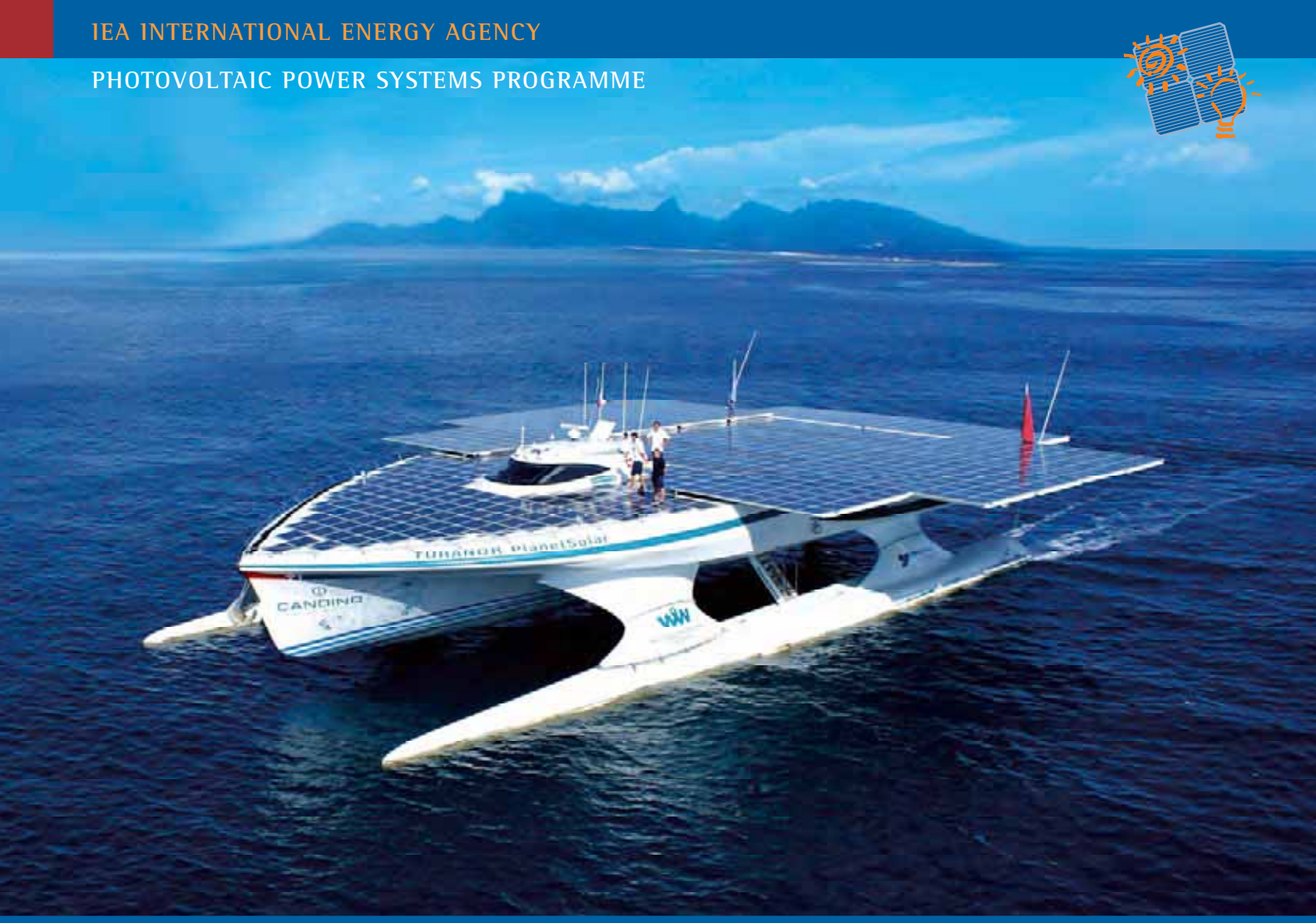
IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME



PVPS annual report 2011

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2011

CHAIRMAN'S MESSAGE

The IEA Photovoltaic Power Systems Programme is pleased to present its 2011 annual report. 2011 has been characterized by exceptional global market dynamics, further significant cost reduction, increased competition and signs of industry consolidation. The so-called grid parity is about to be reached in first countries with high electricity tariffs and high solar irradiation. Going hand in hand with this global photovoltaic market expansion is an increasing awareness of the future potential role of this young energy technology.

From an IEA point of view, a new publication, "Solar Energy Perspectives," dealing with solar energy has been launched in 2011; describing the various technologies and applications as well as the overall solar energy potential in a comprehensive overview. The IEA thereby confirms the high potential contribution of solar energy to the future energy supply: *"If effective support policies are put in place in a wide number of countries during this decade, solar energy in its various forms – solar heat, solar photovoltaics, solar thermal electricity, solar fuels – can make considerable contributions to solving some of the most urgent problems the world now faces: climate change, energy security, and universal access to modern energy services."*

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 continuously 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.

Interest and outreach for new membership within IEA PVPS continued in 2011. The Solar Energy Industries Association (SEIA) from the United States joined the PVPS Programme as the 26th member during the year, thereby strengthening the industrial base of our membership. I welcome SEIA as the most recent IEA PVPS member and look forward to a long and fruitful cooperation. Membership negotiations are also underway with Thailand and Belgium. Contacts have continued with India, New Zealand, Singapore and South Africa. 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 26th European Photovoltaic Solar Energy Conference in Hamburg (Germany), Solar Power International in Dallas, Texas (USA), as well as the 21st International Photovoltaic Science and Engineering Conference PVSEC-21 in Fukuoka (Japan), attracted a large number of visitors and provided an excellent forum for dissemination purposes. Utility related subjects are gaining relevance as evidenced by various workshops organized within the PVPS collaborative projects.

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, Antalya, Turkey, October 2011.

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 2011, fourteen Tasks were established within the PVPS programme, of which seven are currently operational.

The twenty-six PVPS members are: Australia, Austria, 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 and the Solar Energy Industry Association (SEIA) joined PVPS in 2011.

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-domestic applications, community systems, mini-grids and applications in weak grid areas. Depending on the local framework conditions, the infrastructure available as well as appropriate quality management, financing and capacity building schemes, such applications represent new opportunities where PV can increasingly provide the required energy service on a competitive basis. Some of the Kyoto mechanisms may in future provide additional opportunities for PV applications, in particular if they can be aggregated to larger volumes. The sustainable and large-scale introduction of PV is supported by bilateral and multilateral agencies and development banks. At the same time, this large-scale introduction is hampered by various barriers such as acceptable accessible financing structures, institutional and social barriers, infrastructure issues and sometimes technical problems. PVPS expertise can be instrumental to help overcome some of these barriers.

IEA PVPS TASKS

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

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

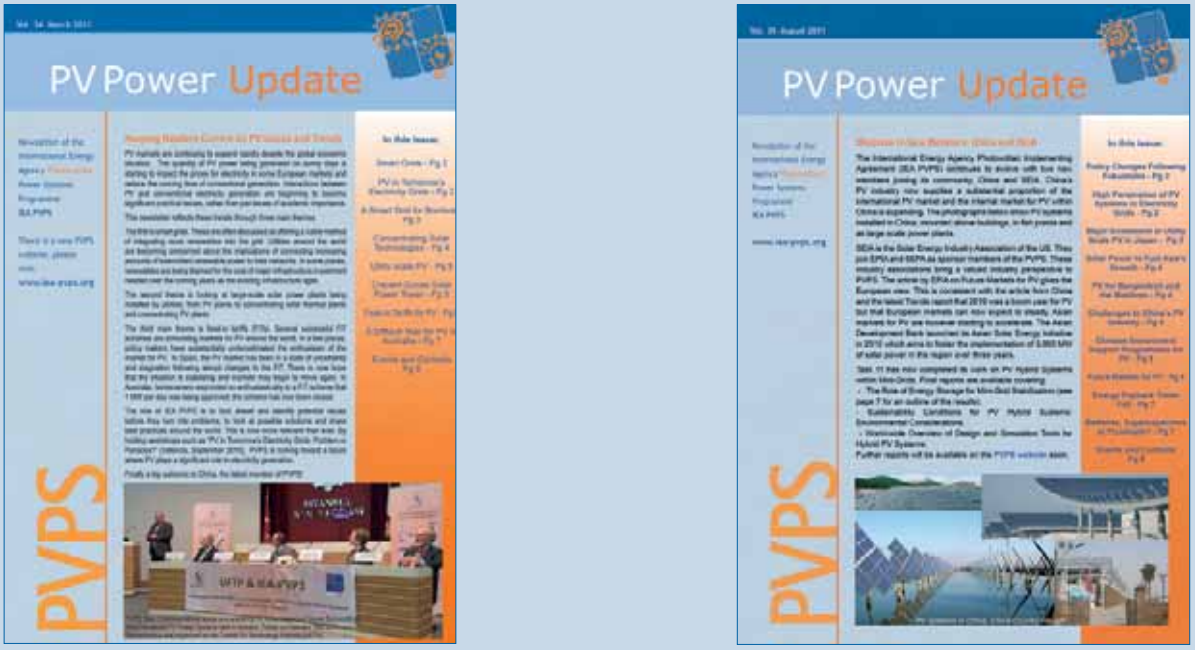

Fig. 1 - "PVPower Update newsletter is based on results and activities of the PVPS Programme and key policy and programme information from the participating countries."

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 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 2011 sixteen 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. The newsletter is now called PVPower Update. Task 1 participants provide material of interest to the newsletter editor and ensure that the newsletter reaches its target audience in the respective countries.

Thirty five issues of the newsletter have been published by the end of 2011.

Fig. 2 – Task 1 Experts Meeting, Amsterdam - "After meeting in Amsterdam, Task 1 members were able to visit Heerhugowaard, the Dutch City of the Sun."

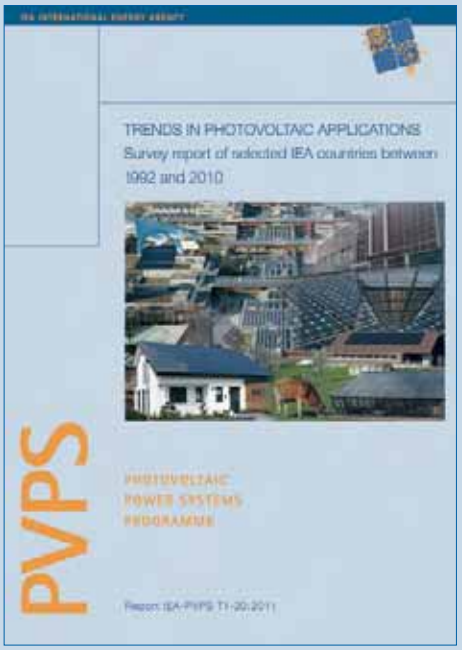

Fig. 3 - "An important deliverable of Task 1 is the annual Trends in photovoltaic applications report. In parallel, National Survey Reports are produced each year by all Task 1 national participants and data from these documents are used to compile the Trends report."

SUBTASK 1.3: Special Information Activities

Under the auspices of Task 1, diverse activities including workshops and documents provide analysis and summary assessment of special topics. These are directed at technical, economic, environmental and social aspects of PV systems and applications and are usually managed by a specific country or a group of countries from the Task 1 membership.

Activities to date include workshops and published reports on Environmental aspects of PV power systems, Photovoltaics in competitive electricity markets, Added values of photovoltaic power systems, PV industry roadmaps, Environmental Safety and Health issues, International PV collaboration and market developments, Finance and PV, Information gathering along the PV industry value chain, the Status of PV in the Asia Pacific region (several workshops), Grid parity and beyond, Towards a future of large-scale deployment of PV, PV in tomorrow's electricity grids – problem or panacea? and Driving Future PV Deployment – Electricity Utility Business Models. 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 2011

The 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 2010 were received from most participating countries during 2011, as required by the Programme. Most are excellent documents and are provided in a timely manner.

The 16th issue of the *Trends in Photovoltaic Applications report* was published in Autumn 2011. Electronic versions of the information were made available progressively on the public website and conference papers were developed based on the Trends report information.

About 14,2 GW of PV were installed in the IEA PVPS countries (now including China) during 2010 - more than double the amount as in the previous year. This brought the cumulative installed capacity to almost 35 GW. By far the greatest proportion (69 %) was installed in Germany and Italy alone. If the US, Japan and France are also included, then over 87 % of PV installations in 2010 occurred in five countries. Continued dramatic growth of the annual grid-connected PV market worldwide was evident, with significant growth of the annual market in a number of the largest markets. Five countries rank in the GW cumulative installed PV capacity grouping. Germany's cumulative installed capacity grew at 74 % whereas Japan's growth rate approached 38 %. Cumulative installed capacity in the US increased at 57 %. Italy's cumulative installed capacity tripled, as did France's.

SUBTASK 1.2: Newsletter

Editorial policy for the newsletter continued to emphasize that projects and products – both PVPS and other - must be tangible to be included. PVPower Update #34 was produced and disseminated in March 2011. Issue #35 was provided in time to also be used as a handout at EUPVSEC in September. Current and back issues of the newsletter are available on the public website.

SUBTASK 1.3: Special Information Activities

Task 1 developed a PVPS workshop for EUPVSEC in Hamburg, Germany, 7th September 2011. The workshop "Driving Future PV Deployment – Electricity Utility PV Business Models" was regarded as a success, with upward of 80 participants, nine expert presentations (including from the utility sector) and stimulating questions and discussion. Another workshop was developed, in conjunction with Task 9, for PVSEC-21 in Fukuoka, Japan,

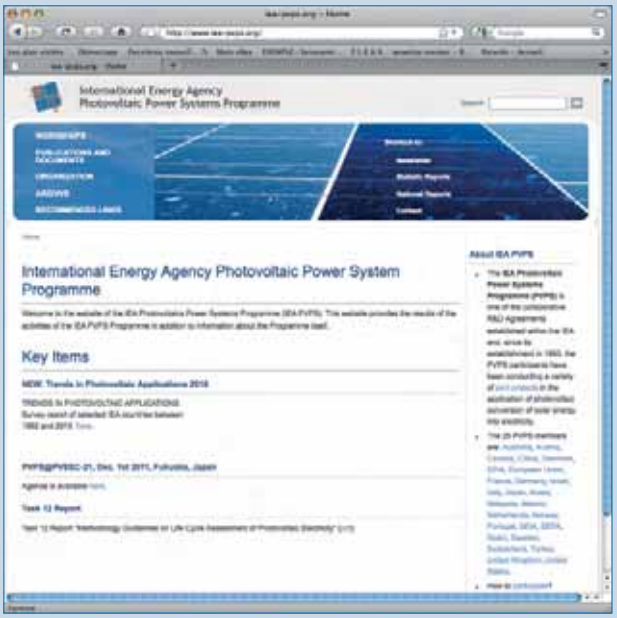

Fig. 4 – The www.iea-pvps.org website provides access to the outputs of the PVPS programme.

1st December 2011. "PVPS@PVSEC-21" was designed to bring delegates the latest information on international PV collaboration and market developments worldwide. All presentations were made available from the PVPS website.

Work commenced on the 'Added Values of PV' activity. A project team comprised of Australian PV Association members is guiding and supervising the study. Four working groups have been established, areas of value suitable for examination are being identified and methodologies are being developed for quantifying selected benefits.

SUMMARY OF TASK 1 ACTIVITIES PLANNED FOR 2012

Task 1 activities will continue to focus on development of quality information products and effective communication mechanisms in support of the PVPS communication strategy. In this context, one-page 'issues grabs' are planned to be introduced as soon as possible and could form the cornerstone of Programme information provision going forward. These require research, writing, design and production, can be printed, electronically distributed and will feature prominently on the website.

SUBTASK 1.1: Status Survey Reports

The deadline for receiving the next National Survey Reports (NSRs) is June 2012. These will all be made available via the public website.

The target date for publication of the 17th 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 from July 2012 and conference papers will also be developed.

SUBTASK 1.2: Newsletter

Items for the newsletter will be based on the results and activities of the IEA PVPS Programme and key policy and programme information from the participating countries. It is planned that PVPower Update will be made available twice yearly, with likely months for publication in 2012 being February and August.

SUBTASK 1.3: Special Information Activities

Work on the Added Values of PV study should be completed and results made available during 2012.

Task 1 (maybe in conjunction with another task and/or others) will develop a workshop for EUPVSEC in Frankfurt, Germany, late September 2012.

Other specific topics that continue to receive attention from the Task 1 group include issues of interest from along the PV industry value chain, the evolution of the global PV market, mapping of electricity utility interests and the non-technical issues (particularly financial, policy and regulatory) associated with large-scale deployment of PV. Eventually some of these may feature in the one-pagers being developed or 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 (2011 AND PLANNED)

The following were published and also made available on the public website during 2011:

Trends in photovoltaic applications in selected IEA countries between 1992 and 2010
Report IEA-PVPS T1-20: 2011 (plus paper and poster at the EUPVSEC conference, paper and presentation at the PVSEC-21 conference).

PVPower Update issues 34 and 35.

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 2012 it is planned to produce the seventeenth issue of the Trends in Photovoltaic Applications report, two PVPower Update issues, and a range of country, workshop and special interest information. The website will continue to be developed during 2012. One-pagers will be developed and published.

