EÜ-GEE.

FUTURE OUTLOOK

Although there is a 600 MW cap for the license required PV power plants, there is not any restriction for the unlicensed PV plant installations (< 500 kW). The demand for these small kW ranges is continuing to increase and its cumulative capacity reached 2,5 MW at the end of 2012. Additionally, off-grid applications (about 6 MW cumulative capacities) account for around 70 % of the cumulative installed PV capacity. However, the share of the grid-connected PV power systems grows year by year.

Another significant key point is the increasing interests of local governments on PV activities. By being the signatures of EU Covenant of Mayors, the municipalities are focusing on sustainability and are willing to increase their PV activities.

Grant donators like SME Support Administration (KOSGEB) and development agencies are prioritizing the renewable themed projects. As an example, İzmir Development Agency (İZKA) announced a new call for project proposal which also covers to install pilot PV power plants.

In the light of the above activities, Turkey's PV sector is expected to be grown significantly in the next decade.

For More Information:

Tel/Fax.: +902323391128
E-mail: mete.cubukcu@uftp.org.tr
Web: http://eusolar.ege.edu.tr, www.uftp.org.tr

UNITED KINGDOM

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

STEVE MARTIN, SCIENCE AND INNOVATION DIRECTORATE
DEPARTMENT OF ENERGY AND CLIMATE CHANGE

GENERAL FRAMEWORK, IMPLEMENTATION & NATIONAL PROGRAMME

The UK Government believes that solar PV has the potential to form a significant part of our renewable energy generation mix. Currently the UK has 1,4 GW of installed solar PV capacity in operation and analysis indicates that the market could bring forward a total of 7–20 GW of solar PV by 2020 (equivalent 6-18 TWh). Smaller scale (less than 50 kW) solar PV installations, supported through the UK's Feed-in-Tariff scheme, are likely to remain the main driver for the growth in solar PV capacity. Installations sized greater than 50 kW have seen a slower rate of uptake and up until recently, there has been little deployment activity for those installations greater than 5 MW.

The solar PV sector has seen a dramatic reduction in costs between summer 2011 and March 2012, with installed costs estimated to have fallen by up to 50 %. The ability to deliver further reductions in the installed costs of solar PV will determine the level of sector growth and the ability for the levelised cost of solar PV to become competitive with other low-carbon electricity sources. The UK Government has introduced a cost-control mechanism for the FITs scheme to promote a predictable and stable environment conducive to sustainable cost reduction.

Solar PV benefits from being easy to install on domestic and commercial buildings, and on the ground. With 82 % public support, it has a role in connecting individuals, communities and businesses with future deployment of renewable energy and the transition to the low-carbon economy. Further growth of solar PV generation will present new challenges to grid balancing but this will be aided by generation used onsite, along with potential improvements in storage technology and active network management.

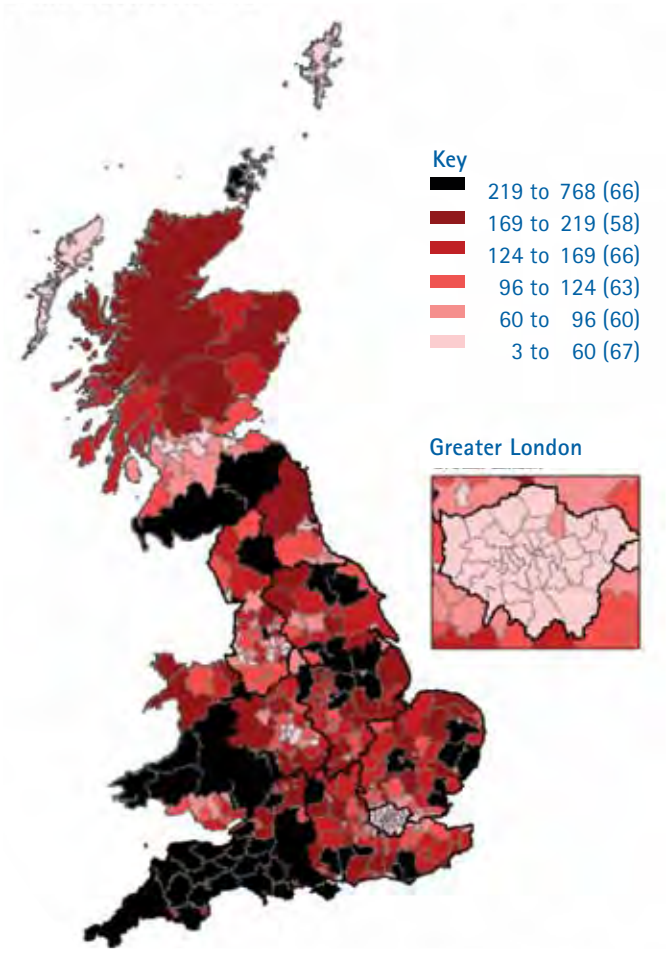
UK Deployment

In February 2012, the European Photovoltaic Industry Association ranked the UK solar market as 8th in the world. The UK has less sunshine (and therefore lower load factors) than some other countries; though our climate is similar to that in Germany, where deployment of solar PV is considerably higher (already over 20 GW). Figure 1 shows the UK map of FITs solar PV deployment: the number of domestic photovoltaic installations per 10,000 households by Local Authority. As at the end of December 2012, the regional data shows the majority of installations are focussed in South West England. Wales also has a significant level of deployment along with the East Midlands.

Deployment in the UK has grown rapidly since the FITs scheme was established in April 2010 to 1.4 GW of operational installed capacity by the end of November 2012, with the majority of current PV deployment at smaller scale installations less than 50 kW. This is changing in 2013, with evidence of substantial activity now underway, including both large commercial rooftops and ground mounted schemes. For example, Lark Energy have recently received planning permission for a new 32 MW solar PV project on an old airfield site in Leicestershire.

Feed In Tariffs in the UK

Number of domestic photovoltaic installations per 10 000 households by Local Authority, as at end of December 2012



Notes:
1. There are 7,190 domestic photovoltaic installations that have not been allocated to Local Authorities.
2. For Scotland, areas are represented as Council Areas.

Fig. 1 – Feed-in Tariffs in the United Kingdom.
Source: ONS, Crown copyright 2004. Crown copyright material is reproduced with the permission of the controller of HMSO. Contains data from OfGem

Case Study – Met Office Supercomputers

The UK's Met Office has recently installed solar PV on the roof of the Energy Centre at its HQ building in Exeter. In order to accurately predict Britain's notoriously changeable weather, the Met Office operates three Supercomputers, which are among the UK's largest. The IBM supercomputer is capable of performing 100 trillion calculations a second. Such a powerful computer requires a large amount of electricity and as a result the Met Office has invested in solar PV to reduce their energy bills and carbon emissions.

The 250 kW array is expected to generate in excess of 221 MWh of clean electricity annually saving 116 Tonnes of CO_2. The array is one of the largest rooftop arrays in the UK, comprising 1 000 mono-crystalline solar modules, chosen for their improved efficiency and long life. The sun path was modelled for the year and the solar panels were connected in such a way as to minimise the effects of shading from the guard rails.

SOLAR STRATEGY

The UK's Department of Energy and Climate Change (DECC) wants to set out a clear vision for solar through to 2020, and to do so in a way which gives industry confidence to invest. In 2013, DECC will produce a solar PV Strategy, in which we will outline the Government's strategic approach to solar PV more fully. The Strategy will reflect both Government and industry perspectives as to the main challenges facing the deployment of solar PV. It will consider the scope for small-scale, community-owned, commercial and utility scale deployment in the UK and identify the barriers to growth that need to be addressed in each case. It will also consider how industry needs to secure cost reductions over time, and how this can best be monitored to inform the UK's overall strategy, helping to set out the potential for economic benefit for the UK from industry growth.