MEETING SCHEDULE (2011 AND PLANNED 2012)

The 35th Task 1 meeting was held in Istanbul, Turkey 16-18 February 2011, in conjunction with a national PV workshop.
The 36th Task 1 meeting was held in Amsterdam, The Netherlands, 2–3 September 2011.
The 37th Task 1 meeting will be held in Sweden, 20-21 April 2012.
The 38th Task 1 meeting will be held in Denmark, 21-22 September 2012

TASK 1 PARTICIPANTS IN 2011 AND THEIR ORGANIZATIONS

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

COUNTRY	NAME	ORGANISATION
Australia	Greg Watt	Australian PV Association
Austria	Hubert Fechner	University of Applied Sciences, Technikum Wien
Canada	Josef Ayoub	Natural Resources Canada
China	Lv Fang	Electrical Engineering Institute, Chinese Academy of Sciences
Denmark	Peter Ahm	PA Energy A/S
France	Yvonnick Durand	ADEME
European Photovoltaic Industry Association	Gaëtan Masson	EPIA
European Union	Pietro Menna	European Commission, Directorate General for Energy
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer	Ben-Gurion National Solar Energy Centre
Israel	Roxana Dann	Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	RSE SpA
Japan	Osamu Ikki	RTS Corporation
Japan	Izumi Kaizuka	RTS Corporation
Japan	Akiko Murata	RTS Corporation
Korea	Kyung-Hoon Yoon	KIER
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	Adam Hultqvist	Uppsala University
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

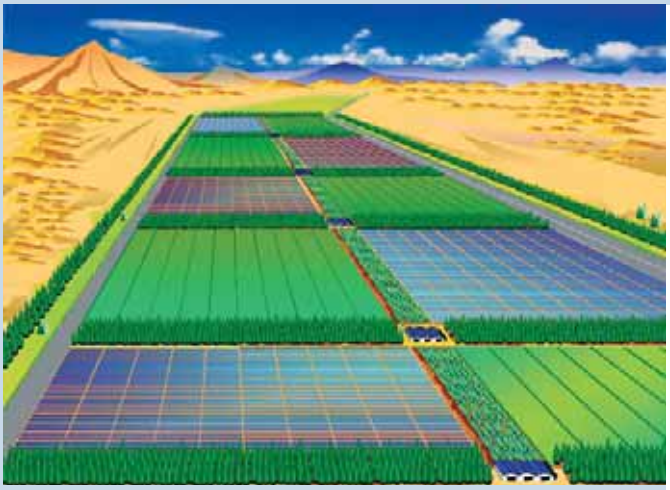

Fig.1 - Image of a VLS-PV System in a Desert Area.

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.

During the past 10 years, MW-scale PV systems have been increasing substantially in the world and 100 MW-scale PV systems are becoming a reality. Further realistic discussions and plans of over 100 MW-scale and GW-scale PV systems are going on in some regions. However, to accelerate and implement real VLS-PV projects, decision-makers should be informed in an appropriate manner on the feasibility of such projects, in and around desert regions.

Our study has comprehensively analysed all major issues involved in such large scale applications, based on the latest scientific and technological developments and by means of close international co-operation with experts from different countries.

Under a three-year Workplan during 2009-2011, three Subtasks were organised:

- Subtask 2: Case studies for selected regions for installation of VLS-PV system on deserts
- Subtask 5: General instruction for practical project proposals to realize VLS-PV systems in the future
- Subtask 6: Future technical options for realizing VLS-PV systems

SUMMARY OF TASK 8 ACCOMPLISHMENTS FOR 2011

During 2011, Task 8 concentrated on drafting a technical report as an integrated result of the three year Workplan for 2009-2011. Each Subtask developed various kinds of outcomes by effective interactions. The draft manuscripts have been developed and the report should be published in 2012. In parallel, Task 8 performed dissemination events 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, as well as other results obtained in the previous phases, case studies on VLS-PV systems for the selected regions are undertaken and the effects, benefits and environmental impacts of VLS-PV systems are discussed. Feasibility and potential of VLS-PV on deserts are evaluated from local and global aspect viewpoints.

The following case studies have been carried out and drafted as the report:

- Environmental aspects of VLS-PV: life-cycle analysis, ecological footprint
- Global potential of solar energy
- Trends and comparison of large scale solar energy technologies

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

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

Detailed practical instructions for implementing VLS-PV projects in the future are discussed. Employing the results obtained in the previous phases, financial and institutional scenarios are further discussed, and the guidelines for practical project proposals are developed.

The following items have been discussed and drafted as the report:

- Engineering and financial guideline for VLS-PV systems
- Possible contribution of VLS-PV to sustainability
- Implementation strategies for VLS-PV policies

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

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

The following items have been discussed and drafted as the report:

- VLS-PV into the grid
- VLS-PV intermittence and stationary storage for VLS-PV
- PV and wind based renewable power methane

OTHER ACTIVITIES

Contribution to the International Conferences

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

- 26th EU-PVSEC in Hamburg, Germany (September 2011)
- ADB seminar in Tokyo, Japan (November 2011)
- IRENA/NREL workshop in Golden, Colorado, USA (November 2011)

Fig. 2 - 25th Task 8 Meeting in Eindhoven, the Netherlands, May 2011.

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2012

Publication of the Technical Report

The final draft of the Task 8 activity based on the current Workplan (2009-2011) has been drafted and is tentatively entitled, "Energy from the Desert: Very Large Scale PV Power - State-of-the-Art and into the Future". The report should be published in 2012.

Starting Up the Extended Task 8 Activity

Based on our previous results and changing market environment, Task 8 will start extended activities under its new Workplan. Through active dissemination and communication with stakeholders, suggestions/recommendations/drafts on how to overcome hurdles/barriers, from technical and non-technical viewpoints, shall be proposed to accomplish the Task 8 activity.

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)
Book: "Energy from the desert: Very Large Scale PV power - state-of-the-art and into the future", (to be published in 2012)

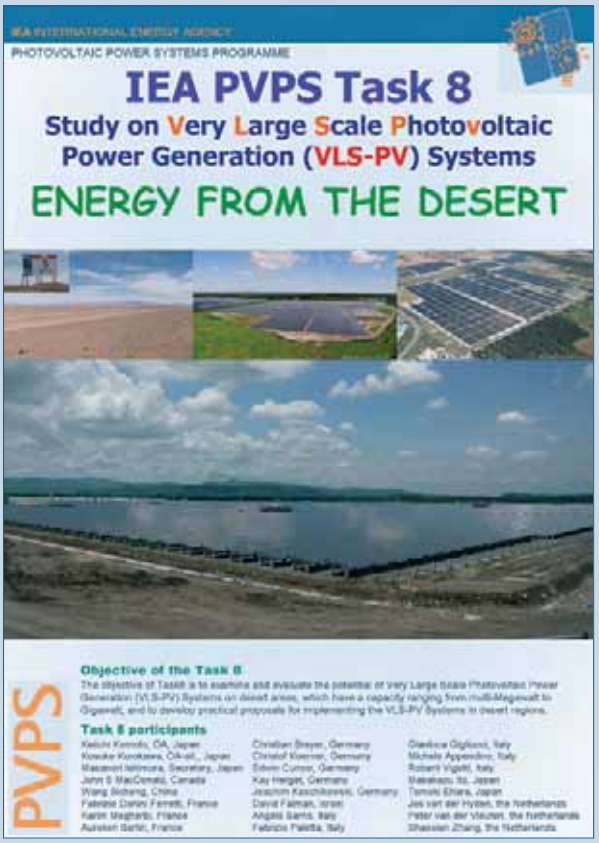

Fig. 3 – Task 8 poster prepared for 26th EU-PVSEC in Hamburg, Germany, 2011.

MEETING SCHEDULE [2011 AND PLANNED 2012]

The 25th Task 8 Meeting was held in Eindhoven, the Netherlands, 5-6 May 2011.
The 26th Task 8 Meeting was held in Rome, Italy, 12-13 September 2011.
The 27th Task 8 Meeting will be held in Madrid, Spain, 19-20 April 2012.
The 28th Task 8 Meeting will be held in Germany, September 2012.

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
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USA	Herb Hayden	Southwest Solar Technologies, Inc.
Mongolia (observer)	Namjil Enebish	National Renewable Energy Center

TASK 9 – DEPLOYING PV SERVICES FOR REGIONAL DEVELOPMENT

Fig. 1 - ADB ASEF Maldives Workshop: 3rd ASEF Meeting in Bangkok, Thailand - ADB South Asia Department of Maldives on Hybrids - June 2011.

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, drinking water, health (refrigeration, lighting, etc., "pico PV services" (highly efficient integrated appliances for lighting and ICT needs), and on relevant business models for deployment. The results of this work will be integrated in the dissemination process.

SUMMARY OF TASK 9 ACTIVITIES

MDG AND DEVELOPMENT RELATED WORK	INTEGRATION OF PV IN ENERGY SYSTEMS
1. PV Water pumping 2. Pico PV Services 3. PV and Health	4. PVPS technical work (Hybrids, BIPV, VLS PV) & secretariat
5. Innovative business models ans financing mechanisms 6. Deployment and outreach: partnerships with megaphones	

Fig. 2 – IEA PVPS Task 9's activities.

SUBTASK 1: PV for Water Pumping

Water is an increasingly scarce resource and harnessing and using it efficiently is of central importance. PV offers this possibility, and is often the least cost option on a life cycle basis, albeit burdened with high upfront costs. 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.

- A position paper on "Policy Recommendations to Improve the Sustainability of Rural Water Supply Systems" has been finalized and is about to be published.
- The paper has been presented by Task 9 during a half day seminar in the frame of the 6th Rural Water Supply Network Forum, Kampala, Uganda, (November 29 to December 1, 2011)
- A compendium of lessons learnt / case studies on the Japanese and African experience will be added to the paper.

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

Fig. 3 - 25th Task 9 Experts' Meeting, December 2011, Fukuoka, Japan - Traditional Dinner.

Fig. 4 - Hybrid PV-Diesel Power Station, Ouélésséébougou, Mali - 2011.

(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. WHO and UNICEF are open to collaboration with IEA PVPS. However, the framework of collaboration is still under discussion within Task 9.

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.

- A concept paper on the paradigm change in Pico PV services including a SWOT analysis is being prepared by Task 9 Experts. The issue of the maintenance will be also taken into account.

SUBTASK 4: Disseminating PVPS Technical Work: Hybrids, PV in the Urban Environment, Large Scale PV, High Penetration PV in Grids

The idea of this Subtask is to produce documents, flyer, 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.

PV and Mini-grids / Hybrids

- Task 9 has capitalised on the work done by Task 11 for the organisation of two training workshops on PV-Diesel Hybrids system for rural electrification for the CLUB-ER (Club of African agencies and structure in charge of Rural electrification) in Nairobi and Mali where T11 work has been used as training material.
- Since there is still a lot of interest on the subject in the developing regions and at the same time the economics and designing issues are evolving, an update of the Task 9 publication "PV Injection in Isolated diesel Grids" with the support of case studies from China and Japan will be prepared by the Task 9.

PV in Urban Environment

Concerning PV and Mini-Grids / Hybrids, there is a lot of interest from the developing regions on PV in urban environment; as economics are changing, design and technology issues are evolving. A lot of initiatives are taking place concerning the development of "Green Cities" as also showed by the Workshop organised by the Turkish PV Technology Platform in Turkey on "Photovoltaics for Solar Cities" in which Task 9 took part.

- Task 9 is currently preparing a concept note trying to capitalise on the book edited by PVPS Task 10 on the subject and complete with case studies from Turkey, Japan, Thailand and Malaysia; possibly leading to the drafting of a flyer.

SUBTASK 5: Innovative Business Models

With current technical evolutions including electronics and cost reduction, trends in urban development and viable business models for PV application, Task 9 is looking into financing, management, capacity building issues which are all evolving very fast. Switzerland, with the contribution of the Netherlands, will try to develop various business models which can serve as a basis for PV deployment in emerging regions.

SUBTASK 6: Deployment and Outreach

This Subtask is the operating arm to establish partnerships with regional organizations, countries, development bodies, etc. During 2011, focus has been placed on Asia, with a very positive collaboration the Asian Development Bank (ADB). First collaboration with the Club of African Rural Electrification Agencies (Club ER) – a club of 25 African countries –, has also been initiated. Collaboration with other "megaphones," such as Asean Center of Energy (ACE), ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the African Development Bank (AfDB), will be explored in 2012. However, since 2011 has been marked by the substantive work done for the Asean Solar Energy Initiative of the ADB, 2012 will see an increased effort in developing partnerships with selected African Megaphones.

Collaboration with Asia:

- IEA PVPS has become one of the Asean Solar Energy Forum (ASEF)'s knowledge partners, contributing the work of the various PVPS tasks and presenting the solutions developed by industry of the member countries of PVPS. As a forum, in the framework of the ADB's Solar Energy Initiative (ASEI), ASEF represents an important bridge between suppliers and developers, a knowledge hub for the public and private sectors,

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Japan	Hiroyuki Watanabe	Japan Photovoltaic Energy Association (JPEA)
Japan	Masanori Ishimura	NEDO (National Contact)
Japan	Atsuhiko KIBA	NEDO (National Contact)
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Netherlands	Johannes Krens	Introvation
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Switzerland	Thomas Meier	ENTEC
Switzerland	Alex Arter	ENTEC
ARE	Simon Rolland	Alliance for Rural Electrification
EPIA	Eleni Despotou	European Photovoltaic Industry Association

- *Sweden and China joined Task 9 in 2011.*
- *Germany, through the Fraunhofer Institute will join Task 9 in 2012.*

supporting the development of local solar energy competence in the developing countries of Asia and the Pacific and international business partnerships. The scope of the initiative ranges from large scale multi MW grid connected power plants, to SHS and pico PV systems for remote communities and including PV integration in the urban environment as well as mini (hybrid) grids for island and isolated communities. It also addresses smart grid applications.

- Partnership with Asia had started in 2010 with the participation of Task 9 experts to the first and second ASEF in Manila and Tokyo. In January 2011, Task 9 participated to the Gujarat (India) conference for the launching of 500 MW solar park. In June, Task 9 experts took part in the 3rd ASEF Meeting in Bangkok, Thailand with the participation to the plenary session as well as to the two side workshops organized by the ADB South Asia Department for 500MW Off Grid / On Grid Project in Bangladesh and by the ADB South Asia Department of Maldives on hybrids.
- In December, a joint workshop within the 21st Asia PVSEC in Fukuoka, Japan, has also been organized by PVPS Task 9 and Task 1.

Collaboration with Africa:

- In February 2011, Task 9 participated in the Workshop on the "Potential for PV Electricity in Sub-Saharan Africa," organized by the Danish Cooperation Agency, DANIDA.
- As mentioned in the Subtask 4, Task 9 has also started its collaboration with the Club ER through the organization of two training sessions in Bamako (Mali) and Nairobi (Kenya) respectively in July and November 2011 on PV-diesel hybrid systems.

There is an interest from the CLUB-ER to pursue the collaboration with the PVPS. In particular, the Club-ER is organising a conference alongside its General Assembly and is seeking the participation of the PVPS for the animation of the part of the workshop concerned with PV issues. The event should take place in Abidjan in October 2012.

KEY DELIVERABLES FOR 2012

- Position Paper on PV Water pumping
- Flyer on Pico PV Services
- Draft Case studies on PV deployment in the urban environment
- Partnership agreement with a Regional organization in Africa

CONFERENCES AND WORKSHOPS FOR 2012 (ALREADY CONSIDERED)

- October 2012: CLUB-ER Conference on renewable energies, Abidjan (Côte d'Ivoire)
- November 2012: ARE Conference on Access to Energy and off-grid solution, TBA

TASK 9 MEETING SCHEDULE (2011 AND PLANNED 2012)

2011

24th Experts' Meeting, 4 February 2011, Copenhagen, Denmark.
25th Experts' Meeting, 1-2 December 2011, Fukuoka, Japan.

2012

26th Experts' Meeting, 26-27 April 2012, Stockholm, Sweden.
27th Experts' Meeting, October 2012, Abidjan, Côte d'Ivoire.

TASK 11 – HYBRID SYSTEMS WITHIN MINI-GRIDS

Fig. 1 - The Aurora Sky Station in Abisko, north of the arctic circle in Sweden is off-grid and powered by a wind-PV hybrid, which has lately been upgraded by Teroc AB. Here the station and the wind turbine is seen with a green Aurora Borealis in the background (Photo published with permission by Lights Over Lapland photographer Chad Blakley; www.lightsoverlapland.com).

In the Aurora Sky Station, energy is used very efficiently by LED lamps etc., so a small hybrid system based on 12 V nominal battery voltage is sufficient. Most loads are 12 V DC, plus a small inverter covers some 230 V AC loads. The SVIAB wind turbine is rated 750 W and the solar PV capacity is 200 W. Excess wind energy is used for heating.

INTRODUCTION

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

TASK 11 STRATEGY AND ORGANIZATION

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

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

SUBTASK 10: Design Issues

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

- Review, analysis and documentation of current hybrid mini-grid system architectures;
- Evaluation and comparison of software based design tools for PV hybrid systems and mini-grids;
- Documentation of best practices for design, operation, and maintenance of PV hybrid projects.

Fig. 2 – Remote hamlet near Manresa (Spain). Three households. Aggregate demand: 12 kWh/day. Solar fraction: 95 %. PV generator capacity (STC): 5760 Wp. Battery Rated Capacity: 72 kWh. Battery Charge controller: 2 X 60A (MPPT). Inverter Capacity: 2 X 3500 VA. Electricity Dispensers: 3 (Photo: TTA (Trama Tecno Ambiental).

SUBTASK 20: Control Issues

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

- Investigation of existing methods for stabilizing voltage and frequency in mini-grids and recommendations for further development;
- Investigation of data communication architectures and protocols for mini-grids;
- Evaluation of supervisory control parameters and strategies for mini-grids;
- Evaluation of the role of energy storage technologies to stabilize mini-grid operation;
- Investigation of technical issues associated with autonomous and interconnected operation of mini-grids and a main utility grid.

SUBTASK 30: PV Penetration in Mini-Grids

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

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

SUBTASK 40: Sustainability Conditions

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

- Documentation of field experience and learning that demonstrate the social and political framework for successful operation of PV hybrid systems within mini-grids;
- Evaluation of the financial aspects of PV hybrid power systems, considering both first costs and operating costs, and determining the conditions for economic sustainability;
- Evaluation of the environmental impacts and benefits of PV hybrid systems with focus on greenhouse gas emission mitigation and potential for recycling of system components.

PROGRESS IN 2011

Task 11 completed the majority of its Workplan in 2011. The following deliverable reports were published, or approved for publication, in 2011:

1	World-wide 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

Another four deliverable reports are in the final draft stage and should be published in 2012.

Other dissemination work also progressed in 2011, with Task 11 Experts presenting results from Task 11 at workshops in Brazil and Thailand.

PLANS FOR 2012

Task 11 plans to publish its remaining deliverable reports in the first half of 2012. Task 11 will also be active at the 6th European PV Hybrid and Mini-Grid Conference in Chambery, France on 26/27 April. 2012. A summary of Task 11 results will be presented

Fig. 3 - PV hybrid system in Kerapa Spak, Malaysia. 21,60 kWp. 3 Sunny Island 5048, 1 Multicluster-Box, 4 Sunny Boy 5000TL (Photo: SMA Solar Technology AG).

to Conference attendees and the Task will convene a meeting to define a possible successor IEA PVPS Task to carry forward work on autonomous PV systems and mini-grids. At that point, Task 11 will complete its work.

PUBLICATIONS AND DELIVERABLE ITEMS

Task 11 deliverable reports are 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.

TASK 11 PARTICIPANTS

As of the end of 2011, the following IEA PVPS countries are participating in Task 1l - PV Hybrids in Mini-Grids: Australia, Austria, Canada, China, France, Germany, Italy, Japan, Malaysia, Spain, and the USA. The management of the Task - the Operating Agent - is being executed by Canada. The national contacts of IEA PVPS Task 11 are listed in Table 1.

MEETING SCHEDULE (2011 AND 2012 PLANNED)

Task 11 had its final Experts Meeting on 7-8 April, 2011 in Chambery, France.

Task 11 will host the meeting to define a possible successor IEA PVPS Task in Chambery, France on 25 April, 2012 in advance of the 6th European PV Hybrid and Mini-Grid Conference.

TABLE 1 – TASK 11 PARTICIPANTS AND THEIR ORGANISATION

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TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

INTRODUCTION

The growth of the PV market is based on the promise of environmentally-friendly energy generation, and is sustained by the support of the environmentally-conscious public. Without such support the industry cannot grow to levels that would enable PV to reach generation cost competitiveness and become a mainstream source of electricity. Furthermore, continuing diligence on environmental, 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 goal of Task 12 is to foster international collaboration in the area of photovoltaic sustainability and to compile and disseminate reliable environmental, health, and safety (EH&S) information associated with the life-cycle of photovoltaic technologies to the public and policy-makers. Accurate information regarding the environmental benefits of photovoltaic technologies builds consumer confidence, as well as policy-maker support, thus improving demand. On the supply-side, environment, health, and safety initiatives set standards for sustainability and social responsibility for manufacturers and suppliers, thus improving the solar electric supply-chain.

The overall objectives of Task 12 are to:

1. Quantify the environmental profile of PV in comparison to other energy technologies.
2. Help improve the environmental profile of PV by collective action on recycling.
3. Define and address EH&S and sustainability 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 Analysis (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., PVCYCLE). The 3rd objective is addressed by advocating best EH&S practices in PV production facilities 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.

APPROACH

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

This is from the recent Task 12 LCA Methodology Guidelines Report, with a caption showing the required degree of reporting.

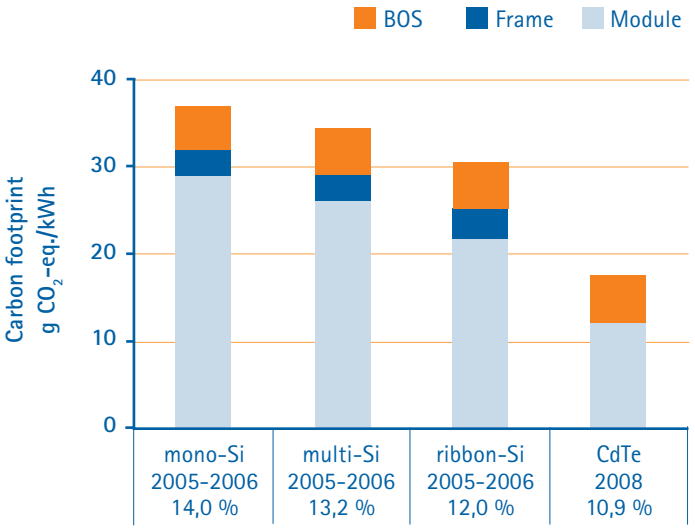

Fig. 1 - Greenhouse gas (GHG) emissions from the life-cycle of rooftop mounted PV systems. The estimates correspond to Southern European irradiation of 1 700 kWh/m²/yr, performance ratio of 0,75 and life expectancies of 30 years with no degradation for either the modules or the BOS. The system includes frames, mounting, cabling, and inverter and excludes maintenance and recycling. This is a static LCA based on European commercial production in 2005. The crystalline-Si LCA was commissioned by the European Crystal Clear program and the CdTe LCA was commissioned by the US-DOE to BNL.

ACCOMPLISHMENTS IN 2011

SUBTASK 1: Life Cycle Assessment

Task 12 participants are engaged in many PV LCA products and they publish and present extensively in this topic. Papers related to Life Cycle Assessment and other environmental aspects can be found at the respective websites of:

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

In addition, Task 12 members completed two IEA reports and contributed to the update of the most commonly used Econinvent LCI data-base.

Fig. 2 - Task 12 Expert meeting in Madrid,Spain, 25th January 2011.

A report on *"Life Cycle Inventories (LCI)"* was published in November 2011.

A report on *"Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity"* was published in December 2011. This document provides guidance regarding technical assumptions related to photovoltaic system LCA, aspects regarding modelling approaches in Life Cycle Inventory, Life Cycle Analysis and Life Cycle Impact Assessment, and requirements for transparency in reporting.

The *Ecoinvent database* is being updated and version 3.0 is planned for publication in June 2012. LCI data have been collected by ECN, BNL, ESU-services Ltd. and industry sources, and were provided to this project.

SUBTASK 2: Recycling of Manufacturing Waste and Spent Modules

Task 12 activities on recycling have been aligned with those of the PVCYCLE program, which includes 196 industry members, representing more than 90 % of the European market. The Experts of Task 12 assisted EPIA and PVCYCLE to host two International Conferences on PV Module Recycling and plan to contribute to the next Conference in early 2013.

SUBTASK 3: Safety in PV Industry

Task 12 members at BNL and SEIA were involved in a number of activities assisting individual PV companies; there were no joint task activities in this area.

SUBTASK 4: EH&S Information Dissemination

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

PLANS FOR 2012

SUBTASK 1: Life Cycle Assessment

- 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: heterojunction solar cells and module technology; organic PV; thin-film PV; concentrator PV; FBR polysilicon production.
- ECN plans a study on external costs, within the framework of the EU project "PV parity" together with EPIA and other institutes.

SUBTASK 2: 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 provides updates on the legislative framework in Europe (WEEE), as well as promotion of best practices.

SUBTASK 3: Safety in PV Industry

This Subtask will be expanded from safety in manufacturing facilities to safety throughout the life-cycle of a PV product, including the safety of solar installers.

- Fire Safety – review of current practices/codes/standards in member countries and promotion of best practices.
- Installer Safety – review of current practices, training, certification adopted by member countries; and promotions of best practices.

2011 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. November 2011. ISBN: 978-3-906042-01-5.
- Life Cycle Inventories and Life Cycle Assessment of Photovoltaic Systems, IEA PVPS Task 12, International Energy Agency Photovoltaic Power Systems Programme. Report T12-02:2011. October 2011. ISBN: 978-3-906042-00-8.

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 Agents:
Vasilis Fthenakis, Brookhaven National Laboratory, email: vmf@bnl.gov
Christine Covington, SEIA, email: CCovington@seia.org

TABLE 1 – TASK 12 PARTICIPANTS

COUNTRY OR SPONSOR MEMBER	ORGANISATION	NAME
Austria	Umweltbundesamt	Werner Polz
EPIA	European Photovoltaic Industry Association	Gaëtan Masson Manoël Rekinger Ioannis-Thomas Theologitis
	PV CYCLE	Jan Clyncke Virginia Gomez
Canada	5N Plus Inc.	Maxime Cossette Marc Suys
France	Centre Energétique et Procédés, MINES ParisTech	Didier Beloin-Saint-Pierre
Germany	LBP Stuttgart University	Michael Held
	Sunicon	Karsten Wambach Sylke Schlenker
	ZSW	Wiltraud Wischmann
Japan	NEDO (Technology Development Organisation)	Ichiro Nakaya
	Kyocera Corporation	Mitsutoshi Hino
	Tokyo Institute of Technology	Masakazu Ito
Norway	ELKEM Solar	Ronny Glockner
		Jan Ove Odden
SEIA	Solar Energy Industry Association USA	Christine Covington
Spain	ESCi (Escola Superior de Comerç Internacional)	Marco Raugei
Switzerland	ESU-Services	Rolf Frischknecht Matthias Stucki
The Netherlands	ECN	Ton Veltkamp (replaced Mariska de Wild-Scholten)
	Raboud University Nijmegen	Nellemieke Mohr
USA	Brookhaven National Laboratory	Prof. Vasilis Fthenakis
	First Solar	Ricky Sinha Andreas Wade

TASK 13 – PERFORMANCE AND RELIABILITY OF PV SYSTEMS

Fig. 1 - Task 13 Expert Meeting at Dead Sea, Israel, 3 - 5 October 2011 (Photo: Thomas Nordmann).

INTRODUCTION

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

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

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

OVERALL OBJECTIVE

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

Task 13 aims at:

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

APPROACH

The PV industry is very interested in information on performance and reliability. Companies which have the required data at their disposal tend, however, to be reluctant to share this information. The project partners aim at meeting this challenge by involving these companies 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.

Fig. 2 - Task 13 experts discussing standardized data plots for PV system performance analysis (Photo: Christian Reise).

Fig. 3 - Task 13 experts during their field trip visiting Ben-Gurion University of the Negev, Sede Boqer Campus, Israel (Photo: Thomas Nordmann).

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.

In 2011 the 'Data Input Tool' was developed and distributed amongst the Task experts and interested third parties. To date 20 datasets from new PV systems plus 55 annual datasets of monitored data have been added to the 445 existing grid-connected PV systems. The interactive 'New PVPS Performance Database' will be available on the Internet from early 2012. The emphasis will be on the comparative evaluation and graphical presentations of groups of PV systems rather than presentation of individual systems.

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 anonymization 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. As a first step, a set of standardised graphical representations was developed. For some 12 PV systems, located in moderate and in tropical climates, these graphs were prepared and discussed during the recent Expert Meeting. It was shown that deficiencies in system component operation and in system overall performance may be detected, understood and explained better than by a simple comparison of monthly yields or PR values.

Based on this experience, further refinements and new graphs will be added to the set of standardized plots. In this way, operational data of a larger number of PV systems will be evaluated in great detail. This again may lead to further improvements in overall system design.

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.

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.

Information on the number and statistical distribution of micro cracks in silicon wafer based PV modules have been collected and published. This information helps PV module manufacturer and experts to judge how many micro cracks are normal in a PV module and which amount or distribution is not acceptable. Furthermore, information on the actual knowledge on snail tracks (an effect correlated to micro cracks) has been collected in Germany and presented to the international press. It has been the first international dissemination of this field relevant topic.

TASK 13 PARTICIPANTS IN 2011 AND THEIR ORGANISATIONS

COUNTRY	ORGANISATION
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	Arava Power Company 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)
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
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 website www.iea-pvps.org

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 Task 13 Technical Papers were published in 2011:

CONTRIBUTIONS TO THE KNOWLEDGE BASE ON PV PERFORMANCE: EVALUATION OF THE OPERATION OF PV SYSTEMS USING DIFFERENT TECHNOLOGIES INSTALLED IN SOUTHERN NORWAY
H.-G. Beyer, Proc. 37th PVSC Seattle, USA, June 2011.

CRACK STATISTICS OF CRYSTALLINE SILICON PHOTOVOLTAIC MODULES
M. Köntges, S. Kajari-Schröder, I. Kunze, U. Jahn, Proc. 26th EU PVSEC, Hamburg, Germany, 2011; 4EO.3.6

FACTORS AFFECTING THE PERFORMANCE OF DIFFERENT THIN-FILM TECHNOLOGIES AND THEIR IMPACT ON THE ENERGY YIELD
M. Schweiger, U. Jahn, W. Herrmann, Proc. 26th EU PVSEC, Hamburg, Germany, 2011

Task 13 will organize a workshop dealing with PV module reliability issues during the EUPVSEC in Frankfurt, Germany, in September 2012.

MEETING SCHEDULE (2011 AND PLANNED 2012)

The 3rd Task 13 Meeting was held in Madrid, Spain, 23 - 25 March 2011.
The 4th Task 13 Meeting took place at the Dead Sea, Israel, 3 - 5 October 2011.
The 5th Task 13 Meeting will be held in Brussels, Belgium, 19 - 21 March 2012.

TASK 14 – HIGH PENETRATION PV IN ELECTRICITY GRIDS

INTRODUCTION

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

Due to the different characteristics of PV compared to other renewable generation in all of these 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 systems, from serving local loads to serving as grid resources for the interconnected transmission and generation system.

Fig. 1 - PV plant connected to HV grid.

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

OVERALL OBJECTIVES

Against this background, Task 14 addresses the role of PV in electricity grid configurations with a high penetration of Renewable Energy Sources (RES), where PV constitutes the main RES. Although up to now, no common definition of "high-penetration PV scenarios" exists, there is common consensus that high penetration situation exists if additional efforts will be necessary to integrate the dispersed generators in an optimum manner.

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

Easy access to the main findings of the reports is expected to mitigate concerns of high penetration PV to the benefit of a large number of countries. By international collaboration, issues relating to the role of PV in the future electricity supply system will be investigated, particularly facing future high-penetration scenarios, which are now becoming reality in a number of locations around the globe.

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 be necessary to integrate the dispersed generators in an optimum manner. The aim of these efforts is to reduce the technical barriers to achieving 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 mainly technical issues with high penetration of PV in electricity networks. Technical issues include energy management aspects, grid interaction and penetration aspects related to local distribution grids and central PV generation scenarios.

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

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

Fig. 2 - Task 14 Experts at Meeting in Lisbon, Portugal.

The work programme is organized into four main Subtasks and one cross-cutting subtask, which will be the link between the main Subtasks.

CROSS-CUTTING SUBTASK: Information Gathering, Analysis and Outreach

The scope of this Subtask is to collect and share state of the art information amongst the various tasks as well 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.

The Task has the following activities:

SUBTASK 1: PV Generation in Correlation to Energy Demand

This Subtask deals with local solutions to increase PV penetration in grids and is coordinated by Switzerland. The objective of the task is to show and determine how with better prediction tools, an optimized local energy management and a better understanding of temporal fluctuation PV penetration level can be improved in grid. Case study will be oriented to demonstrate the feasibility of local high PV penetration in grid (different penetration scenarios and different urban scale in case studies).

Within the Subtask's activities, monitoring and prediction tools will be reviewed and adapted to anticipate the shift in local grid to answer to the prediction need of utilities (interaction on solar resource prediction with IEA SHC's Task 36).

A review of Demand Side Management (DSM) – PV approaches in different countries, including profiling (annual, etc.) will be made. The necessity of storage (options) will be investigated in order to achieve an optimum scale for micro smart grids.

Finally, temporal fluctuations will be characterised in relation to local weather conditions according to the topology of the PV plants to improve short terms predictions.

SUBTASK 2: High PV Penetration in Local Distribution Grids

Subtask 2, coordinated by Germany addresses the Identification and Interpretation of the Role of PV in Distribution Grids and includes an Impact Analyses of high PV penetration in Distribution Grids and concludes with recommendations on grid codes, incentives and regulation.

Fig. 3 - IEA PVPS Task 14 organisation.

Information provided by distribution system operators will be used to review the current state of distribution grids with high PV penetration in a number of case studies. 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, will be reviewed. Leading experts already have developed approaches that will be analyzed with regard to their applicability in other participating countries. On the basis of grid simulations the different impacts on countryspecific grids with high PV penetration will be analyzed. Aspects regarded are voltage stability, losses, component heating and economical impacts. These parameters provide measures to assess the technical effectiveness and economic efficiency of the analyzed approaches of active and reactive power balancing for country-specific distribution grids in an international benchmark.

Case studies of distribution grids in different countries with high PV penetration that have changed to supply grids (at least at certain periods of time reverse power plows) conclude the work in this Subtask.