RESEARCH, DEVELOPMENT & DEMONSTRATION

Innovation is key to improving performance and efficiency of mono/polycrystalline and hybrid panels in order to bring down the cost of production.

Developing cost-effective storage solutions could also make a step-change in affordability and long-term potential for solar PV in the UK. There are encouraging plans to develop a UK Solar Energy Centre in Cornwall that will be a centre of excellence for the development of solar technology.

UK Research Councils spent about 10 MGBP annually over the last three years on solar energy research. They expect similar annual expenditure till 2014. As part of that, the Engineering and Physical Sciences Research Council (EPSRC) awarded a 4 MGBP grant to SUPERSOLAR Solar Energy Hub which is a consortium led by Loughborough University (together with the Universities of Bath, Liverpool, Oxford, Sheffield and Southampton) that is aimed at research on new materials and systems performance.

SUPERSOLAR intends to set up a national solar cell efficiency measurement facility for the benefit of the solar PV community in the UK. EPSRC has also set out the SUPERGEN Solar Energy Challenge, a 5 MGBP Call, with grants that aim to optimise solar systems in order to reduce the cost of solar energy. This will fund research improvements in solar cell efficiency, overall system performance, and analysis of whole life system costs. These are likely to be awarded in early 2013.

DECC will be working with industry, the Research Councils and other members of the UK's Low Carbon Innovation Coordination Group (LCICG) to understand progress of the research undertaken and the outcomes, in order to influence policy developments and encourage deployment.

SOURCES OF FURTHER INFORMATION

DECC Renewables Statistics

Provides annual tables on capacity and generation across renewable electricity, heat and transport. Also includes quarterly information on deployment of renewable electricity and liquid biofuels from Energy Trends.

https://www.gov.uk/government/publications/renewables-section-6-energy-trends

Feed-in Tariff Statistics

Quarterly and Monthly data on capacity and installations

https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/feed-in-tariff-statistics

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DAVID FELDMAN, NATIONAL RENEWABLE ENERGY LABORATORY

Fig. 1 - NREL's newest PV array at the National Wind Technology Center near Boulder, Colo., is an opportunity to study how ecosystems respond to renewable energy development and develop best management practices that re-establish habitat, minimize weed invasion, prevent erosion and protect wildlife. NREL's newest source of clean energy - a 1 megawatt solar array - is supplying laboratory researchers with more than carbon-free electricity. It's also an opportunity to examine a sensitive topic - the potential environmental impacts of large-scale renewable energy projects (Photo: Dennis Schroeder / NREL).

GENERAL FRAMEWORK AND IMPLEMENTATION

The United States (U.S.) PV market development is supported by both federal and state level financial incentives, yet state and local policies in support of increased solar deployment are more varied than federal policies. Over the course of 2012, the federal government outlined the potential for a federal level clean energy standard that would mandate a certain percentage of the nation's energy portfolio be derived from "clean" sources. However, to date, a federal level mandate has not been implemented. However existing policy at the federal and state level has enabled PV to continue growing rapidly in the U.S. as a result of local and state initiatives, with the U.S. adding approximately 3,3 GWdc of PV capacity in 2012. At the end of 2011, cumulative installed PV capacity in the U.S. totaled approximately 3,9 GW, bringing the U.S. cumulative installed total to approximately 7,2 GW. [1]

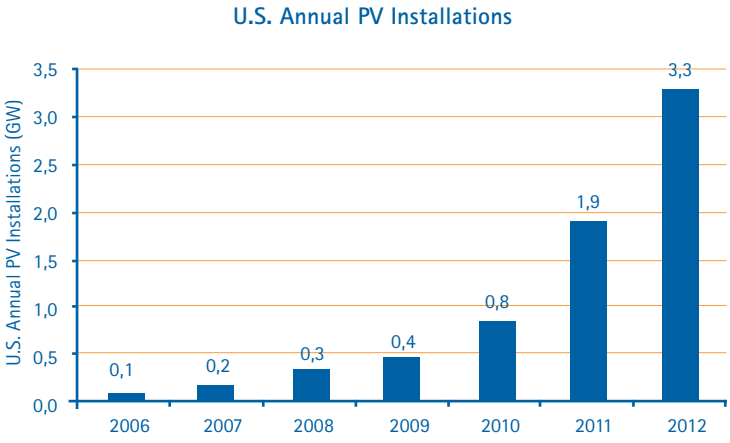


Fig. 2 – U.S. Annual PV Installations. Sources: 2006-2009: IREC, U.S. Solar Market Trends. 2010-2012: GTM Research/ SEIA, Q4 2012: U.S. Solar Market Insight. March 2013

Several policy and financing mechanisms are emerging that have the potential to incite further solar market expansion through the establishment of widespread local and utility programs. Such policies include state level feed in tariffs and time of use rate structures. Previously, innovative public/private financing programs that allow property owners to finance PV systems through adjustments to their property taxes were gaining traction in the U.S. However, such programs, commonly referred to as Property Assessed Clean Energy (PACE) programs, stalled in 2011 as a result of Federal Housing Finance Administration concerns that PACE assessments establish senior liens with priority over existing mortgages.

NATIONAL PROGRAM

The United States (U.S.) supports the domestic installation and manufacturing of PV generating assets. Financial incentives for U.S. solar projects are provided by the federal government, state and local governments, and some local utilities. Historically, federal incentives have been provided primarily through the U.S. tax code, in the form of an Investment Tax Credit (ITC) (which applies to residential, commercial, and utility-scale installations) and accelerated 5-year tax depreciation (which applies only to commercial and utility-scale installations). For commercial installations, the present value to an investor of the combination of these two incentives – which can be used only by tax-paying entities – amounts to about approximately 56 % of the installed cost of a solar project.

In 2011, two additional federal programs supporting PV expired. They included the grant in lieu of tax credit through Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA), as well as the temporary loan guarantee program through the Department of Energy (DOE), which provides loan guarantees for renewable energy installations and manufacturing facilities for renewable energy components. Because the Section 1603 grants allow businesses to receive a grant for projects which began construction in 2011 but are completed before the end of 2016, this program continued to fund the deployment of solar assets in 2012. In addition, many of the manufacturing and solar installations which received loan guarantees in 2011 or earlier, continued construction or operation of those assets in 2012.

State incentives in the U.S. have been driven in large part due to the passage of Renewable Portfolio Standards (RPS). An RPS, also called a renewable electricity standard (RES), requires electricity suppliers to purchase or generate a targeted amount of renewable energy by a certain date. Although design details can vary considerably, RPS policies typically enforce compliance through

RESEARCH	USD	61,722,772
DEVELOPMENT	USD	132,753,505
DEMONSTRATION	USD	54,296,297
DEPLOYMENT	USD	12,784,197
TOTAL	USD	261,556,771

Fig. 3 - Breakdown of Solar Energy Technologies Program FY 12 R&D Activities.

penalties, and many include the trading of renewable energy certificates (RECs). A clean energy standard (CES) is similar to an RPS, but allows a broader range of electricity generation resources to qualify for the target. As of January 2013 sixteen states and Washington D.C. had RPS policies with specific solar provisions.

The U.S. government also supports PV manufacturing and deployment through its work at the Department of Energy's SunShot Program, discussed in the Research and Development section below.

RESEARCH, DEVELOPMENT & DEMONSTRATION

The DOE is one of the primary bodies that support research, development, and demonstration (RD&D) of solar energy technologies. In February 2011, the Secretary of Energy launched the SunShot Initiative, a program focused on driving innovation to make solar energy systems cost-competitive with other forms of energy. To accomplish this, the DOE is supporting efforts by private companies, academia, and national laboratories to drive down the cost of solar electricity to about USD 0,06 per kilowatt-hour. This in turn will enable solar-generated power to account for 15–18 % of America's electricity generation by 2030. By funding selective RD&D concepts, the SunShot Initiative promotes a genuine transformation in the ways the U.S. generates, stores, and utilizes solar energy.