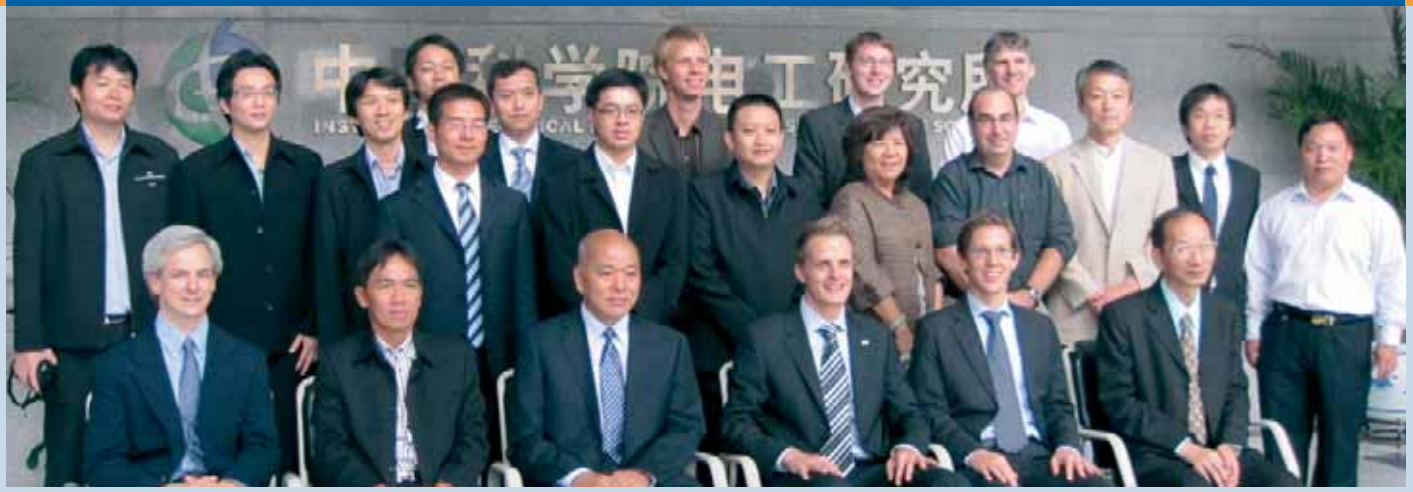

Fig. 4 - Task 14 High Penetration PV Workshop in Beijing, China.

SUBTASK 3: High Penetration Solutions for Central PV Generation Scenarios

Subtask 3 addresses the PV integration into power systems from the total power system view point. In order to realize high PV penetration to a power system, it is crucial to evaluate the impact and envision the future power system. The focus will be laid on grid interaction and penetration related aspects. Gaps in current PV system technology and electric power system operation practices will be identified. Furthermore, detailed analyses, how large numbers of PV installations can be successfully integrated total power system including the technology of smart grids will be made.

Organized in three activities, questions related to system-wide PV generation analysis and forecast, power system operation and augmentation planning with PV integration will be addressed. The work items include a survey and review of existing methodologies to analyze and forecast the system-wide PV Generation focusing on smoothing effects. Existing methodologies for long-term power system operation planning including PV integration and Demand Side Management/Demand Response technologies will be reviewed, in order to develop criteria and scenarios for case studies including applicability of new technologies.

Based on the outcome, simulation case studies of long-term power system operation and augmentation planning for selected regions will be conducted.

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 coordinated by Austria 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.

Current functional, protection, control, safety and other requirements for inverters will be reviewed and the impact of different applications, connection levels and network topologies will be investigated in order to define performance, operating ranges and utility compatibility with high penetration PV.

A collection and review of the suitability of different hardware and control topologies for the application in High PV Penetration scenarios will be made. The impact of additional functionalities on the design, dimensioning and performance of PV inverters will be investigated, aiming at the improvement of available inverter simulation models.

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 2011

In its second period, Task 14 continued the successful series of high penetration workshops with two well received events held in 2011. In May, the Task 14 *Iberian High Penetration PV Utility Workshop*, was hosted by EDP Inovação in Lisbon, Portugal, discussing high PV penetration issues. With about 30 participants from berian utilities, 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, successful examples of high penetration PV projects and the associated challenges from Iberian framework and International framework as well as the USA and Australia.

The second event was organized in October when Task 14 held the *Utility and Research Workshop*, in Beijing, China; hosted by the IEE, Chinese Academy of Science. With more than 40 participants, this event brought together Chinese utilities researchers and industry, and IEA-PVPS Task 14 experts.

Presentations were made on case studies, successful examples of high penetration PV projects and the associated challenges in China (e.g. PV programs, standardization activities).

Task 14 Workshop presentations of both workshops held in 2011 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=154

In Task 14 a collection of pertinent case studies of high penetration PV scenarios in the participating countries was performed. The cases include PV penetration scenarios in local distribution grids as well as from the overall power system wide perspective.

Fig. 5 - 2 MW PV system at U.S. Army Fort Carson, NREL Photographic Information Exchange (Photo: NREL).

In addition the expert group investigated the suitability of Forecast Tools with respect to high penetration PV, linking together weather forecasts, prediction and monitoring tools.

SUMMARY OF TASK 14 ACTIVITIES PLANNED FOR 2012

Task 14 activities in 2012 will focus on the analysis of the collected case studies of high penetration PV scenarios in the participating countries. The objective of this activity is to provide 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.

The focus for 2012 will be the investigation of requirements for PV inverters in terms of protection, control, safety and their impact of different applications, connection levels and network topologies. The result will be a definition of performance, operating ranges and utility compatibility with high penetration PV.

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.

During 2011, Task 14 actively integrated industry by organizing special workshops for knowledge exchange between experts from utilities and the Task 14 group.

PUBLICATIONS AND DELIVERABLES

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

During 2011, Task 14 work was presented at some of the key events, including the paper "Is the Distribution Grid Ready to Accept Large Scale Photovoltaic Deployment? - State of the Art, Progress and Future Prospects," which was presented at the 26th European PVSEC/ WCPEC in Hamburg, September 2011.

Fig. 6 - Integration of PV in electricity grids.

In addition, Task 14 had a poster at the IEA PVPS Workshop, during the European PVSEC in Hamburg, September 2011.

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

- A report describing Forecast Tools with link 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.

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

MEETING SCHEDULE

Recent Meetings:

- April 12-14, 2010: **Kick-Off Meeting**, hosted by AIT, Vienna, Austria
- December 2-4, 2010: **2nd Experts Meeting and Utility workshop**, hosted by NREL, Golden, CA, U.S.A.
- May 11-13, 2011: **3rd Experts Meeting**, hosted by EDP, Lisbon, Portugal
- October 10-12, 2011: **4th Experts Meeting**, hosted by Chinese Academy of Science, Beijing, China

2012 Meetings (Planned):

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

TABLE 1 – LIST OF TASK 14 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Australia	Ian McGill	University of NSW
Australia	Glenn Platt	CSIRO Energy Technology, Australia
Austria	Roland Bründlinger	AIT - ÖFPZ Arsenal GmbH
Austria	Christoph Mayr	AIT - ÖFPZ Arsenal GmbH
Belgium (observer)	Karel Debrabandere	3E
Canada	Ravi Seethapathy	Hydro One, Ontario
Canada	Andrew Swingler	Schneider Electric
Canada	Dave Turcotte	Natural Resources Canada
Canada	Sophie Pelland	Natural Resources Canada
China	Yibo Wang	Chinese Academy of Science, IEE
Denmark	Kenn H.B. Frederiksen	EnergiMidt A/S
Germany	Martin Braun	Fraunhofer IWES
Germany	Thomas Stetz	Fraunhofer IWES
Germany	Gunther Arnold	Fraunhofer IWES
Germany	Daniel Premm	SMA Solar Technology
Israel	Moshe Ohayon	Israel Electrical Company
Italy	Giorgio Graditi	ENEA
Italy	Iaria Adriano	RSE - Ricerca sul Sistema Energetico.
Japan	Noriyuki Kawana	NEDO
Japan	Kazuhiko Ogimoto	The University of Tokyo
Japan	Hiroshi Takemoto	New Energy and Industrial Technology Development Organization (NEDO)
Portugal	Catarina Calhau	EDP Inovação, S.A.
Portugal	Joao Maciel	EDP - Energias de Portugal
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Antonis Marinopoulos	ABB Corporate Research
Switzerland	Lionel Perret	Planair SA, Switzerland
Switzerland	Jan Remund	Meteotest
Switzerland	Pierre Renaud	Planair SA, Switzerland
USA	Julia Hamm	SEPA

AUSTRALIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DR MURIEL WATT, IT POWER AUSTRALIA

Fig. 1 - 120 kW PV system at Newman Airport, Pilbara, WA, using First Solar modules and installed by Commsolar (Photo: Commsolar).

GENERAL FRAMEWORK AND IMPLEMENTATION

The Australian PV market grew rapidly in the first half of 2011, in response to State Government feed-in tariffs and the Australian Government Renewable Energy Target (RET) mechanism. Streamlined system delivery and installation, combined with continued module price drops and a high Australian dollar exchange rate, saw local installed system prices drop from an average of around 6 AUD to around 4 AUD/Wp. At this price, and with rapidly increasing grid electricity prices, PV has reached grid parity against residential systems in many parts of Australia.

The rapid uptake, however, resulted in a curtailment or reduction of some feed-in tariffs and a reduction in RET support. High penetration levels in some areas also resulted in installation restrictions being imposed by the electricity network operators.

As feed-in tariffs are reduced or removed, electricity retailers are not reverting to the net metering arrangements that previously applied. Hence, although grid parity has been reached, there is little or no incentive for systems to feed excess power back into the grid. This is restricting system sizes and increasing interest in storage and energy self-sufficiency – concepts familiar in off-grid applications.

Electricity prices are expected to continue to rise over the next few years, and a carbon price will be introduced from mid 2012, starting at 23 AUD/$tCO_{2\text{-}eq}$. Hence the market for PV will remain strong and increased emphasis will now be placed on grid integration issues.

NATIONAL PROGRAMME

The main support for PV at a national level is the Renewable Energy Target. Support for large systems is via the Large-scale Renewable Energy Target 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 the Small-scale Renewable Energy Scheme. Systems up to 1,5 kW (20 kW off-grid) are eligible to create Solar Credits based on a multiple of Small-scale Technology Certificates (STCs) per MWh, according to the schedule shown below. In addition, all PV systems up to 100 kW are 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 act as an up-front capital cost reduction.

Various State and Territory based feed-in tariffs were also available in 2011.

YEAR	2011-12	2012-13	2013 ONWARDS AND > 1,5 KW OR > 20 KW OFF-GRID
STCs/MWh	3	2	1

Fig. 2 - 43 kW PV array on the Australian Parliament House, Canberra using Silex Solar PV panels installed by Todae Solar (Photo: Todae Solar).

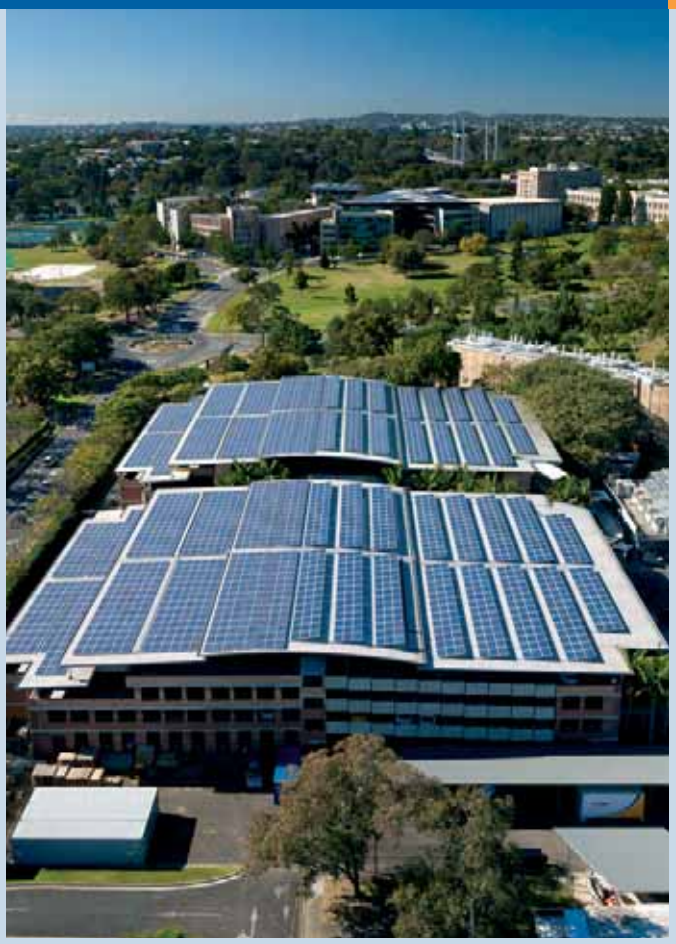

Fig. 3 - St Lucia 1,22 MW PV System University of Queensland using Trina modules and installed by Ingenero (Photo: University of Queensland).

RESEARCH, DEVELOPMENT & DEMONSTRATION

PV research, development and demonstration are supported at the national, as well as the State and Territory levels. Research grants are available through the Australian Research Council and the Australian Solar Institute. The latter invested over 4 MAUD in 2011 on PV research ranging from 3rd generation and organic solar cells to forecasting and grid integration of PV. Industry funding for technology development and demonstration was also available through the Australian Centre for Renewable Energy and the Solar Flagships programme. Consortia have been short-listed for the Round 1 Flagship grants to construct a 150 MW PV array. The system is expected to be operational by 2013.

In 2011 the Australian Government launched its Clean Energy Initiative, which will see all R&D support for renewables placed under the Australian Renewable Energy Agency (ARENA) from 2012. A new Clean Energy Finance Corporation will also be established. At State and Territory level, a number of large systems have been supported in 2011. The Queensland Government provided support towards a 1,22 MW flat panel PV array which was installed at The University of Queensland's St Lucia Campus in Brisbane. This is currently the largest flat panel PV array in Australia, and is to be used primarily for research purposes, with a number of projects planned for 2012, focusing on storage, shading, soiling and anti-reflective coatings. The system will produce ~ 1,8 GWh of energy per annum and meet ~ 5 % of the St Lucia campus peak load.

INDUSTRY AND MARKET DEVELOPMENT

After two years of rapid growth, the industry consolidated significantly in the second half of 2011, as support programs wound back. By the end of the year, many companies, even those with years of experience, were struggling to survive the slow market and the low prices. Local PV cell and module production has now ceased. Rapid uptake, and an increase in new installation companies, resulted in State and Federal governments instigating a series of PV inspection programs. These are serving to ensure component and installation standards are maintained. Specialist information on PV in cyclone areas and for groups such as fire-fighters is now available. Several PV standards are being revised in line with product developments and international standards.

An estimated 780 MW was installed in 2011, mainly in small-scale residential systems. The market in 2012 is likely to be lower than it was in 2011, with a further reduction in the Solar Credit multiplier planned for mid-year, although feed-in tariffs remain in some States. There is increased interest in commercial applications, with this sector also experiencing high electricity price rises, particularly daytime rates.

Larger-scale installations will be more prominent from 2012, with large systems due to come on line in several States, and installation of the 150 MW Solar Flagship system commencing. In Western Australia, First Solar has already started construction on the largest PV installation to date in Australia, the 10 MWac Greenough River project on an 80 hectare site, 50 km southeast of Geraldton, WA, assisted by WA State Government funding.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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Fig. 1 - A proven steel solution for mounting PV modules (Photo: © Welser Profile).

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

The Austrian photovoltaic industry, active in many different areas of the whole value chain is well established and clearly oriented to the global market. Therefore, the number of employees in the total PV business is increasing significantly. The market is continuously rising, having doubled the annual installations for a third time in a row.

Differently to most other PV supporting countries, Austria has mainly three levels of supporting PV systems, the feed-in-tariff system will only be responsible for one part of the supported PV systems in Austria, investment support systems are well established on federal and regional level as well.

- Feed-in Tariff is provided via the national green-electricity act (GEA), firstly issued in 2002, and meanwhile revised several times. Even though the "new RES" are supported by this act mainly via up to 13 years guaranteed feed-in tariffs, the financial cap in 2011 was raised from 2,1 MEUR to 8 MEUR. For the first time, a clear target is fixed in the law, with 1,2 GW installed in 2020, which would mean approximately 2 % of the electricity consumption in that year. 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. Not only this increase for the future PV budget was fixed, but also the applicants on the waiting list reaching up to 2023, received an offer to build the system immediately, but with less financial support.
- Systems up to 5 kW are supported by the governmental Austrian Climate and Energy Fund. This public initiative, launched once a year, will support only small systems (private households) and was opened for the first time in August 2008 by one tender with a total budget of about 10 MEUR. In 2009, the budget was 18 MEUR, leading to about 7-8 MW, of which part was installed in 2009 and part in 2010, of PV installations. In 2010 and 2011 35 MEUR might have led to an estimated 20-25 MW of installations since the support per kW installation was reduced significantly according to the lower PV prices. This support scheme provides additional financial benefits to building integrated systems (BIPV).
- Additionally, some regions provide PV support budgets as well.

At the end of 2010, about 96 MW were installed in Austria. The Austrian Photovoltaic Association which announced 8 % of total Electricity by PV to be realized until 2020, expects doubling the market in 2011 by another 80 -100 MW installations in 2011. At the end of 2011, about 0,2 % of the total electricity might have been provided by photovoltaics.

RESEARCH AND DEVELOPMENT

The National PV Technology Platform, founded in September 2008 along with the 6th Austrian PV Conference, experienced a very good development in 2010: by support of the Ministry of Transport, Innovation and Technology, a financial basis provided more backing in order to achieve the following targets: The PV Technology Platform brings together about 30 leading Austrian PV industries, Universities and Research Institutes in order to boost innovation, to start R&D collaborations as well as to generally discuss their needs for a long term strategy towards an international competitive positioning on the growing world market. Creating awareness amongst the relevant stakeholders aiming at further improving the frame conditions for manufacturing and innovation in Austria is a further important target. At the end of 2010, about 4 400 employees were working in the PV industry in Austria. This technology platform is coordinated by the University of Applied Sciences Technikum Vienna.

For many years, the Austrian PV research activities have been 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, which is now transferred to the new ISGAN Implementing Agreement. The RTD development and approach is widespread located and decentralised orientated.

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

On the European level, the initiatives to increase the coherence of European PV RTD programming (PV-ERA-NET, the planned SOLAR ERA-Net as well as PV relevant activities within Smart Grid ERA

Fig. 2 - Web handling of a Roll-to-Roll tool for thermal treatment of thin film on flexible substrate (Photo: Ebner Industrieofenbau Ges.m.b.H.).

Net) is actively supported by the Austrian Ministry of Transport, Innovation and Technology.
PV becomes more and more a driver for the further smart grid development within the electricity network-operators of Austria. Some model regions are just about to start operation with high penetration of PV in electricity networks. The utility of Salzburg, the upper Austrian Energie AG, as well as the network operator of Vorarlberg, are currently leading this topic and have established Smart Grids Demo-regions; frequently with photovoltaics as one of the core elements.

The Austrian Ministry of Transport, Innovation and Technology is coordinating this topic by means of official multilateral cooperation, engagement in European and international networks, as well as by organising international events such as the Smart Grids Week, which takes place on an annual basis at locations where an intelligent integration of renewable electricity generation into networks is demonstrated.

Research Highlights of Photovoltaic in Austria are:

- The AIT Energy Department focuses on the strategic research fields "Electrical Infrastructure" and "Energy for the Built Environment." The integration of PV into Smart Electricity Networks is in the centre of research efforts in the field of distributed energy resources (DER). Low and high voltage technology, power quality, safety and reliability analysis are investigated. In 2012, an extensive laboratory infrastructure for high power testing of DER will be developed. Since 2003, AIT Energy runs a fully fledged Photovoltaic Module Test Laboratory, accredited according to EN 17025, for R&D on crystalline and thin-film modules. With this background, research focuses on new PV technologies, advanced experimental investigation, characterisation and modelling of PV modules, cells and systems. Regarding PV performance, the simulation of system output and life-cycle testing as well as building-integrated PV systems (BIPV) are addressed. On a European level, AIT Energy is participating in the DERlab, in projects such as METAPV and EcoGRID, as well as in the EU infrastructure projects DERri and SOPHIA; offering access to its research infrastructures in the areas PV, inverter and power technologies. On an international level, AIT Energy is engaged in national and international standardisation for distributed generation and PV systems.
  It takes part in several IEA PVPS activities, such as Task 13 (Performance and Reliability of Photovoltaic Systems), and holds the lead in Task 14 (High Penetration of PV Systems in Electricity Grids).
- The Christian Doppler Laboratory at the **University of Salzburg** "Applications of Sulfosalts in Energy Conversion" installed a new method to grow single sulfosalt crystals using melt solution growth and a new photoacoustic spectroscopy system for semiconductor band gap determination. The improvement of solar cell efficiencies by use of buffer layers was investigated and sulfosalt candidates with high Seebeck coefficients combined with high electrical conductivity for applications in thermoelectrical energy conversion were identified.
- In the Christian Doppler Laboratory for Nanocomposite Solar Cells scientists of **Graz University of Technology** and NanoTecCenter Weiz Forschungsgesellschaft are working in cooperation with the industry partner ISOVOLTAIC AG on new nanostructured materials for flexible organic based photovoltaic modules which can be fabricated with roll-to-roll processing technologies.
- Due to the intensive investigation of thin-film Organic Solar Cells at the Johannes Kepler University, **Konarka Technologies**, a US-based PV-company is operating a Research and Development centre in Linz.
- Ofi - **Austrian Research Institute for Chemistry and Technology** - started research work in the field of PV-material characterisation and studies on the ageing behaviour of PV-modules and materials in 2009. The focus of the PV activities is set on (accelerated) ageing tests - including the influence of air pollutants - on PV modules and on polymeric materials/composites used for module production. The application of non destructive methods for the chemical, physical and optical characterisation of PV-modules and materials during production and operation is a key issue. With innovative and highly sensitive analytical tools, material incompatibilities and their influence on module performance are investigated in line with the aims of the IEA PVPS Task 13.
- **Vienna University of Technology**, Energy Economics Group (EEG), major topics of teaching and research on Photovoltaics: diffusion of technology and market penetration on national and international level, non technical obstacles and supporting factors for diffusion of technology (e.g. socio-economic impact parameters), energy policy design and political economy effects of PV, PV integration in buildings as well as medium and long term diffusion scenarios of PV.
- At the Energybase, the largest passive solar office building in Austria, the **University of Applied Sciences Technikum Vienna** offers Bachelor- and Master Programmes with a strong focus on PV and other solar technologies. Research at the University Institute is focused on PV strategies, smart grids as well as on system- and building integration.

- The **Austria Solar Innovation Center** (ASIC) covers consultation for PV, as well as teaching and training in collaboration with the Upper Austria University of Applied Sciences, degree programme Eco-Energy Engineering (BSc, MSc). Students have lectures and laboratory classes where also the 17 kWp PV system – 5 different module types, 5 different inverter types, 2 monitoring/data logging systems, meteorological station – is used for practice.
- The **Institute of Polymeric Materials and Testing (IPMT) at the Johannes Kepler University Linz (JKU)** established the science-driven research project platform SolPol (Solar Energy Systems based on Polymeric Materials). The platform's main aim is to foster and strengthen the worldwide position of the Austrian solar industry by novel polymer based product developments and innovations. Within the collaborative, industrial research project SolPol-3 (funded by the Austrian Climate and Energy Fund) novel polymeric encapsulation materials for rigid and flexible photovoltaic (PV) modules with improved service performance, but reduced material and processing costs are developed. JKU-IPMT is participating in IEA PVPS Task13 providing advanced methods and know how on the performance characterization of encapsulation materials for PV modules.
- The Polymer Competence Center Leoben (PCCL) is working in the field of polymeric encapsulation materials for solar cell and PV module encapsulation. Since 2003, the main focus of the research was set on durability testing, lifetime modelling and aging characterization of polymeric materials and components as well as the evaluation and qualification of new materials for PV encapsulation. A newly installed research focus is the establishment of correlations between material properties, processing parameters and PV module failure.
- The National Photovoltaic Association is very active in public relations and by creating a national network for dissemination of information on PV and initiating various workshops, press conferences and other awareness raising activities. By fostering the political contacts, intensive political lobbying work and a broad series of articles in newspapers for PV, the association is aiming at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives; preferably based on feed in tariffs. At the end of 2011, well over 200 companies and people involved in the PV business were Association members.

IMPLEMENTATION & MARKET DEVELOPMENT

Approximately 96 MW of PV power had been installed in Austria by the end of 2010. No figures are available yet for 2011 but it is expected that around 180 MW are totally installed in Austria at the end of 2011.

The annual growth rate in 2010, with a total of 43 MW newly installed PV systems, amounted to nearly 82 %, by far the largest rate ever. 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 more than 96 % 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 2011.

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

INDUSTRY STATUS

The Austrian PV industry could still expand their activities during 2010, focussing on the export of their products predominately to the booming European and non-European markets. In Austria, about 4 400 employees in the PV business seems to be a success, but this is dependent very much on the global market development.

- **Crystalsol** is developing a new type of flexible photovoltaic module with a significant versatility and cost advantage, compared to currently known photovoltaic technologies. Crystalsol's first product will be a low cost semi-finished photovoltaic film for the building integration market. The core innovation is the light absorbing layer made of a patented new crystalline semiconductor powder and the low-cost roll-to-roll production process. For this innovative technology development, Crystalsol was selected as winner of "Innovative Companies of the Future," by News, an Austrian weekly magazine, and the City of Vienna.
- **Energetica**, as one of the biggest suppliers in Austria of installers and wholesalers, is producing high-quality PV-modules with sophisticated technology and attractive design at its own production facility. The core competences are clearly defined as producer of PV-modules, OEM PV panel producer, customized BIPV producer, PV solution provider and project contractor for large and medium scale projects all over Europe. The history of the company goes back to 1995, when they started as a pioneer in the Austrian Photovoltaic market.
- Since the beginning of 2010, the **Ertex Solartechnik GmbH** is an independent company with the main investor being ERTL Glas. Ertex Solar received the approval of the DIBt (Deutsches Institut für Bautechnik) for their laminated safety glass module (VSG), in December 2011. A huge range of cell types and material combinations are tested and certified regarding the IEC guidelines by Kiwa, an independent certification body in Europe. In 2011, Ertex Solar realized BIPV projects mainly in Austria, Germany and France, and also in non-European countries such as Abu Dhabi and Turkmenistan.
- **Fronius International GmbH** has been researching new technologies for converting electrical energy since 1945. That's more than sixty years of experience, progress and continuous innovation. The company is based in Pettenbach, Upper Austria and in addition to its Solar Electronics Division, it is internationally successful in the fields of battery charging systems and welding technology. Outstanding products and services, such as the Fronius IG Plus series of inverters and the unique Fronius Service Partner programme, make Fronius Solar Electronics the quality leader in the global market, as well as a classic example of sustainability.

- **ISOVOLTAIC AG** is the global market and technology leader in the development and production of backsheets for photovoltaic modules. It has 25 years of experience in the production of high-quality composite protective sheets for solar cells – the well-established ICOSOLAR® backsheets.
- **Lisec Maschinenbau GmbH** provides fully automatic production lines for any kind of PV-modules based on the Lisec encapsulation technology which benefits from 50 years of experience in the production of insulating glass. The tempered thin glass used for the glass-glass-modules guarantees more robust, absolutely diffusion-proof and high-efficient PV-modules.
- **PLANSEE SE** is headquartered in Reutte/Tyrol. The company is the leading expert for refractory metals and supplies sputtering targets for thin film solar cells (CIGS). In addition to pure molybdenum and tungsten, PLANSEE offers molybdenum alloys such as MoNa and MoTa as well as CuGa, CuIn and CuInGa. With its in-house laboratory, PLANSEE supports its customers in creating innovative thin-films.
- **RESolution** is a division of **EBNER Industrieofenbau**, a worldwide leading supplier of thermal equipment. RES offers heat treatment equipment for thin film PV applications such as CIGS, CdTe or other functional materials.
- **Sunplugged**, based in Tyrol, is developing a new type of flexible CIGS Cells. Energy supply for efficient cooling systems in commercial vehicles will be one specific application of this new development. Besides PV module and cell production, various other companies are manufacturing components for modules and BOS-components, such as batteries, inverters, cell-wiring or mounting systems
- **Ulbrich of Austria** is a technology company that manufactures high-quality cells and edge connectors for the connection of solar cells in a photovoltaic module. The fully automated plant in Müllendorf is able to supply a market demand of 2,5 GW. The company has a 35 % market share in Europe and is supplying most of the key manufactures in the industry. Ulbrich of Austria is a division of Ulbrich Solar Technology Inc.
- **Welser Profile** is a manufacturer of cold-roll formed, customised special sections, tubes, components and complete profile systems made from steel and non-ferrous metals. Welser Profile uses its professional know-how to create optimised and long-lasting system solutions for the global production of solar energy; e.g. mounting posts, carriers and longitudinal carriers, as well as a wide range of profiles required for base constructions.

MARKET DEVELOPMENT

The National Photovoltaic Association is very active in public relations and has been creating a national network for dissemination of information on PV and initiating various workshops, press conferences and other awareness raising activities. By fostering the political contacts, intensive political lobbying work and a broad series of articles in newspapers for PV, the association is aiming at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives preferably based on feed in tariffs. At the end of 2011, well over 200 companies and people involved in the PV business were Association members.

The 9th Annual National Photovoltaic Conference (in 2011, a two day event, organised by the University of Applied Sciences Technikum Vienna and supported by the Ministry of Transport, Innovation and Technology) is established as THE annual come together of the Austrian PV community, bringing together about 250 PV stakeholders in industry, research and administration. The main focus of this Conference is on research and innovation as a basis for a strong industry. Meanwhile, a lot of other events are organised for different target groups; most of them organised by the Austrian Photovoltaic Association.

The "Certified PV Training" for planners and craftsmen, offered by the Austrian Institute of Technology, has increased its PV program significantly by performing 8 day-training courses all over the country; with a total of more than 190 participants in 2011. For the year 2012, a further 16 courses are planned.

FUTURE OUTLOOK

- The situation of the steadily growing export oriented Austrian PV industry is expected to be further improved; mainly due to the further booming global PV market. Innovation and research are seen as crucial elements for competitiveness on the global market.
- In general, the situation of the local PV market is improving quite well but would benefit from more stability in the support system.
- Some strategic initiatives to show the potential of PV for Austria are the PV Technology Roadmap, PV Technology Platform, PV Lobbying by the Association and PV Conferences.
- PV research and development will be further concentrated on international projects and networks, following the dynamic know-how and learning process of the world-wide PV development progress. Mainly within IEA PVPS, Task 14 on "High Penetration Photovoltaics in Electricity Networks," commenced in 2010 and is lead by Austria, might just about become a focal point of the international research activities. However, the national energy research programmes are also more and more dedicated to PV issues, with many projects just in operation.
- The direct links to the 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 a more and more important role.
- The level of the public know-how and interest in the potential and perspectives of PV is continuously growing. Several renewable energy education courses are already implemented, some new are currently under development. All of them include PV as an essential part of the future energy strategy. The importance of proper education for installers and planners of PV systems will increase, depending on the market situation. The training is already available and can be extended easily. Meanwhile, at the University of Applied Sciences Vienna (Technikum-Wien), about 200 students are studying in the Bachelor and Master courses in "Urban Renewable Energy Technologies;" with solar and specifically PV systems, as one core element of the education.

CANADA

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

Fig. 1 - Dual Axis solar tracking system developed by Magna Closures Advanced Energy Systems in the province of Ontario, Canada (Photo: Andrew Bowerbank).

GENERAL FRAMEWORK

Canada's Department of Natural Resources (NRCan) supports priorities to promote the sustainable and economic development of the country's natural resources, while improving the quality of life of Canadians. CanmetENERGY [1], reporting to the Innovation and Energy Technology Sector of NRCan, is the largest federal energy science and technology organization working on clean energy research, development, demonstration and deployment. Its goal is to ensure that Canada is at the leading edge of clean energy technologies to reduce air and greenhouse gas emissions and improve the health of Canadians. The federal photovoltaic activities is led by the CanmetENERGY research centre located in Varennes, Quebec and funded through federal RD&D programs that include the Program of Energy Research and Development [2], the ecoENERGY Innovation Initiative [3], and the Clean Energy Fund [4].
The Province of Ontario, Canada's second largest province, leads the country in photovoltaic (PV) investment. In 2010, the Ontario Ministry of Energy reaffirmed, in its Long Term Energy Plan [5], its commitment to "maintaining a clean, modern and reliable electricity system." Renewable energy sources, such as solar and wind, are slated to play a prominent role in new generation, assisted through continuation of the successful Feed-in Tariff (FIT and micro-FIT) programs [6] administered by the Ontario Power Authority (OPA) [7]. In 2011, the OPA had 378 MW_{AC} of in-service generation capacity from solar photovoltaic systems compared to 186 MW_{AC} in 2010. Another 1,636 MW_{AC} of PV capacity was under development as of September 2011 [8].

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 [9], funded by the Natural Sciences and Engineering Research Council (NSERC), brings together a core group of 25 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners. The network held the second national scientific conference and its fourth annual PV workshop focusing on "How to Make Photovoltaics Happen in Canada." The network focuses its efforts on organic, nanostructure and other innovative PV device approaches that have the potential to leapfrog existing and established technologies.

In 2011, the NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBSN) initiated its five-year work program [10]. 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. Task 40 published a book entitled "Net Zero Energy Buildings" in September 2011. [11]

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

Standards and Codes

The Standards Council of Canada, a crown corporation, is responsible for the National Standards System. It is responsible for standards accreditation of organizations and test laboratories. Standards Council of Canada is Canada's representative at the International Electrotechnical Commission (IEC), a global organization that works towards the harmonization of standards in a broad range of electrical product safety and quality. The Canadian sub-committee to the IEC TC 82 actively participates in the development of PV standards. It collaborates with the Canadian Standards Association to make recommendations on international standards adoption. To

date, Canada has adopted the international IEC61215 and IEC61646 standards that define the test and qualification requirements for crystalline and thin-film solar PV modules. It has completed a process for the adoption of the IEC 61730 for PV module safety, through the Canadian Solar Industry Association and the Canadian Standard Association, that now replaces the former ULC-1703 PV module safety standard.