Examples of SunShot Initiative funded research and development activities include:

- Demonstrate and prove new concepts in materials, processes, and device designs to feed into component development at the laboratory scale, with subsequent component integration, engineering scale-up, and eventual commercial production.
- Research, development, and demonstration of new balance of system components including power electronics and building-integrated photovoltaics, as well as investments in smart grid technologies that will enable higher penetrations of photovoltaic systems on the grid.
- Conduct applied scientific research that provides the technical foundation for significant increases in solar photovoltaic (PV) cell efficiency, to enable commercial and near-commercial PV technologies to achieve USD 1,00 per watt direct current installed system cost targets by the end of the decade.
- Provide 21 MUSD in funding to advance the development of a commercial "plug-and-play" PV system – an off-the-shelf product that is fully inclusive with little need for customization. The homeowner simply plugs the system into a PV-ready circuit, and an automatic PV discovery process initiates communication between the system and the utility.
- Provide 8 MUSD to fund projects that are helping utilities and grid operators better forecast when, where, and how much solar power will be produced at U.S. solar energy plants. Part of the SunShot Systems Integration efforts, the Solar Forecasting projects will allow power system operators to integrate more solar energy into the electricity grid, and ensure the economic and reliable delivery of renewable energy to American families and businesses.
- Implemented awards totaling 12 MUSD for the Rooftop Solar Challenge, an initiative in which cities, states, and regions were awarded funding to develop innovative ways to drive measurable improvements in market conditions for rooftop photovoltaic across the United States, with an emphasis on streamlined and standardized permitting and interconnection processes.

INDUSTRY AND MARKET DEVELOPMENT

After a doubling of annual PV installations in the U.S. from 2009-10 and from 2010-11, the U.S market continued its rapid development in 2012; growing annual installations 76 % from 2011, totaling around 3,3 GW [2]. Much of the growth came from the utility-scale installations. PV capacity continues to be concentrated in a small number of states, such as California, Arizona and New Jersey. However, this trend is changing slowly as 14 states currently have 100 MW or more of PV capacity and 11 states each installed more than 50 MW in 2012 alone. With more than 2,9 GW of PV projects under construction at the end of 2012, that have individual capacities above 1 MW in size, total installations in 2013 are expected to increase yet again. Though some incentive programs in the U.S. have expired or been reduced, many projects currently under construction have already qualified to receive an award. In addition, PV component pricing, globally, has reached historic lows, which should further drive U.S. demand in the near future.

U.S. manufacturing, which had grown in shipments 10x from 2003-2010, continued to have challenges in 2012. Due to overcapacity issues in global PV manufacturing, which caused a rapid decline in price, many U.S. companies have found it challenging to stay competitive. U.S. PV cell production, which peaked in 2010 at 611 MW, is estimated to decrease year over year by 50 % to approximately 230 MW in 2012. U.S. PV module production, which peaked in 2011 at 1,333 MW, is estimated to decrease year over year by 65 % to approximately 500 MW in 2012 [2]. In December of 2012, in an effort to make U.S. PV manufacturing more competitive, and to settle claims by U.S. manufacturers that Chinese manufacturers "dumped" product into the U.S. market and received unfair subsidies from the Chinese government, the U.S. Department of Commerce issued orders to begin enforcing duties to be levied on products with Chinese made PV cells. The majority of the tariffs range between 23 % -34 % of the price of the product. However, some U.S. PV manufacturers unsuccessfully filed a petition with the Department of Commerce seeking to extend the tariffs to modules assembled in China, claiming that Chinese manufacturers are circumventing these duties by sourcing their PV cells from Taiwan.

[1] GTM Research/ SEIA. Q4 2012: U.S. Solar Market Insight. March 2012.
[2] Ibid.
[3] Ibid.

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

For information, contact the former Task 2 Operating Agent or visit the PVPS website:

Ms Ulrike JAHN
Senior Scientist
Renewable Energies
TÜV Rheinland Energie und Umwelt GmbH
Test Centre for Energy Technologies
Am Grauen Stein, D-51105 Köln, **Germany**
Tel: +49 221 806 2232, fax: +49 221 806 1350
Email: ulrike.jahn@de.tuv.com

COMPLETED TASKS
TASK 3 - USE OF PHOTOVOLTAIC POWER SYSTEMS IN STAND-ALONE AND ISLAND APPLICATIONS

OVERALL OBJECTIVE

Task 3 was established in 1993 to stimulate collaboration between IEA countries in order to improve the technical quality and cost-effectiveness of photovoltaic systems in stand-alone and island applications.
When the **first programme (1993-1999)** was approved, the stand-alone photovoltaic sector was largely comprised of solar home systems for rural electrification, remote 'off-grid' homes in industrialised countries and PV consumer goods. PV hybrid systems and niche off grid applications such as PV powered bus shelters were also being introduced in certain countries.
As part of this programme, a number of documents were published as information about installed stand-alone PV systems worldwide. These included a **lessons learned book** featuring case studies from each country, as well as a survey of **PV programmes in developing countries**.

Task 3's **second programme (1999-2004)** was initiated against this background with the following overall objectives:

Considering all types of stand-alone photovoltaic systems, ranging from small PV kits to power stations supplying micro-grids, the main objective of Task 3 is to improve the technical quality and cost-effectiveness of PV systems in stand-alone and island applications.

Task 3 Aimed:

- To collect, analyse and disseminate information on the technical performance and cost structure of PV systems in these applications
- To share the knowledge and experience gained in monitoring selected national and international projects
- To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems
- To contribute to the development of improved photovoltaic systems and subsystems"

The main target audience of Task 3 activities were technical groups such as project developers, system designers, industrial manufacturers, installers, utilities, Quality organisations, training providers, end users.

The 1999-2004 work programme included the following subtasks and activities:

SUBTASK 1: QUALITY ASSURANCE

Activity 11: Critical Review of Implementation of Quality Assurance Schemes

To develop quality assurance schemes that will lead to a warranty for all system installations at reasonable cost.

Activity 12: Technical Aspects of Performance Assessment on Field - Quality Management

To identify and establish practical performance assessment guidelines.

SUBTASK 2: TECHNICAL ISSUES

Activity 21: Hybrid Systems

To contribute to cost reduction through standardisation and modularity in order to facilitate large scale dissemination of PV hybrid systems.

Activity 22: Storage Function

To provide recommendations to decrease the cost of storage in PV and PV hybrid systems.

Activity 23: Load/Appliances : Load Management and New Applications

To provide a technical contribution to cost reduction by showing the cost efficiencies associated with effective load management and efficient appliance selection.

Collaborative activities had to develop knowledge based on project implementations, technological improvements from the equipment manufacturers, R&D programmes results, and feed-back coming from the field.

PUBLICATIONS

Task 3 publications can be downloaded from the IEA PVPS website www.iea-pvps.org and are listed below:

TECHNICAL REPORTS PUBLISHED BY TASK 3 DURING THE PERIOD 1999-2004

TITLE	REFERENCE NUMBER
Survey of National and International Standards, Guidelines and Quality Assurance Procedures for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-07:2000
Recommended Practices for Charge Controllers	IEA-PVPS T3-08:2000
Use of Appliances in Stand-Alone Photovoltaic Systems: Problems and Solutions	IEA-PVPS T3-09:2002
Management of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems	IEA-PVPS T3-10:2002
Testing of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-11:2002
Selecting Stand-Alone Photovoltaic Systems - Guidelines	IEA-PVPS T3-12:2002
Monitoring Stand-Alone Photovoltaic Systems: Methodology and Equipment - Recommended Practices	IEA-PVPS T3-13:2003
Protection Against the Effects of Lightning on Stand-Alone Photovoltaic Systems - Common Practices	IEA-PVPS T3-14:2003
Managing the Quality of Stand-Alone Photovoltaic Systems - Recommended Practices	IEA-PVPS T3-15:2003
Demand Side Management for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-16:2003
Selecting Lead-Acid Batteries Used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-17:2004
Alternative to Lead-Acid Batteries in Stand-Alone Photovoltaic Systems	IEA-PVPS T3-18:2004

SCOPE FOR FUTURE ACTIVITIES

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, "PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website:
www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities:
Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

CONTACT INFORMATION

For information, contact the former Task 3 Operating Agent or visit the IEA PVPS website.

Former Task 3 Operating Agent:
Mr. Philippe JACQUIN
PHK Consultants
17 bis, Rue Jean Marie Vianney
FR-69130 Ecully
Tel.: 33-(0) 4 78 33 3614
Fax: 33-(0) 4 78 33 3808
Email: philippe. jacquin@phkconsultants.com

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 pea kilowatts. Task 5 was officially concluded in 2003.

MEANS

Participants carried out five subtasks; Subtasks 10,20,30,40 and 50 in order to achieve these objectives. The objectives of each subtask were as follows:

SUBTASK 10: Review of Previously Installed PV Experiences (From 1993 to 1998)

To review existing technical guidelines, local regulations and operational results of grid interconnection with building- integrated and other dispersed PV systems to aid Subtask 20 in defining existing guidelines and producing concepts for new requirements and devices.

SUBTASK 20: Definition of Guidelines to be Demonstrated (From 1993 to 1998)

Utilizing the results of Subtask 10 and a questionnaire, existing technical guidelines and requirements to be demonstrated will be defined, and concepts for new requirements and devices will be developed; with safety, reliability, and cost reduction taken into consideration.

SUBTASK 30: Demonstration Test Using Rokko Island and/or Other Test Facilities (From 1993 to 1998)

To evaluate, by demonstration tests, the performance of existing and new technical requirements and devices defined in Subtask 20.

SUBTASK 40: Summarizing Results (From 1993 to 2001)

To summarize the results of Task 5 and to produce a general report for all participating countries of Task 5, as well as for the ExCo members.

SUBTASK 50: Study on Highly Concentrated Penetration of Grid Interconnected PV Systems (From 1999 to 2001)

To assess the net impact of highly concentrated PV systems on electricity distribution systems and to establish recommendations for both distribution and PV inverter systems in order to enable widespread deployment of solar energy.

TASK 5 REPORTS AND WORKSHOP PROCEEDINGS:

Task 5 produced the following reports and workshop proceedings:

Task 5 Reports

1. «Utility aspects of grid interconnected PV systems», IEA-PVPS T5-01: 1998, December 1998
2. «Demonstration tests of grid connected photovoltaic power systems», IEA-PVPS T5-02: 1999, March 1999
3. «Grid-connected photovoltaic power systems: Summary of Task V activities from 1993 to 1998», IEA-PVPS T5-03: 1999, March 1999
4. «PV system installation and grid-interconnection guideline in selected IEA countries», IEA-PVPS T5-04: 2001, November 2001
5. "Grid-connected photovoltaic power systems: Survey of inverter and related protection equipments", IEA-PVPS T5-05: 2002, December 2002
6. "International guideline for the certification of photovoltaic system components and grid-connected systems", IEA-PVPS T5-06: 2002, February 2002
7. "Probability of islanding in utility networks due to grid connected photovoltaic power systems", IEA-PVPS T5-07: 2002, September 2002
8. "Risk analysis of islanding of photovoltaic power systems within low voltage distribution networks", IEA-PVPS T5-08: 2002, March 2002
9. "Evaluation of islanding detection methods for photovoltaic utility-interactive power systems", IEA-PVPS T5-09: 2002, March 2002
10. "Impacts of power penetration from photovoltaic power systems in distribution networks", IEA-PVPS T5-10: 2002, February 2002
11. "Grid-connected photovoltaic power systems: Power value and capacity value of PV systems", IEA-PVPS T5-11: 2002, February 2002

Task 5 Internal Reports (Open to Public)

1. "Grid-connected photovoltaic power systems: Status of existing guidelines and regulations in selected IEA member countries (Revised Version)", IEA-PVPS V-1-03, March 1998
2. "Information on electrical distribution systems in related IEA countries (Revised Version)", IEA-PVPS V-1-04, March 1998

Proceedings of Final Task 5 Workshop

1. Introduction and table of contents
2. Flyer of the workshop
3. List of participants of the workshop
4. Final programme of the workshop
5. Key note speech
6. Islanding detection methods
7. Probability of islanding in power networks
8. Risk analysis of islanding
9. Conclusions of task V islanding studies
10. Recapitulation of first day
11. Overview of (inter)national interconnection guidelines for PV-systems
12. State of the art inverter technology and grid interconnection
13. Impacts of PV penetration in distribution networks
14. Power value and capacity of PV systems

DELIVERABLES - Where to get them?

All reports are available for download at the IEA PVPS website: http://www.iea-pvps.org
A Task 5 CD-ROM including all the reports was published for distribution. This can be ordered at the contact address below.

CONTACT INFORMATION

For information, contact the former Task 5 Chairman or visit the PVPS website:
For the Task 5 Chairman:
Mr Tadao ISHIKAWA
CRIEPI
2-11-1 Iwato-kita Komea-shi
JPN - 2018511, Tokyo
Email: ishikawa@criepi.denken.or.jp

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 subtasks, for a total of fifteen activities.

SUBTASK 10: Review of Design and Construction Experiences of Large-Scale PV Plants

To perform, on the basis of the Paestum Workshop results, an in-depth review of existing large-scale PV plants aimed both to identify the remarkable technical solutions adopted in such plants and the main common criteria applied for their design, installation, operation, monitoring, and to perform a detailed cost analysis of the plants taken into account.

SUBTASK 20: Review of Operational Experiences in Large-Scale PV Plants

To perform, also utilising the work in progress of Subtask 10 and on the basis of the Paestum Workshop results, an in-depth review of operational experiences in existing large-scale PV plants. The analysis of the acquired data was focused on the comparison between the expected and actual results, both technical and economical; the information flow was continuously updated through acquisition of data from all the plants in operation.

SUBTASK 30: Development of Improved System Design and Operational Strategies for Large-Scale PV Plants

Based on the work of Subtasks 10 and 20, the evaluation work, together with the information gathering activity, let the assessment of most appropriate, innovative technical options for modular design of large-scale PV plants. Both PV and BOS components were dealt with, taking into account: performances improvement, costs reduction, and realisation simplification.

The co-operation among utilities and industries of many countries offered the opportunity to review in detail the performance data and the technical aspects which determined the design approach of the largest PV plants in the world, and to develop improved system design, and operational strategies for such plants.

SUBTASK 40: Outlook of Perspectives of Large-Scale PV Plants

Based on the assumption that large grid connected PV power plants have proven their applicability under the technical point of view, the Subtask was aimed at identifying the path in order to let such plants become a substantial option and play an increasing role in a future oriented energy concept in OECD countries, as well as in developing countries.

TASK 6 REPORTS AND WORKSHOP PROCEEDINGS

Task 6 produced the following reports and workshop proceedings from 1993 to 1998:

1. The Proceedings of the Paestrum Workshop.
2. A PV Plant Comparison of 15 plants.
3. The State of the Art of: High Efficiency, High Voltage, Easily Installed Modules for the Japanese Market.
4. A document on "Criteria and Recommendations for Acceptance Test."
5. A paper entitled: "Methods to Reduce Mismatch Losses."
6. Report of questionnaires in the form of a small book containing organized information collected through questionnaires integrated with statistical data of the main system parameters and of the main performance indices.
7. The "Guidebook for Practical Design of Large Scale Power Generation Plant," edited by the Japanese expert.
8. The "Review of Medium to Large Scale Modular PV Plants Worldwide."
9. Proceedings of the Madrid Workshop.