NRCan's CanmetENERGY, in partnership with key industry players and associations, has championed a national effort to address the delays and avoid multiplication of regional grid interconnection requirements across the country. This included the development of two harmonized national interconnection standards, CSA C22.2 no.257 and the CSA C22.3 no.9. CanmetENERGY conducts research and field-testing, addressing concerns raised by electricity distributors to update and improve the electrical code. Distributed generation installations of PV systems must be installed in accordance with all applicable general rules of the Canadian Electrical Code: Part I and II for low voltage installations at load centers such as residences and commercial buildings and Part III for medium to high voltage of the electricity distribution and transmission systems. This national effort has been expanded to address future Smart Grid applications. The Standard Council of Canada and NRCan's CanmetENERGY have established a Canadian Smart Grid Technology and Standards Task Force in support of a global effort to harmonize requirements. As an example of its commitment to the International Electrotechnical Commission, Canada provided support for the development of an international standard for electricity network communication and distributed energy resources. This was a key issue to ensure that systems were inter-operable with utility networks, and was reflected in the first edition of the IEC 61850-7-420 Ed.1 standard for basic communication structure, including photovoltaic device and system logical nodes.

IMPLEMENTATION

Ontario's Feed-In Tariff Program

Ontario's Feed-In-Tariff program [6], managed by the OPA, is North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuels sources including solar-PV, bioenergy, waterpower and wind. The incentive program is divided into two streams, one targets the small, medium and large renewable energy projects generating more that 10 kW of electricity (referred as the "FIT Program"), and the other targets very small renewable projects generating 10 kW of electricity or less, such as home or small business installations (referred to as the "microFIT Program"). Prices paid for renewable energy generation under FIT and microFIT programs vary by energy source and take into account the capital investment required to implement the project. Under the program, solar PV enter into a 20 year contract to receive a fixed price of up to 0,802 CAD per kWh for the electricity they generate (Table 1).

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

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

** These tariffs were still under review in December 2011 and will be adjusted in 2012*

As of December 2011, the OPA received, under the FIT program, 9 585 applications representing about 8 427 MW_{AC} of PV generating capacity (Table 2a). Under the microFIT program, the OPA received 9 161 applications representing 84 MW_{AC} of generating capacity (99 % of which was for PV, Table 2b) [13]. Because of delays, the RESOP program applicants were given an extension to complete their projects. Approximately 268 MW_{AC} is operational and 212,9 MW_{AC} is still under development (Table 2c).

Given limited transmission capacity and an extremely large number of applications, a transmission planning process, known as the Economic Connection Test (ECT), was created to facilitate generator investment in new transmission "enabler" lines. A comprehensive regulatory evaluation of these new electricity network investment proposals is being conducted by the Ontario Energy Board (OEB) [14], the province's regulatory authority. The OEB created exemptions for small projects connected within the distribution system that would normally be required to pass a series of connection tests before being offered a contract (or capacity to connect). Known as "capacity allocation exempt," these projects have "no more than 250 kilowatts of rated generating capacity where the facility is connected to a less than 15 kV line" and "500 kW or less of rated generating capacity where the facility is connected to a 15 kV or greater line" [15].

Alberta Microgeneration Program

A new renewable energy micro-generation program was initiated by ENMAX, a utility corporation that is a subsidiary of the City of Calgary in the province of Alberta, in 2011. [16] As part of the new program funded by the Alberta Climate Change and Emissions Management (CCMEC) Corporation, ENMAX will deliver 8 300

turnkey home generation solutions (including wind and solar) to residential consumers across Alberta. To date, ENMAX has 178 applications representing 213,6 kilowatt of PV power capacity. 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.» [17]

TREC Renewable Energy Cooperative Effort

A national task force report on social finance recently addressed the opportunity of cooperative effort between finance institutions and community leaders [18]. One example is the SolarShare fund created by the Toronto Renewable Energy Cooperative that aims to purchase, own and operate solar PV installations. With the introduction of the feed-in tariff program, the community cooperative saw an opportunity for individual Ontario residents to benefit from these incentives by investing and developing renewable energy projects. SolarShare privately raised bridge financing totalling over 3,7 MCAD in order to construct its initial round of solar projects. To date, 18 projects are completed and the SolarShare Community Solar Bonds offer a steady income for 20 years. [19]

INDUSTRY STATUS

There are over 440 solar photovoltaic companies operating in Canada, many of which are members of the Canadian Solar Industries Association [20] and Énergie Solaire Québec [21]. The majority of these companies are participants in Ontario's FIT Program, since developers must show that the equipment and labour for system installations consist of 60 % 'Ontario' content for all PV projects since the beginning of 2011.

Since 2010, several companies announced major investments in Ontario that would lead to new "green jobs" in Ontario; they included Celestica [22], Flextronics/MEMC [23], ATS Photowatt Ontario [24], Canadian Solar Inc. [25]. In addition to module manufacturing, new companies also address the balance of systems area, such as the Magna Closures [26] solar tracking system for ground-mounted applications (Figure 1).

TABLE 2A: SUMMARY OF PROGRESS IN THE FIT PROGRAM IN THE PROVINCE OF ONTARIO [13]

FIT	APPLI-CATIONS	AWAITING ECT	OFFERED CONTRACTS	EXECUTED/ OPERATIONAL
NUMBER	9 585	190	2 249	150
CAPACITY (MW_{AC})	8 427	1 601	1 332	23

TABLE 2B: SUMMARY OF PROGRESS IN THE "MICROFIT" PROGRAM IN THE PROVINCE OF ONTARIO [13]

MICROFIT	SUBMITTED	CONDITIONAL OFFER	EXECUTED/ OPERATIONAL
NUMBER	9 161	14 723	10 018
CAPACITY (MW_{AC})	84	137	87

TABLE 2C: SUMMARY OF PROGRESS IN THE RESOP PROGRAM IN THE PROVINCE OF ONTARIO AS OF SEPT. 2011 [8]

RESOP	UNDER DEVELOPMENT	OPERATIONAL
NUMBER	22	35
CAPACITY (MW_{AC})	213	268

MARKET

PV power capacity in Canada grew at an annual rate of 22 % between 1992-2008. In the last two years this growth was 791 % in 2009 and 218 % in 2010 due to the Ontario Incentive programs. The Ontario feed-in-tariff program is paving the way for a steep uptake for grid-connected PV. Provincial and Territorial government policies are now all supporting "net-metering" of PV power and have encouraged a number of building integrated PV applications. The market uptake has been low for net-metering applications due of the low price of electricity in most regions of Canada as shown in Figure 2.

A sustainable market for remote and off-grid applications has developed over the last 18 years in Canada and accounted for 75 % of total PV installed in 2009, however this was only 21 % in 2010 due to the large growth of grid-connected applications in the province of Ontario.

Employment in PV-related areas in Canada grew by 100 % in 2010 to 5 440 jobs compared to 2 700 jobs in 2009. These positions included those in manufacturing, sales and installation, R&D, and other positions in the PV-value chain including company R&D, as well as utility PV dedicated labour (IEA-PVPS NSR 2010: R&D 150; Manufacturing 3 510; Other 1 780). The main increase was in the manufacturing sector as new companies have set up manufacturing bases in Ontario to enable them to satisfy the FIT Program Ontario content requirements.

The national survey completed in 2010 showed a significant decrease in PV module prices (weighted average) to 2,27 CAD per watt. Compared to 10,70 CAD in 2000, this represents an average annual price reduction of slightly over 14 % over a 10-year period. The Canadian total PV power installed capacity is expected to nearly double, reaching an estimated capacity of 500 MW at the end of 2011, compared to 281 MW that was in operation in 2010. As expected, a large fraction of this growth is in the grid-connected market segment in the province of Ontario.

Utility Interconnected PV Systems 2010

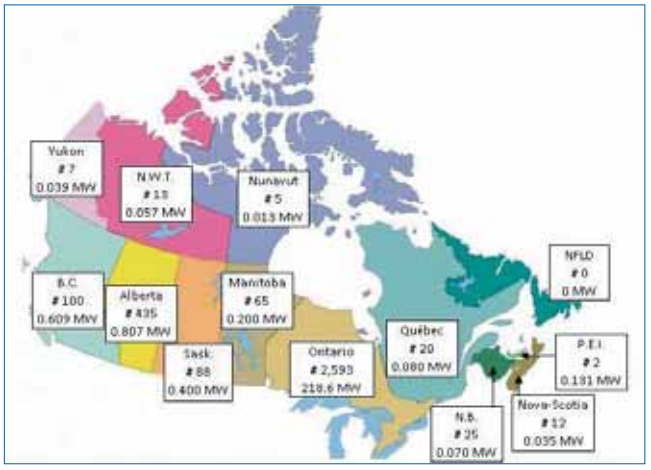

Fig. 2 - Map showing the Canadian provinces, the number of utility interconnected PV Systems and the PV capacity per province in MW_{DC}.

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. The FIT program addressed many of the concerns regarding the delays and interconnection obstacles identified by the industry during the review process. The tremendous initial response to the microFIT program signals a strong support for residential solar rooftop applications in Ontario. Unfortunately new micro-fit project delays have been reported due to concerns by the electricity distribution companies regarding the physical limits of system. Detailed studies to monitor and document these interconnection issues are being conducted. The federal government is also leading the efforts of a technical study group to better understand the technical interconnection issues for high penetration levels of PV systems in electricity grids. This work will be undertaken in collaboration with the International Energy Agency PVPS Task 14 and Canadian stakeholders to better address the emerging field of PV integration enabled through smart grid infrastructure in Canada.

Alberta is the second province in Canada to establish a new solar rooftop program. The target of the program, championed by ENMAX, is to install 8 300 new PV systems and build the local capacity. It aims to extend the benefits of the deregulated electricity market through 15-year leasing arrangements with its customer.

Natural Resources Canada announced a call for new research and demonstration projects under the ecoENERGY Innovation Initiative (ecoEII). The program's objective is to support energy technology innovation to produce and use energy in a more clean and efficient way. This Initiative is a key component of the Government of Canada's actions to achieve real emissions reductions, while maintaining Canada's economic advantage and its ability to create jobs for Canadians.

REFERENCES

[1] CanmetENERGY: http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/

[2] Program of Energy Research and Development: http://www.nrcan.gc.ca/eneene/science/perdprde-eng.php

[3] ecoENERGY Innovation Initiative: http://www.nrcan.gc.ca/energy/science/2003

[4] Clean Energy Fund Program: http://www.nrcan.gc.ca/eneene/science/ceffep-eng.php

[5] Ontario's Long-Term Energy Plan: http://www.mei.gov.on.ca/en/pdf/MEI_LTEP_en.pdf

[6] OPA Feed-in Tariff Program: http://fit.powerauthority.on.ca/

[7] Ontario Power Authority: http://powerauthority.on.ca/

[8] A Progress Report on Electricity Supply - Third Quarter 2011 http://fit.powerauthority.on.ca/

[9] Photovoltaic Innovation Network: http://www.pvinnovation.ca/

[10] NSERC Smart Net-Zero Energy Buildings Strategic Network: http://www.nsercpartnerships.ca/How-Comment/Networks-Reseaux/SNEBSN-BICENN-eng.asp

[11] IEA-SHC/ECBS Task 40/Annex 52, entitled "Towards Net Zero Energy Solar Buildings": http://www.iea-shc.org/task40/

[12] Sustainable Development Technology Canada: http://www.sdtc.ca/

[13] Bi-weekly FIT and microFIT Program reports: http://fit.powerauthority.on.ca/Page.asp?PageID=749&ContentID=&SiteNodeID=1144&BL_ExpandID=273

[14] Ontario Energy Board: http://www.oeb.gov.on.ca/OEB/

[15] Capacity Allocation Exempt Projects: http://fit.powerauthority.on.ca/Page.asp?PageID=751&SiteNodeID=1118

[16] ENMAX renewable energy microgeneration program: http:// www.generatechoice.ca

[17] Alberta Climate Change and Emissions Management Corporation (CCMEC): http://ccemc.ca/_uploads/2011-CCEMC-284-AnnualReport.pdf

[18] National Task Force report on Social Finance, 2010: http://socialfinance.ca/

[19] TREC SolarShare fund: http://www.trec.on.ca/generation/solarshare

[20] Canadian Solar Industries Association: http://www.cansia.ca/

[21] Énergie Solaire Québec: http://www.esq.qc.ca/

[22] Celestica: http://www.celestica.com

[23] Flextronics moves to solar production with MEMC and SunEdison subsidiary: http://www.ept.ca/news/flextronics-moves-to-solar-production-with-memc-and-sunedison-subsidiary/1000523195/

[24] ATS Photowatt Ontario: http://www.photowattontario.com/

[25] Canadian Solar Inc.: http://www.canadian-solar.ca/

[26] Magna Closures Advanced Energy Systems: http://www.magnaclosures.com

CHINA

PV TECHNOLOGY AND PROSPECTS

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GENERAL FRAMEWORK

China is facing serious pressure on energy supply and environment issues: China has been the country with highest GHG emission in the world since 2007; China is the country with the highest installed power capacity and the highest electricity consumption in the world; China is the largest country to import coal and the second largest country to import oil and the imported oil shared 53 % of total demand in China. 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 1 January 2006, to support the RE power supply by way of "Feed in Tariff" (FIT) policy. The law requires that the grid company buys all of the electricity generated by RE power systems with reasonable FIT. The excess costs between the RE power and conventional power should be subsidized by government and the subsidy money will be collected from all end users by means of surcharge to the electricity retail price. The surcharge level has been doubled from 0,4 CNY cents/kWh to 0,8 CNY cents/kWh since 1 December 2011. Then, 22 BCNY of the surcharge for RE power subsidy can be collected per year. Today, wind farms, large-scale PV power plants and biomass power plants enjoy the incentive policy of FIT.

Beside the FIT policy, China has launched other government supported projects, known as the "Golden Sun Demo Program" and "Solar Building Project." These two government projects enjoy the subsidy to capital investment. The subsidy money is coming from the Special RE Fund (SREF) instead of surcharge. The SREF is controlled by the Ministry of Finance and is currently used only on the two government projects. The detailed information for the two government projects is listed in Table 1:

TABLE 1 – SUBSIDY LEVEL OF GOVERNMENT SUPPORTED PROJECTS

PV BUILDING PROJECT					
Year	project	Total Capacity (MW)	Subsidy Level (Yuan/Wp)		Remarks
			BIPV	BAPV	
2009	111	91	20	17	Self Consumption
2010	99	90,2	17	13	
2011	128	120	12		
2012	Under going		9	7,5	
GOLDEN SUN DEMONSTRATION PROGRAM					
2009	98	201	14,5	20	Self Consumption
2010	50	272	11,5	16	
2011	140	690	9(C-Si) 8,5(Thin Film)		
2012	Under going		7,0	> 7,0	

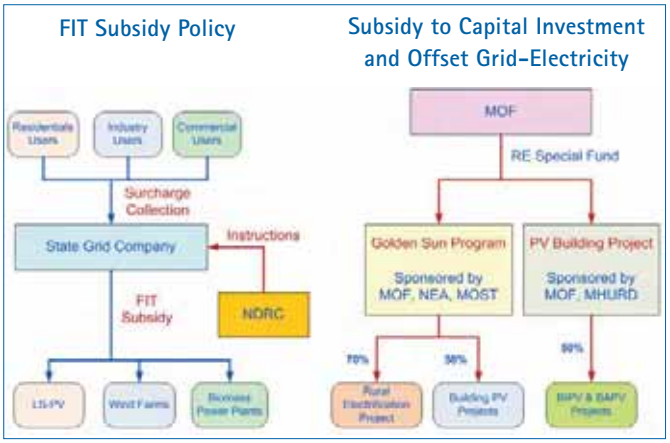

Fig. 1 - Incentive Structure for RE in China.

NATIONAL PROGRAM

At the Copenhagen International Climate Change Conference in 2009, premier Wen Jiabao, on behalf of the Chinese government, announced the targets of GHG reduction and energy structure of China: 1) 40-45 % of GHG Emission for unit GDP will be reduced by the year of 2020 compared with the level of 2005; 2) Non-fossil Energy will share 15 % of total energy consumption by 2020. By 2020, total energy consumption in China will reach 4,6 billion Tce, so the total non-fossil energy should be around 0,7 billion Tce. To reach this target, estimated by experts, the non-fossil energy structure should be as noted in Table 2:

TABLE 2 - CHINA NON-FOSSIL ENERGY STRUCTURE OF 2010, 2015, 2020

TYPE	2010	2015	2020			Share
	Inst. Cap.	Inst. Cap.	Inst. Cap.	Genera-tion	Tce	
Power Gen.	GW	GW	GW	TWh	Million Tce	%
Hydro	213,00	260,0	300,0	1 000,0	318,2	6,92
Wind	31,00	100,0	150,0	300,0	100,0	2,17
PV & CSP	**0,80**	**15,0**	**50,0**	**75,0**	**25,0**	**0,54**
Biomass Power	5,00	13,0	40,0	200,0	70,0	1,52
Nuclear	10,80	40,0	70,0	350,0	102,0	2,22
Total	260,60	428,0	610,0	1 925,0	615,2	13,37
Solar Thermal						
SWH	168 Mm^2	300 Mm^2	500 Mm^2		75,0	1,63
Biomass Util.						
Bio-gass	13 Bm^3	25 Bm^3	40 Bm^3		28,0	0,61
Bio-ethanol	1,8 MT	3,0 MT	11 MT		13,0	0,28
Bio-Diesel	0,5 MT	1,5 MT	3 MT		4,5	0,10
Total					735,7	15,99

For solar PV and CSP, the targets were set by National Energy Administration (NEA). The detailed annual installation and market share by sectors are estimated in Table 3:

TABLE 3 – SOLAR POWER TARGET AND ANNUAL PROGRESS FORECAST

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual Inst. (GW)	2,2	2,5	3,0	3,0	3,5	4,0	5,0	6,0	8,0	12,0
Cumul Inst. (GW)	3,0	5,5	8,5	11,5	15,0	19,0	24,0	30,0	38,0	50,0

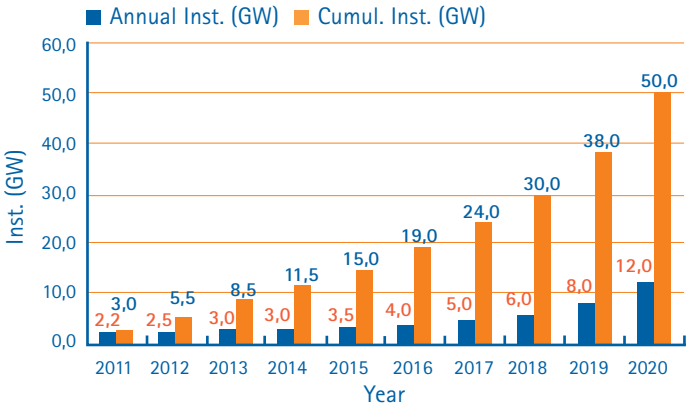

Fig. 2 - Solar Power Target and Annual Progress Forecast.