DELIVERABLES - Where to get them?

All reports are available for download at the IEA PVPS website:
http://www.iea-pvps.org

CONTACT INFORMATION

For information contact the former Operating Agent of Task 6 of visit the IEA PVPS website:

Mr Alberto Iliceto
CESI S.p.A.- SFR/ERI
Via Rubattino, 54
20134 Milano
Italy
Fax: +39 (0)2 2125.5626
Email: iliceto@cesi.it
Web: http://www.cesi.it

COMPLETED TASKS
TASK 7 - PHOTOVOLTAIC POWER SYSTEMS IN THE BUILT ENVIRONMENT

OVERALL OBJECTIVE

The objective of Task 7 was to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment. The objective was also to assess and remove non-technical barriers for their introduction as an energy-significant option.

It is expected that successful integration of PV systems into the built environment (BIPV) will contribute significantly to the future spread of PV.

For this, active involvement of urban planners, architects and building engineers is required. Task 7 motivated the collaboration between these groups and PV system specialists, utility specialists, PV and building industry and other professionals involved in photovoltaics.

Task 7 considered all grid connected systems other than classified as «ground based arrays». Primary focus of this Task was on the integration of PV into the architectural design of roofs and facades of residential, commercial and industrial buildings and other structures in the built environment (such as noise barriers, parking areas and railway canopies), and on other market factors, both technical and non-technical, that need to be addressed and resolved before wide spread adoption of PV in the built environment will occur. Task 7 officially started on January 1, 1997 and finished end 2001. In 2002, the last reports and deliverables were published. At the end of 2003 there remained only one outstanding issue: the publication of the book «Designing with Solar Power». This book is expected in Spring 2005.

SUBTASK 1: Architectural Design of Photovoltaic Power Systems in the Built Environment

Participants worked on the improvement of the architectural design of PV systems as an integral element in buildings and other structures in the built environment. For this purpose, existing PV projects were documented. In addition, case studies were followed and evaluated by the Task Participants. Many of these case studies were realised as demonstration projects.

SUBTASK 2: Systems Technologies for Photovoltaic Power Systems in the Built Environment

Participants worked on the development of new concepts for photovoltaic power systems in the built environment that can enhance the electrical performance or the performance of the PV system as a building component. New concepts, developed by the Participants shall enhance market opportunities for the industry. This Subtask aims for a number of standardised and certified PV elements for integration in buildings and other structures in the built environment. The Subtask will also provide a number of options to effectively utilise PV electricity and to connect PV systems safely and reliably to the electricity grid, as far as this topic is not addressed by Task 5 of the PVPS Implementing Agreement.

SUBTASK 3: Non-Technical Barriers in the Introduction of Photovoltaic Power Systems in the Built Environment

Participants assessed the non-technical barriers to be removed to make PV in the built environment an energy-significant power supply option. The purpose of this Subtask was to identify the barriers on one side and the (technical, economic, market) potential of PV in the built environment on the other. The main result of this Subtask will be an executive IEA report on strategies for barrier removal and utilisation of the PV potential.

SUBTASK 4: Demonstration and Dissemination of Photovoltaic Power Systems in the Built Environment

The results of the other Subtasks were brought to the market by dissemination of collected information and the demonstration of new concepts. Demonstration of mounting and system concepts takes place through the EPFL Demosite. Results are disseminated by the use of different media (ranging from papers, books, and brochures to new media such as a CD-ROM or a WWW-site). Dissemination will also occur through the second and third International Solar Electric Buildings Conferences and national workshops in conjunction with the semi-annual meetings of the Task. Furthermore, the possibility of a training and education program was assessed and resulted in a CD-ROM.

TASK 7 REPORTS

Task 7 produced the following reports from 1999 to 2002:

1. Literature Survey and Analysis of Non-technical Problems for the Introduction of BIPV Systems, B. van Mierlo & B. Oudshoff, IVAM Environmental Research, 1999. To be ordered at IVAM Environmental Research, NL, Fax + 31 20 525 58 50
2. PV in Non Building Structures - A Design Guide, M.A. Romero, EcoCode-Miljö och Architectur, 1999. To be ordered at Energiebanken, SE, Fax: +46 652 13 427
3. Potential for Building Integrated Photovoltaics, M. Gutschner, NET Nowak Energie & Technologie AG, 2001. To be ordered at NET, CH, Fax: +41 26 49 40 034
4. Guidelines for the Economic Evaluation of Building Integrated Photovoltaics, P. Eiffert, National Renewable Energy Laboratories, 2002. To be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance.
5. Market Deployement Strategies for Photovoltaics in the Built Environment, R. Haas, Technische Universität Wien, 2002. To be ordered at Technische Universität Wien, AT, Fax: +43 1 588 013 7397
6. Innovative electric concepts, H. Wilk, Energie AG, 2002. To be ordered at Energie AG, AT, Fax: +43732 9000 3309
7. Reliability of Photovoltaic Systems, H. Laukamp, Fraunhofer Institute für Solar Energiesysteme, 2002. To be ordered at Fraunhofer Institute für Solar Energiesysteme, GE, Fax: +49 761 4588 217
8. PV/Thermal Solar Energy Systems, Status of the Technology and Roadmap for future Development, H. Sorensen, Esbensen Consulting, 2002, To be ordered at Esbensen Consulting Engineers, DK, Fax: +45 33 26 73 01

11. Executive Summary Report - Non-technical Barriers to the commercialisation of Photovoltaic Power in the Built Environment, P. Eiffert, National Renewable Energy Laboratories, to be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance

DELIVERABLES - Where to get them?

All reports are available for download at IEA PVPS website: www.iea-pvps.org.
In addition, all reports and many other deliverables are summarized on CD-ROM, which can be ordered at Novem, The Netherlands.

Task 7, Project Results and Documents.
To be ordered at:
Novem, Publication Centre
PO Box 8242
3503 RE Utrecht
The Netherlands
Tel.: +31 30 2393493
Email: publicatiecentrum@novem.nl.

Task 7 book: Designing With Solar Power"
To be ordered at:
The Images Publishing Group Pty Ltd
6 Bastow Place
Mulgrave, Victoria 3170, Australia

PARTICIPANTS

In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

CONTACT INFORMATION

For information contact the former Task 7 OA or visit the websites:

Former Task 7 Operating Agent:
Mr van Schalkwijk
Ecofys, Utrecht, the Netherlands
Email: M.vanSchalkwijk@ecofys.nl

Task 7 deliverables: www.iea-pvps.org
Task 7 website: www.task7.org
Task 7 demosite: www.demosite.ch
PV Projects database: www.pvdatabase.com

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.pvdatabase.com

PowerPoint
Network Issues and Benefits Visual Tool

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

CONTACT INFORMATION
For information, contact the former Task 10 Operating Agent or visit the PVPS website:

Ms Christy HERIG
Regional Director- East Director
Solar Electric Power Association
1220 19th Street, Suite 401
USA- Washington, DC 20036
Tel: 001 (0) 202 559 2020
Fax: 001 (0) 202 59 2035
cherig@solarelectricpower.org

COMPLETED TASKS
TASK 11 – HYBRID SYSTEMS WITHIN MINI-GRIDS

INTRODUCTION

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

TASK 11 STRATEGY AND ORGANIZATION

In general, Task 11 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 was 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 addressed 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 had 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 addressed 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 had 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 addressed the goal of increasing the use of the PV resource in PV hybrid systems and displacing fossil fuel resources. It had the following two activities:

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

SUBTASK 40: Sustainability Conditions

Subtask 40 addressed the social, political, economic, and environmental factors necessary for successful implementation of PV hybrid power systems within mini-grids. It had 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.

TASK 11 KEY DELIVERABLES

Task 11 completed the majority of its Workplan. The following deliverable reports were published:

1 Worldwide Overview of Design and Simulation Tools for PV Hybrid Systems - T11-01:2011
2 The Role of Energy Storage for Mini-Grid Stabilization - T11-02:2011
3 Sustainability Conditions for PV Hybrid Systems: Environmental Considerations - T11-03:2011
4 COMMUNICATION BETWEEN COMPONENTS IN MINI-GRIDS: Recommendations for communication system needs for PV hybrid mini-grid systems - T11-04:2011
5 Social, Economic and Organizational Framework for Sustainable Operation of PV Hybrid Systems within Mini-Grids - T11-05:2011
6 Design and operational recommendations on grid connection of PV hybrid mini-grids - T11-06:2011
7 PV Hybrid Mini-Grids: Applicable Control Methods for Various Situations - T11-07:2012
8 Overview of Supervisory Control Strategies Including a MATLAB® Simulink® Simulation - T11-08:2012

DELIVERABLES – WHERE TO GET THEM?

Task 11 deliverable reports have been published electronically on the IEA PVPS website http://www.iea-pvps.org 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.

PARTICIPANTS

In the final year of the Work Plan, eleven IEA PVPS countries participated in Task 1l: Australia, Austria, Canada, China, France, Germany, Italy, Japan, Malaysia, Spain, and the USA. The management of the Task - the Operating Agent - was executed by Canada.

SUBSEQUENT ACTIVITY

PVPS Task 9 has taken on the dissemination and further development of several of the Task 11 results and activities.

CONTACT INFORMATION

For information, contact the former Task 11 Operating Agent or the Task 9 Operating Agent, or visit the PVPS website:

Mr Konrad MAUCH
Task 11 Operating Agent
KM Technical Services
1358 Sea Lovers Lane
CAN - Gabriola BC V0R 1X5
Tel: 1(0)25 0247 9577
konrad.mauch@ieee.org
konrad.mauch@gmail.com

Ms. Anjali SHANKER
Task 9 Operating Agent
Directeur Général Délégue
IED
2, chemin de la Chauderaie
FRA - 69340 Francheville (Lyon)
Tel: 33 (0)4 72591320
a.shanker@ied-sa.fr

ANNEX A

IEA-PVPS EXECUTIVE COMMITTEE

AUSTRALIA

Ms Muriel WATT – Deputy Chair
IT Power Australia
Unit 6, 9 McKay St
Turner
AUS – ACT 2612
(or this address)
PO Box 6127
O'Connor
AUS - ACT 2602
Cell: 61(0)4 2772 7368
muriel.watt@itpau.com.au

Mr Greg WATT - Alternate
Australian PV Association
PO Box 145
AUS - Port Macquarie NSW 2444
Tel: 61(0)400 768885
tallowood@westnet.com.au

AUSTRIA

Mr Hubert FECHNER – Deputy Chair
Renewable Urban Energy Programme
University of Applied Sciences
Technikum Wien
Giefinggasse 6
AUT -1210 Vienna
Tel: 43 (0)133 3407 7564
Cell: 43 (0)66 4619 2572
hubert.fechner@technikum-wien.at

Mr Fritz FAHRINGER – Alternate
Austrian Federal Ministry for Transport,
Innovation and Technology
Renngasse 5
AUT -1010 Vienna
Tel: 43 (1)71162 652 919
fritz.fahringer@bmvit.gv.at

BELGIUM

Mr Bart HEDEBOUW
Vlaams Energieagentschap
Koning Albert II-laan 20 bus 17
BEL - 1000 Brussels
Tel: 32 (0)2 553 46 27
Fax: 32 (0)2 553 46 01
bart.hedebouw@vea.be

Ms Leen VAN LISHOUT
Projectbeheerder, Directie Energie
Leefmilieu Brussel – BIM
Gulledelle 100
BEL - 1200 Brussels
Tel: 32 (0)2 563 42 97
Fax: 32 (0)2 563 43 26
lvanlishout@leefmilieu.irisnet.be

Ms Laurence POLAIN
Energy Research Team
Service Publique de Wallonie – DGO4
Direction de la Promotion de l'Énergie durable
Chaussée de Liège, 140-142
BEL - 5100 Jambes
Tel: 32 (0)81 48 63 42
Fax: 32 (0)81 48 63 03
laurence.polain@spw.wallonie.be

All three of Belgium's regions represented by:

Mr Achim WOYTE
3E nv/sa
R&D Manager
Vaartstraat 61
Rue du Canal
BEL – 1000 Brussels
Tel: 32 (0)2 217 58 68
Fax: 32 (0)2 219 79 89
Achim.Woyte@3E.eu
Tel: 32 (0)2 229 15 26

CANADA

Mr John GORMAN
President
CANSIA
Canadian Solar Industries Association
150 Isabella Street, Suite 605
CAN - Ottawa, ON, Canada, K1S 1v7
Tel: 1 613 736 9077 Ext. 223
Toll free: 1 866 522 6742 Ext. 223
j.gorman@cansia.ca

Mr Patrick BATEMAN – Alternate
CANSIA
Canadian Solar Industries Association
Policy and Research Advisor
150 Isabella Street, Suite 605
CAN - Ottawa, ON, Canada, K1S 1v7
Tel: 1 613 736 9077
1 866 522 6742
Fax: 1 613 736 8938
pbateman@cansia.ca

CHINA

Mr Xu HONGHUA
Researcher
Electrical Engineering Institute
Chinese Academy of Sciences
No. 6 Bei-er-tiao
Zhongguancun
Haidian Dist.
CHN - 100190 Beijing China
Cell: 13701021351
Tel: 86 10 825 47026, 82 37 9398
Fax: 86 10 825 47028
hxu@mail.iee.ac.cn

Mr Wang SICHENG
Researcher
Energy Research Institute
National Development and
Reform Commission, China
No. 6 Bei-er-tiao
Zhongguancun
Haidian Dist.
CHN - 100190 Beijing China
Cell: 13901388270
Tel: 86 10 825 47025
Fax: 86 10 825 47028
wangsc@eri.org.cn

COPPER ALLIANCE

Mr Fernando NUNO
Project Manager
CEDIC Copper Alliance
International Copper Association
Calle Princesa 79 – 1ºI
28008 Madrid, Spain
Tel: 34 670 80 46 37
fernando.nuno@copperalliance.es

Mr Hans De KEULENAER - Alternate
Director – Energy & Electricity
European Copper Institute
Avenue de Tervueren 168 B 10
1150 Brussels, Belgium
Tel: 32 (0)2 777 7084
hans.dekeulenaer@copperalliance.eu

DENMARK

Mr Flemming KRISTENSEN
EnergiMidt A/S
Tietgensvej 2 - 4
DEN – 8600 Silkeborg
Tel: 45(0)7 658 1130
Cell: 45(0)2 086 9638
fvk@energimidt.dk

Mr Peter AHM - Alternate
Director, PA Energy A/S
Snovdrupvej 16
DEN - 8340 Malling
Tel: 45 (0)8 693 3333
ahm@paenergy.dk

EUROPEAN UNION

Mr Fabio BELLONI
European Commission
Directorate-General for Research & Innovation
New & Renewable Energy Sources
Rue du Champ de Mars 21
BEL - 1049 Brussels, Belgium
Tel: 32 (0)229 52472
Fax: 32 (0)229 94991
Fabio.BELLONI@ec.europa.eu

Mr Pietro MENNA
European Commission
Directorate-General for Energy
Office: DM24 3/116
BEL - 1049 Brussels, Belgium
Tel: 32 (0)2 295 4512
Fax: 32 (0)2 296 6221
Pietro.MENNA@ec.europa.eu