TABLE 4 – SOLAR POWER TARGET AND MARKET SHARE BY SECTORS

CUMULATIVE INSTALLATIONS OF SOLAR POWER IN CHINA				
TYPE	MARKET SECTORS	2010	2015	2020
Off-Grid PV	Rural Electrification	0,072	2,0	5
	Communication & Industry	0,043	0,5	1
	PV Products	0,042	0,5	1
Grid-Tied PV	PV Buildings	0,240	4,0	20
	LS-PV Power Plants	0,402	7,0	20
CSP	Concentrating Solar Power (CSP)	0,000	1,0	2
Total		0,8	15	50

RESEARCH AND DEVELOPMENT (R&D)

China has got the key technology for all the links on the photovoltaic production chain with innovation and development, such as solar cell technology and polycrystalline silicon manufacturing technology. Factory efficiency of polycrystalline silicon solar cell has been increased to 16 %; Chinese companies have become world leaders in product quality and production cost. Pluto Technology of Suntech has increased the conversion efficiency of monocrystal silicon solar cells to 18,8 % and as well as polycrystalline silicon solar cells to 17,2 %. Some international companies, such as: Yingli, Trina Solar, Canadian Solar, JA Solar, Hanwha Solar, China Sunergy (Nanjing) Co., Ltd (CSUN), have some patent technologies, and the conversion efficiency of solar cells goes into the word-class level. Consumption of silicon rate has been dropped from average 9g/w to 6g/w, which reduces the manufacturing cost, and enhances the price competitiveness in the global market.

The PV application technology is pretty much the same as in other countries. The commercialization of the PV business on the grid-connected PV power plant and the distributed generation on the demand side has started, industrialization of large capacity power inverters is being achieved and the research of photovoltaic micro-grid technology is just beginning.

PV INDUSTRY DEVELOPMENT

China has been the largest producer of PV modules in the world since 2007. More than a 100 % annual increase of PV production has been achieved in the last 5 years. In 2011, PV shipments from China shared about 50 % of total world PV shipment.

TABLE 5 - PV CELL PRODUCTION AND Y/Y INCREASE

YEAR	2007	2008	2009	2010	2011(E)	2007-2011
China PV Shipment (MW)	1 088	2 600	4 011	10 800	13 500	Average
Y/Y(%)	172,0	139,0	54,3	169,3	25,0	111,9

The high purity poly-silicon supply was the bottleneck before 2010 and most of poly-silicon material was imported from other countries. Since 2010, significant progress is achieved in this field. In 2011, domestic production of solar grade poly-silicon was about 60000 Tons to meet nearly 70% PV industry demand.

TABLE 6 – DEMAND AND SUPPLY OF POLY-SILICON IN CHINA

YEAR	2006	2007	2008	2009	2009	2011(E)
Production (Ton)	300,0	1 100,0	4 729,0	20 357,0	45 000,0	60 000,0
Demand (Ton)	4 000,0	10 000,0	25 000,0	40 000,0	89 000,0	90 000,0
Shortage (Ton)	3 700,0	8 900,0	20 271,0	19 643,0	44 000,0	30 000,0
Share of Import (%)	92,5	89,0	81,1	49,1	49,4	33,3

Now, the capacity of PV production chain is nearly balanced, but seems over-capacity compare with market demand.

TABLE 7 – CAPACITY OF PV PRODUCTION CHAIN

YEAR	2007	2008	2009	2010	2011
Poly-Si (Ton)	4 500	20 000	40 000	60 000	80 000
Wafer (GW)	2	3	5	12	20
Cells (GW)	2	4	5	12	20
Modules (GW)	3	5	8	15	30

PV MARKET DEVELOPMENT

Currently, Incentive policies are mainly applied on grid-connected PV, such as PV buildings and large-scale PV (LS-PV) power plants. Today, the grid-connected PV shared 90 % of the whole PV market in China. Government also provides funds to off-grid PV for rural electrification, but the market size is limited. The PV market development of last 12 years is listed in Table 8:

TABLE 8 - PV MARKET DEVELOPMENT IN CHINA

YEAR	RURAL (MWp)	COM & IND (MWp)	PRO (MWp)	BIPV (MWp)	LS-PV (MWp)	ANNUAL (MWp)	CUMUL. (MWp)
2000	2,00	0,80	0,20	0,00	0,00	3,00	19,00
2001	2,50	1,50	0,50	0,01	0,00	4,50	23,50
2002	15,00	2,00	1,50	0,01	0,00	18,50	42,00
2003	6,00	3,00	1,00	0,07	0,00	10,00	52,00
2004	4,00	2,80	2,00	1,20	0,00	10,00	62,00
2005	2,00	2,90	1,50	1,30	0,20	8,00	70,00
2006	3,00	2,00	4,00	1,00	0,00	10,00	80,00
2007	8,50	3,30	6,00	2,00	0,20	20,00	100,00
2008	4,00	5,00	20,50	10,00	0,50	40,00	140,00
2009	9,80	2,00	6,00	34,20	108,00	160,00	300,00
2010	15,00	6,00	6,00	190,00	283,00	500,00	800,00
2011(E)	10,00	5,00	5,00	380,00	1 800,00	2 200,00	3 000,00

Fig. 3 - 30 MW PV Plant in Ningxia.

Fig. 5 – 10 MW BAPV in Changzhou.

Fig. 4 - 20 MW CPV Power Plant in Qinghai.

Fig. 6 - 10MW Thin-Film BIPV in Shenzhen.

LS-PV Power Plants

NDRC released FIT of PV in July 2011: 1,15 CNY/kWh for the projects finished before the end of 2011 and 1,00 CNY/kWh for the projects in 2012. This tariff is suitable only for the locations in north-west China, where the solar resources is good and the annual full running hours of the PV plants is equal or higher than 1 500 hours. Stimulated by FIT policy, nearly one hundred LS-PV power plants were installed in Qinghai, Ningxia, Gansu, Tibet and Xinjiang. The total capacity of LS-PV power plants installed in 2011 is about 1 800 MW, among them, 1 003 MW in Qinghai and 700 MW in Ningxia. The largest single PV plant is 200 MW, sponsored by the Hydro-Power Company of Yellow River, and its size may make it one of the top three in the world.

PV Building Projects

Driven by the government supported projects, "Golden Sun Program" and "PV Buildings," about 400 MW of PV buildings were installed in the eastern part of China in 2011. The 690 MW of Golden Sun projects and 120 MW PV Building projects, approved in 2011, should all be finished by the end of June of 2012. Thus, the total annual installation of PV building projects in 2012 will be at least 800 MW.

DENMARK

PV TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - A 50 kWp PV-plant on the roof on the public school in Resen in Skive Municipality.

Fig. 2 - Skive Raadhus: CdTe modules used for visual covering of ventilation equipment on the roof of the city hall in Skive.

GENERAL FRAMEWORK

The new Danish government launched its energy plan, called Our Energy, in November 2011 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. Primo 2012, the plan is still under political debate.

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 2011 about 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 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 it does have a number of projects supported mainly by the Danish Energy Authority and via the Public Service Obligation (PSO) of Danish transmission system operator, Energinet.dk, a fully government owned body. A couple of public funds also supports 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. In late 2002, the net-metering scheme was extended another four years up to the 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 2011 at a level of approx. 0,30 EURcents/kWh primarily because of various taxes - appears now to be able to stimulate PV deployment as the installed capacity during 2011 is estimated to exhibit a growth rate of about 120 %. For PV systems qualifying to the net-metering scheme, grid-parity has been reached.

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

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

Fig. 3 - A 50 kWp PV plant under construction on the public school "Dalgas Skolen" in Skive Municipality.

Fig. 4 - Skive Raadhus: CdTe modules used for visual covering of ventilation equipment on the roof of the city hall in Skive.

The Skive municipal project has by end of 2011 implemented about 1,1 MW on municipal buildings and is expected to implement in total 1,5 MW, more than the targeted 1 MW – this due to decreasing prices.

The PVIB project on the island of Bornholm has implemented around 2 MW by the end of 2011 and was ahead of schedule. The BIPV project 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 has proven fully operational for new installations in 2011. With a market growth of 120 % in 2011, a reliable registration of new installations is found crucial. About 9 MW of grid connected PV systems were installed during 2011.

RESEARCH AND DEVELOPMENT

R&D efforts are concentrated on crystalline Si cells and modules, polymer cells and modules, dye sensitized cells 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 gird codes are under revision to accommodate a high penetration of inverter-based decentralized generation.

INDUSTRY AND MARKET DEVELOPMENT

A Danish PV industrial association (Dansk Solcelle Forening) was established in late 2008. With about some 40 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 households coming from PV by 2020.

During 2011, the inverter manufacturer Danfoss Solar Inverters has continued its successful expansion, mainly in terms of export and has increased its staff considerably.

A couple of Danish module manufacturers each with an annual capacity of about 2 MW per shift are on the market. A few other companies producing tailor-made modules such as window-integrated PV cells can be found.

There is no PV relevant battery manufacturing in Denmark at present.

A few companies develop and produce power electronics for PVs, mainly for stand-alone systems for the remote-professional market sector such as telecoms, navigational aids, vaccine refrigeration and telemetry.

A number of companies are acting as PV system integrators, designing and supplying PV systems to the home market. With the rapidly expanding market and 120 % growth in 2011, 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.

The 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.

By the end of 2011, the cumulative installed PV capacity in Denmark (including Greenland) was estimated at about 16 MW.

FUTURE OUTLOOK

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

The Skive project now targeting 1,5 MW on municipal buildings, is expected to exhibit a high replication potential, stimulating other municipalities to similar initiatives. The PVIB project targeting 5 MW has started implementation in 2010, initially with funding to reach about 3 MW; by end of 2011, 2 MW was committed and the regional municipality of Bornholm has indicated plans for about another MW on municipal buildings.

The present net-metering scheme – in 2011 providing a value of PV power at around 0,30 EURcents/kWh – appears to have reached a level really stimulating PV deployment within the limits of the scheme. For private households and other entities entitled to the net-metering scheme, grid-parity can be said to have been reached during 2011. Given no impairments to the existing net-metering scheme, the accelerated market growth experienced in 2011 can be expected to continue.

EUROPEAN COMMISSION

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

PIETRO MENNA, EUROPEAN COMMISSION, DG ENERGY
FABIO BELLONI, EUROPEAN COMMISSION, DG RESEARCH & INNOVATION

POLICY

The European Commission Communication *Renewable Energy: Progressing Towards the 2020 Target* [1] reviewed the state of play of the legal framework for the development of renewable energy in Europe and the extent of the development. The Communication recalls that overall growth in developing renewable energy has been slow, at least as shares of electricity consumption or transport fuel consumption. So whilst there has been growth, with a significant increase in absolute production quantities, expectations have not always been met. In this context, it becomes important the entry into force of the Directive 2009/28/EC [2], setting legally binding targets for all Member States, which will cover all energy consumption (i.e. including the heating sector for the first time) to achieve a 20 % share by 2020. A key requirement of the Directive is the elaboration of national renewable energy action plans (NREAPs) by each Member State. These plans provide detailed roadmaps for the achievement of the targets and represent a new wealth of information for industry and other stakeholders [3]. Overall, NREAPs imply that we will exceed the 20 % 2020 target. For photovoltaics (PV) they indicate that capacity should surpass 80 GW by 2020 (Fig. 1). The Commission scrutinizes the implementation of these plans, including the measures put into place to stay on the trajectory towards the 2020 targets, and will produce its progress report by end 2012, on the basis of the Member States' reports. Notably, the growth of the renewable electricity production as projected in the plans reveals a major industrial change, as the renewable share of electricity is expected to rise to 34 % by 2020. The improvements and changes needed for the electricity grid to respond to these developments are now occurring. ENTSO-E and the European Commission in its energy infrastructure package are planning how to absorb this energy.

For the growth projections to be met, annual capital expenditure needs to double (to 70 BEUR/year) across the EU. Such an expenditure, combined with the necessary grid reinforcements, make the development of energy infrastructure a significant investment item for the next decade. A positive element to stress is that manufacturing costs have declined significantly, particularly for PV. So whilst there is still the need to monitor costs and to optimise support schemes to ensure they drive down costs and still promote growth, the industry is showing that it can respond, continuing to drive down costs and increasing the competitiveness of PV across the board.

The growth of renewable energy – the expectation that it will soon provide a third of our electricity and 10 % of our transport needs – has also triggered discussion of «beyond 2020.» The European Commission has published an overall «low carbon economy» roadmap to 2050, as well as a transport sector -specific 2050 paper. On 15 Dec 2011, the Commission adopted the **Energy Roadmap 2050**, a communication exploring the challenges posed by issuing the EU's decarbonisation objective while at the same time ensuring **security of energy supply** and **competitiveness** [4].

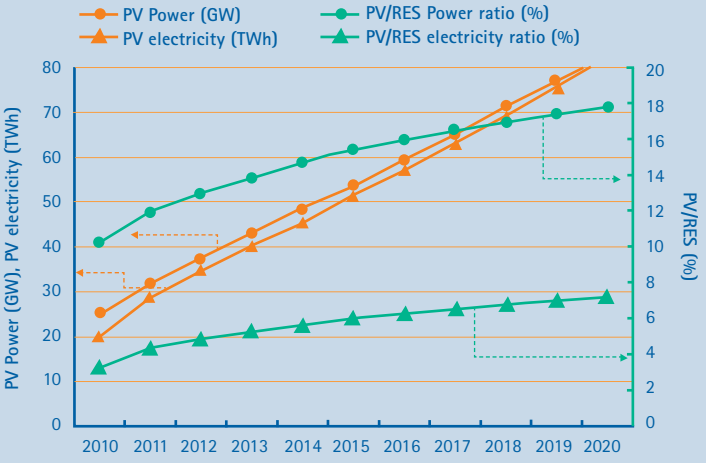

Fig. 1 - PV sectorial targets estimates, based on the NREAPs notified to the European Commission by the 27 Member States.

DEPLOYMENT

Photovoltaics continues to be one of the fastest growing sectors in the worldwide economy, creating additional economic value, generating growth and providing jobs. In Europe, in 2010 the PV sector surpassed any other renewable electricity sector, in terms of installed power capacity. In that year, more than 13 GW of PV installations have been connected to the European grid [5]. This figure attests the leading market role of Europe, as it represents more than 80 % of the yearly world installed capacity. Most of the photovoltaic power capacity has been installed in Germany (7,4 GW), Italy (2,3 GW), Czech Republic (1,5 GW) and France (0,7 GW). These figures show that the European market remains quite heterogeneous, even though less than before. The cumulated PV capacity installed in Europe by the end of the year 2010 is higher than 29 GW.

On the supply side, Europe is a net importer of PV devices and the trend will likely continue as the recent rapid growth of PV production capacity in Asia brings new challenges to EU players.

While solar electricity is still not competitive with conventional power generation, its cost is closer to the electricity tariffs charged to consumers. This is particularly evident in the case of PV installations sited at the consumers' premises, when the cost of PV electricity has to be directly compared to the tariff, rather than to the cost of power generation. The gap between the best PV electricity prices, in the sunniest locations, and the highest tariffs has been narrowing. On the one hand, support schemes that bridge this gap have been causing rapid growth in sales of photovoltaic modules, especially in Germany and Italy. On the other hand, support schemes have substantially been revised almost everywhere. Nevertheless, the price of PV modules has experienced a downward trend in recent years and is expected to decline further in the near future. This should allow absorbing future reductions of feed-in tariffs, provided that they are well planned and soundly shaped.

EUROPEAN SOLAR INDUSTRIAL INITIATIVE OF THE SET-PLAN

The European Industrial Initiatives (EIIs), stemming from the Strategic Energy Technology Plan (SET-Plan) of the European Union [6], have been conceived as large scale programmes aiming at the rapid development of key energy technologies. To this purpose, EIIs bring together the industry, the research community, the Member States and the Commission. The Solar European Industrial Initiative (SEII), in particular, was launched in June 2010 to contribute to reach very ambitious objectives in terms of solar electricity share of the European electricity consumption by 2020. SEII deals with both PV and concentrating solar power (CSP). The *SEII-Team* is the plenary body composed of representatives of fourteen countries, industry, EERA-PV and EERA-CSP and Commission.