EPIA

Mr Reinhold BUTTGEREIT
Secretary General
European Photovoltaic Industry Association
Rue d'Arlon 63-67
BEL - 1040 Brussels
Tel: 32 (0)2 400 1011
Fax: 32 (0)2 400 1010
r.buttgereit@epia.org

Mr Gaëtan MASSON - Alternate
Head of Business Intelligence
European Photovoltaic Industry Association
Rue d'Arlon 63-67
BEL - 1040 Brussels
Tel: 32 (0)2 400 10 58
Fax: 32 (0)2 400 10 10
g.masson@epia.org

FRANCE

Mr Yvonnick DURAND
PV R&D and Market Engineer
ADEME – Service Réseaux et Energies Renouvelables
500 route des Lucioles
FRA - 06560 Valbonne, France
Tel: 33 (0)4 93 95 79 11
yvonnick.durand@ademe.fr

GERMANY

Mr Christoph HÜNNEKES - Deputy Chair
Forschungszentrum Jülich GmbH
Projektträger Jülich - EEN
DEU - 52425 Jülich
Tel: 49 (0)24 6161 2227
Fax: 49 (0)24 6161 2840
ch.huennekes@fz-juelich.de

Mr Klaus PRUME – Alternate
Projektträger Jülich - EEN
DEU - 52425 Jülich
Tel: 49 (0)24 6161 9174
Fax: 49 (0)24 6161 2840
k.prume@fz-juelich.de

ISRAEL

Mr Yoel COHEN
Program Manager
Division of R&D, Ministry of Energy
and Water Resources
234 Yaffo St.
POB 36148
ISR- 234 Jerusalem
Tel: 972 2 5316055
Cell: 972 506206579
Fax: 972 2 5316017
yoelc@energy.gov.il

Mr Dan WEINSTOCK – Alternate
Better Place
13 Ha'amal St.
Afek Industrial Park
P.O. Box 11793
ISR – 48092 Rosh-Ha'ayin
Tel: 972 (0)3 644 8655
Cell: 972 (0)50 620 6077
Fax: 972 (0)3 644 8699
dan.weinstock@betterplace.com

ITALY

Mr Salvatore CASTELLO
ENEA - Casaccia
Via Anguillarese, 301
ITA - 00123 S. Maria di Galeria - RM
Tel: 39 06 3048 4339
Fax: 39 06 3048 6486
salvatore.castello@enea.it

Mr Salvatore GUASTELLA
RSE S.p.A. (Ricerca Sistema Elettrico S.p.A.)
via Rubattino, 54
ITA - 20134 Milano
Fax: 39 02 3992 5626
salvatore.guastella@rse-web.it

Mr Fabrizio PALETTA - Alternate
RSE S.p.A. (Ricerca Sistema Elettrico S.p.A.)
via Rubattino, 54
ITA - 20134 Milano
Fax: 39 02 3992 5626
fabrizio.paletta@rse-web.it

JAPAN

Mr Hiroyuki YAMADA – Deputy Chair
Director
Solar Cells and System Technology
New Energy Technology Dept.
New Energy and Industrial Technology
Development Organization (NEDO)
18F Muza Kawasaki Building, 1310, Omiya-cho, Saiwai-ku,
JPN - Kawasaki City Kanagawa 212-8554
Cell: 81 (0)80 4103 9831
Tel: 81 (0) 4 4520 5277
Fax: 81 (0)4 4520 5276
yamadahry@nedo.go.jp

Mr Masanori ISHIMURA - Alternate
Project Coordinator
Solar Cells and System Technology
New Energy Technology Dept.
New Energy and Industrial
Technology Development Organization (NEDO)
18F Muza Kawasaki Building, 1310, Omiya-cho, Saiwai-ku,
JPN - Kawasaki City Kanagawa 212-8554
Cell: 81 (0)80 4103 9756
Tel: 81 (0)4 4520 5277
Fax: 81 (0)4 4520 5276
ishimuramsn@nedo.go.ip

KOREA

Mr Dong-gun LIM
Korea National University of Transportation
50 Dae-hack roe, Chungju-si
KOR – Chungbuk, Korea (380-702)
Tel: 82(0)43 841 5172
Fax: 82(0)42 841 5160
dglim@ut.ac.kr

MALAYSIA

Dato' Haji Badaruddin Bin MAHYUDIN
Deputy Secretary General (Energy Sector)
Ministry of Energy, Green Technology and Water
Block E 4/5, Parcel E
MAS – 62668 Putrajaya
Tel: 603 8883 6280
Fax: 603 8889 1335
badaruddin@kettha.gov.my

Mrs Badriyah Binti Abdul MALEK – Alternate
Chief Executive Officer
Sustainable Energy Development Authority Malaysia
Galeria PjH, Aras 9, Jalan P4W, Persiaran Perdana, Presint 4
MAS - 62100 Putrajaya, Malaysia
Tel: 603 8870 5800
Fax: 603 8870 5900
badriyah@seda.gov.my

MEXICO

Mr Jaime AGREDANO DIAZ
Instituto de Investigaciones Electricas
Energías no Convencionales
Reforma 113 Colonia Palmira
MEX - Cuernavaca, Morelos 62490
Tel: 52 (0)77 7362 3811 ext. 7771
Fax: 52 (0)77 7362 3808
agredano@iie.org.mx

Mr Jorge M. HUACUZ VILLAMAR - Alternate
Instituto de Investigaciones Electricas
Energías no Convencionales
Reforma 113 Colonia Palmira
MEX - Cuernavaca, Morelos 62490
Tel: 52 (0)77 7318 3806
Fax: 52 (0)77 7318 3808
jhuacuz@iie.org.mx

NETHERLANDS

Ms Suzanne BREMAN -VRIJMOED
Ministry of Economic Affairs
P.O. Box 20401
NLD - 2500 EK Den Haag
Tel: 31 (0)7 0379 6524
Fax: 31 (0)7 0379 6872
s.breman-vrijmoed@minez.nl

Mr Otto BERNSEN - Alternate
NL Agency
Directorate, Energy & Climate
The Hague
P.O. Box 93144
NLD - 2509 AC Den Haag
Tel: 31 (0)8 8602 9023
Fax: 31 (0)7 0373 5650
otto.bernsen@agentschapnl.nl

NORWAY

Mr Trond MOENGEN
Senior Advisor
Research Council of Norway / Forskningsrådet
P.O. Box 2700 St. Hanshaugen
NOR - 0131 OSLO
Tel: 47 (0)952 73 220
Fax: 47 (0)220 37 362
trond.moengen@energidata.no

Mr Knut-Erik MADSEN - Alternate
E-CO Vannkraft AS
P.O. Box 1050- Sentrum
NOR - 0104 OSLO
Tel: 47 (0)2 411 6905
Fax: 47 (0)2 411 6901
knuterik.madsen@e-co.no

PORTUGAL

Mr João Gonçalo MACIEL
EDP Inovação
Av. Sidónio Pais, 24 - 2o Esq.
PRT - 1050-215 Lisboa (Portugal)
Tel: 351938193039
Fax: 351210018990
joaogoncalo.maciel@edp.pt

Mr Pedro SASSETTI PAES - Alternate
EDP - Energias de Portugal, S.A.
Praça Marquês de Pombal, 13 – 6o
PRT - 1250-162 Lisboa (Portugal)
Tel: 351210021563
Fax: 351210021387
pedro.paes@edp.pt

SEPA

Ms Julia HAMM
President & CEO
Solar Electric Power Association
1220 19th Street, Suite 800
USA- Washington, DC 20036 USA
Tel: 001 (0)202 559 2025
Fax: 001 (0)202 59 2035
jhamm@solarelectricpower.org

SEIA

Mr Tom KIMBIS
Vice President, External Affairs
and General Counsel
Solar Energy Industries Association SEIA
505 9th Street, NW, Suite 400
USA- Washington, DC 20004
Tel: 001 (0)202 469 3737
Cell: 001 (0)202 714 3737
tkimbis@seia.org

Mr John P. SMIRNOW - Alternate
Vice President of Trade & Competitiveness
Solar Energy Industries Association
505 9th Street, NW, Suite 400
Washington, DC 20004
Tel: 001 (0)202 556-2906
Cell: 001 (0)202 213-6084
JSmirnow@seia.org

SPAIN

Ms Ana Rosa LAGUNAS ALONSO
Photovoltaic Department Manager
CENER (National Renewable Energy Centre)
Ciudad de la Innovación 7
ESP - 31621 Sarriguren-Navarra
Tel: 34 (0)9 4825 2800
Fax: 34 (0)9 4827 0774
alagunas@cener.com

SWEDEN

Ms Sara BARGI
Energy Technology Department
Swedish Energy Agency
P.O. Box 310
Kungsgatan 43
SWE - 631 04 Eskilstuna
Tel: 46(0)1 6544 2170
sara.bargi@energimyndigheten.se

Mrs Monika ADSTEN - Alternate
ELFORSK
Olof Palmes Gata 31
SWE - 10153 Stockholm
Tel: 46 (0)8 677 2735
Fax: 46 (0)8 677 2535
monika.adsten@elforsk.se

SWITZERLAND

Mr Stefan OBERHOLZER
Sektion Energieforschung
Bundesamt für Energie
CHE - 3003 Bern
Tel: 41 (0)3 1325 8920
Cell: 41 (0)7 9231 4850
stefan.oberholzer@bfe.admin.ch

Mr Stefan NOWAK - Chairman
NET - Ltd.
Waldweg 8
CHE - 1717 St. Ursen
Tel: 41 (0)2 6494 0030
Fax: 41 (0)2 6494 0034
stefan.nowak@netenergy.ch

TURKEY

Mr Mete CUBUKCU
General Secretary
Turkish PV Technology Platform (UFTP)
Ege University Solar Energy Institute
TUR - 35100 Bornova – IZMIR
Tel. & Fax: +902323391128
mete.cubukcu@uftp.org.tr

Mr Sener OKTIK
President of Research and Technological Development
Turkiye Şişe ve Cam Fabrikaları A.Ş.
İş Kuleleri Kule 3, Kat: 22
TUR - 34330 4.Levent/İstanbul
Tel: +90 212 350 34 34
Fax: +90 212 350 44 34
SEOKTIK@sisecam.com

UNITED KINGDOM

Mr Steve MARTIN – UK CERT Delegate
Senior Policy Adviser
Energy Innovation Unit
Science and Innovation Directorate
Department of Energy and Climate Change
3 Whitehall Place
GBR - London SW1A 2AW
Tel: 0044 (0) 300 068 6141
steve.martin@decc.gsi.gov.uk

UNITED STATES OF AMERICA

Mr Kevin LYNN
Lead for Systems Integration
SunShot Initiative
US Department of Energy
1000 Independence Avenue S.W.
USA - Washington, DC 20585-0121
Tel: 1 (0)20 2586 1044
Cell: 1 (0)20 2251 3452
kevin.lynn@ee.doe.gov

EXCO SECRETARY

Mrs Mary Jo BRUNISHOLZ
NET - Ltd.
Waldweg 8
CHE - 1717 St. Ursen
Tel: 41 (0)2 6494 0030
Fax: 41 (0)2 6294 0034
mary.brunisholz@netenergy.ch

IEA DESK OFFICER

Mr Yoshiki ENDO
Renewable Energy
Implementing Agreement Desk Officer
International Energy Agency
9, rue de la Fédération
FRA - 75739 Paris Cedex 15
Tel: 33 (0)1 4057 6562
yoshiki.endo@iea.org

ANNEX B

IEA-PVPS OPERATING AGENTS

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

Mr Gaëtan MASSON
148, Vieux Chemin de l'Helpe
BEL – 1332 Genval, Belgium
Cell: 32 478 28 05 11
g.masson@iea-pvps.org

TASK 8 – STUDY ON VERY LARGE SCALE PV POWER GENERATION SYSTEMS

Mr Keiichi KOMOTO
Mizuho Information & Research Institute Inc.
Environment, Natural Resources and Energy
2-3 Kanda-Nishiki-cho, Chiyoda-ku, Tokyo
JPN - 101-8443
Tel: 81 (0)3 5281 5286
Fax: 81 (0)3 5281 5466
keiichi.komoto@mizuho-ir.co.jp

Prof Kosuke KUROKAWA - Alternate
Tokyo Institute of Technology
2-12-1-I6-25 Ookayama, Meguro-ku, Tokyo
JPN – 152-8550
Tel: 81 (0)3 5734 3754
Fax: 81 (0)2 5734 3754
kurochan@iri.titech.ac.jp

TASK 8 SECRETARY
Mr Masanori ISHIMURA
Project Coordinator
New Energy and Industrial
Technology Development Organization (NEDO)
18F Muza Kawasaki Building, 1310, Omiya-cho, Saiwai-ku,
JPN - Kawasaki City Kanagawa 212-8554
Tel: 81 (0)4 4520 5277
Fax: 81 (0)4 4520 5276
ishimuramsn@nedo.go.jp

TASK 9 – PHOTOVOLTAIC SERVICES FOR DEVELOPING COUNTRIES

Ms Anjali SHANKER
Directeur Général Délégue
IED
2, chemin de la Chauderaie
FRA - 69340 Francheville (Lyon)
Tel: 33 (0)4 72591320
a.shanker@ied-sa.fr

TASK 12 – PV ENVIRONMENTAL, HEALTH AND SAFETY (E, H & S) ACTIVITIES

Mr Garvin HEATH
National Renewable Energy Laboratory
15013 Denver West Parkway
USA - Golden, CO 80401
Tel: 1 (0)303-384-7460
garvin.heath@nrel.gov

Mr Kevin LYNN
Lead for Systems Integration
SunShot Initiative
US Department of Energy
1000 Independence Avenue S.W.
USA - Washington, DC 20585-0121
Tel: 1 (0)20 2586 1044
Cell: 1 (0) 202-251-3452
kevin.lynn@ee.doe.gov

TASK 13 – PERFORMANCE AND RELIABILITY OF PHOTOVOLTAIC SYSTEMS

Ms Ulrike JAHN
TÜV Rheinland Energie und Umwelt GmbH
Am Grauen Stein
DEU - 51105 Köln, Germany
Tel: 49 (0)221 806 2232
Fax: 49 (0)221 806 1350
ulrike.jahn@de.tuv.com

Mr Nils REICH
Internationalisation & Acquisition Group PV Power Plants
Division Photovoltaic Modules, Systems and Reliability
Fraunhofer Institute for Solar Energy Systems ISE
Heidenhofstrasse 2, 79110 Freiburg, Germany
Tel: 49 (0)761 4588 5826
Fax: 49 (0)761 4588 9217
nils.reich@ise.fraunhofer.de

TASK 14 – HIGH-PENETRATION OF PV SYSTEMS IN ELECTRICITY GRIDS

Mr Roland BRÜNDLINGER
AIT Austrian Institute of Technology GmbH
Giefinggasse 2
AUT - 1210 Vienna
Tel: +43 50550-6351
Fax: +43 50550-6390
roland.bruendlinger@ait.ac.at

Mr Christoph MAYR
AIT Austrian Institute of Technology GmbH
Giefinggasse 2
AUT - 1210 Vienna
Tel: + 43 50550-6633
Fax: +43 50550-6390
christoph.mayr@ait.ac.at

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