The SEII 2010-2012 Implementation Plan for PV, aiming at achieving cost reduction and enabling large-scale deployment, identifies RD&D needs for about 1,2 BEUR to be invested in new production technologies, as well as in the integration of PV into the grid and the built environment.

The current focus of the Initiative is the definition of an ERA-NET funding proposal, dedicated to the implementation of the SEII priorities. The ERA-NET will complement existing mechanisms of trans-national cooperation, offering to participants the opportunity to explore the benefits of variable geometry arrangements among funding bodies supporting both private and public RD&D in the fields of PV and CSP. The activities funded by the ERA-NET will have to be coordinated with funding prospects at national level in other schemes (e.g. NER300), avoiding double funding while allowing synergies and complementarities. The ERA-NET will primarily involve the launching of joint calls (starting as of the end of 2012).

RTD & DEMONSTRATION

Six calls for proposals have already been launched for the years from 2007 to 2012, under the **7th Framework Programme for Research**, FP7 (2007-2013). So far, development of materials for longer-term applications, concentration PV and manufacturing process improvement have attracted considerable European funding. Furthermore, significant funding has been made available for thin-film technology. The PV projects granted and/or selected following the calls have been described elsewhere [7].

The Commission maintains long-term support for research, development and demonstration in the solar PV sector, providing a framework within which researchers and industrialists can work together to develop technology and applications. With the first five calls launched under the 7th Framework Programme for Research, more than 172 MEUR has already been invested in innovative projects on PV (Fig. 2).

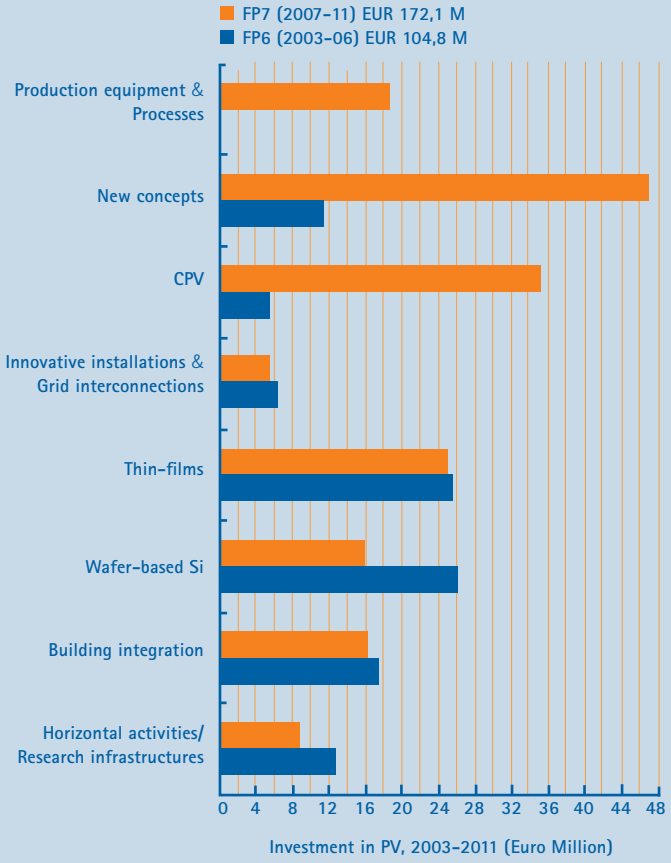

Fig. 2 - Investment in PV under FP6 and FP7, 2003-2011 (in Million EURO).

CONCLUSIONS

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

The Commission continues to ensure the policy framework for the development of the PV sector and, mainly within FP7, to financially support RD&D activities. Commission's actions are complemented by the SEII, which offers a timely opportunity for European PV companies to accelerate their development and demonstration activities, to increase their innovation base, and to improve their competitiveness.

REFERENCES

[1] *Renewable Energy: Progressing Towards the 2020 Target COM(2011)31*

[2] *Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.*

[3] *http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm*

[4] *Energy Roadmap 2050, COM(2011) 885/2*

[5] *Photovoltaic Barometer, Eurobserver-Systèmes Solaires, Le Journal du photovoltaique, n.5 (2011).*

[6] *A European strategic energy technology plan (SET Plan) - Towards a low carbon future COM(2007) 723 final.*

EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S ACTIVITIES AND ROADMAP

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

The PV Industry Value Chain

EPIA Members are present throughout the whole PV value chain

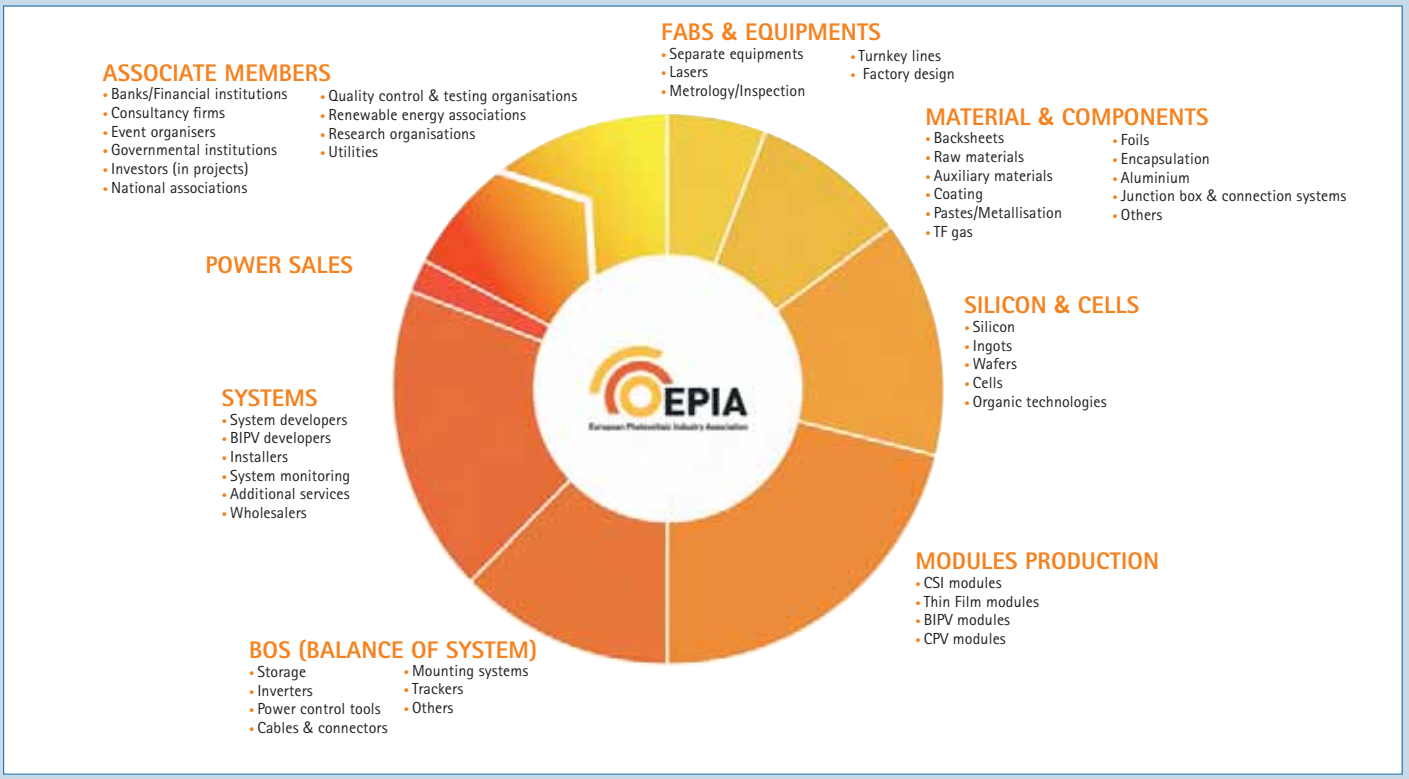

Fig. 1 – EPIA Members are present throughout the entire PV value chain.

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 EU decision-making process
- 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

BUSINESS INTELLIGENCE

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) and task 14 (grid integration)

COMMUNICATION ACTIVITIES

Over the years EPIA has developed strong and well-regarded tools for communicating to key stakeholders – including EU decision-makers

Fig. 2 – Networking at the EPIA Stand in Hamburg, Germany during the 26th EUPVSEC.

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
  - 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 – helping 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 Working Groups** (on ad hoc basis) 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 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, which took-off during 2008 after launching in 2007. Task 12 meetings were hosted by EPIA during the 26th EU PVSEC in Hamburg, Germany, and in conjunction with the 2nd International Conference on PV Module Recycling, organized in Madrid, Spain by EPIA and PV Cycle.

The last version of the "Guidelines for a Common Approach in Photovoltaics Life Cycle

Inventory and Life Cycle Assessment" was finalized and published in November 2011. In 2011 an updated version of the "Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity" was published as well.

Task 14: High Penetration of PV Systems in Electricity Grids

EPIA will start 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 world-wide 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 26th EU PVSEC in Hamburg, Germany, in September 2011. Gaëtan Masson, Head of Business Intelligence, took part as speaker and panelist at the two workshops organized by or with IEA-PVPS, in Istanbul in February 2011 and in Hamburg during EU PVSEC in September 2011.

FRANCE

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

Fig. 1 – PV System integrated to a tertiary building (Gard department) – 86,5 kW (Photo: SETA ENERGIES).

GENERAL FRAMEWORK AND IMPLEMENTATION

The French government has introduced a favourable electricity purchase price scheme for energy producers to encourage the expansion of solar photovoltaic (PV) energy production. The cost of this scheme is redistributed across all consumer electricity bills via the *Contribution au service public de l'électricité* (CSPE – public electricity service contribution).

At the end of 2008, the total power of all photovoltaic systems installed in France was 80 MW. By the end of 2010, this figure had risen sharply to 1 000 MW, with a waiting list of new grid connection requests totalling 6 000 MW.

According to the government, this spectacular increase demonstrated that the «bedding in» phase was complete, with the sector substantially exceeding the targets set in 2008 (1 100 MW of installed systems by the end of 2012 and 5 400 MW by 2020). The sector was now entering its second, maturation phase.

Since 2009, substantial technical progress has been made in the photovoltaic sector, along with improving economies of scale due its rapid global expansion. Despite successive purchase price reductions (in January and September 2010), the rate at which new projects were emerging remained too high to be sustainable. This rapid expansion also failed to meet the desired industrial development and environmental performance goals. As a result, the government made the decision to partially suspend the compulsory purchase mechanism for photovoltaic installations above 3 kW, from 9 December 2010 for a period of three months. During this suspension, a broad consultation programme was undertaken, covering all parties involved in the photovoltaic sector in France, with the aim of introducing a new regulatory framework. At the end of this consultation period, a new support system was proposed. This system involves two separate mechanisms, based on the installation's power. Under the first mechanism, for installations of less than 100 kW located on buildings, purchase prices are adjusted automatically each quarter based on the total volume of projects submitted. The second mechanism involves a bidding system for large roof installations and photovoltaic power plants with a power output above 100 kW. The purpose of this new system is to strike the right balance between creating a competitive industrial sector (export in particular) and improving energy and environmental performance.

The new support system aims to achieve a target of 500 MW of new projects per year over the next few years. It will place stricter environmental and industrial quality requirements on all new projects, including mandatory end-of-life dismantling and recycling and an obligation to produce a life-cycle analysis report. For non-residential projects, a bank certificate or loan offer will also be required to prove that the project is financially viable. This will avoid the situation in which the waiting list becomes saturated with connection requests for projects that are subsequently abandoned.

The government announced the suspension of the compulsory purchase mechanism for photovoltaic installations above 3 kW between 9 December 2010 and 9 March 2011. The French government decree of 4 March 2011 set out a new framework governing photovoltaic electricity purchase prices.

Since 1 July 2011, prices have been revised on a quarterly basis based on the number of projects submitted in the previous quarter (see Table 1).

TABLE 1 – APPLICABLE PURCHASE PRICES UP TO 31.12.2011

TITLE	BUILDING USAGE	POWER	PRICE (EUR/KWH)
IAB (Building-integrated photovoltaic systems)	Mainly residential use	P < 9 kW 9 kW < P < 36 kW	0,4063 0,3555
IAB	Building for education or health activities	P < 36 kW	0,3325
IAB	Other type of building	P < 9 kW	0,2882
ISB (Simplified building-integrated)	Mainly residential use, building for education or health activities, other type of building	P < 36 kW 36 kW < P < 100 kW	0,2485 0,2361
Other installations	Other installations	0 kW < P < 12 MW	0,1138

Fig. 2 – PV system integrated into the roof of an industrial building (Loire department) – 111 kW (Photo: Photowatt Bernard & Bonnefond).

The government's policy priority is to focus on building-integrated photovoltaic systems. This concept allows producers to access the highest purchase price and required the government to produce a precise set of technical rules. The *Comité d'évaluation des produits photovoltaïques intégrés au bâti* (CEIAB – Building-integrated photovoltaic product assessment committee) examines all photovoltaic system submissions that it receives and determines whether they comply with the technical criteria governing building-integrated photovoltaic systems (IAB) or simplified building-integrated photovoltaic systems (ISB), as defined under the new price order issued on 4 March 2011. The photovoltaic array field must be parallel to the roof and must be water- and air-tight to the roof. For building-integrated photovoltaic systems (IAB), the gap between the roofline and the upper limit of the array field must be less than 2 cm. Where the PV array field rests on top of another water- and air-tight element, however, they belong to a different category, known as simplified building-integrated photovoltaic systems (ISB). At the end of 2011, CEIAB published a list of the products that it had examined. This list featured around 100 systems eligible for IAB pricing and 150 systems eligible for ISB pricing.

The new support system proposes two types of bidding processes for photovoltaic installations located on buildings producing more than 100 kW and ground-based photovoltaic power plants:

- PV installations on buildings, between 100 kW and 250 kW: this simplified bidding process, launched in August 2011, is designed to ensure that project initiators get a quick response and to prevent any speculative activities or rapid expansion in a particular sector, with an optimal volume control system. Applications are staggered over seven periods, with the deadline for the first period on 20 January 2012 and the last on 30 June 2013. Bids that meet the specifications will be selected based on the applicant's proposed electricity price. This means that only the most competitive bids will be chosen, limiting the impact of the CSPE on the electricity bills of consumers in mainland France.
- Large PV roof installations of more than 250 kW, and ground-based photovoltaic power plants: bids will be selected according to a range of different criteria (price, environmental aspects, innovation, etc.). In the interest of attracting investors, bids may cover several years. Low-value plots of land (e.g. industrial wastelands) will be given priority, in order to protect biodiversity, farmland and forests. Bidders will be required to comply with a range of environmental and industrial criteria to ensure that the installation produces energy efficiently and to encourage innovation.

The first call for bids was issued on 15 September 2011, with the bid submission deadline set for 8 February 2012.

At the government level, the Ministry for Ecology, Sustainable Development, Transport and Housing manages this policy and implements it through a number of subsidiary agencies such as ADEME (French Agency for Environment and Energy Management), ANR (French National Research Agency) and OSEO (Innovation support organization).

Regional Councils and General Councils in each administrative department also implement complementary local policies to encourage photovoltaic installation projects.

In France, PV energy purchase contracts are managed by the EDF Compulsory Purchase Agency (EDF OA), however, other municipal electricity utilities may also fulfil this role. ERDF is responsible for the national grid and provides connection and access contracts for the public distribution and operation network (photovoltaic systems < 36 kVA).

NATIONAL PROGRAMME

At the end of 2009, the government launched a major national future investment programme. This programme is based around five main themes and is one of the key elements of France's economic crisis resolution strategy. The sustainable development sector is one of the programme's five strategic priorities, and one of the goals in this area is to boost industrial development around renewable energy sources. Photovoltaic technology was identified as a key target, with ADEME given responsibility for launching a call for expressions of interest (AMI PV). The deadline for this process was in May 2011. The aim of this programme is to improve the economic and environmental performance of photovoltaic solutions. The chosen projects will involve demonstrations of research findings, pre-industrial developments and technology platforms designed to:

- reduce the cost of photovoltaic systems;
- develop and create new, highly efficient components and technical processes (e.g. high-efficiency photovoltaic modules, solar tiles, etc.);
- improve the performance of photovoltaic systems throughout their life cycle;
- experiment with new business models to ensure that the sector is profitable.

These demonstrations will also help to make French industrial companies more competitive in these markets, especially on the international scene. ADEME selected around 30 projects in total.

Another aspect of the future investment programme involves the creation of *Instituts d'excellence dans le domaine des énergies décarbonées* (IEED – carbon-free energy excellence institutes).

An IEED is a thematic institute which – via a public-private partnership – conducts experimental, needs-oriented research and development work, helps to design professional training courses and ensures that the results of these research exercises are disseminated and exploited, both socially and economically. ANR (French National Research Agency) selected the theme of solar energy, with its second call for proposals closing in October 2011. The same year ANR launched the PROGELEC (renewable electricity production and management) research programme in early 2011. This three-year programme (2011-2013) is located upstream from ADEME's future investment demonstration and technology platform projects. The aim of the "Photovoltaic electricity production" theme is to overcome the scientific, technical and economic challenges posed by the materials and processes involved. This programme focuses on conversion efficiency, energy cost price, reliability, ease of implementation and maintenance, life cycle and recyclability.

The three chosen research topics cover the crystalline silicon, thin films and innovative concept and process sectors. The ANR bid submission deadline was set for 7 April 2011 and 5 projects were selected.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

RDD activities form part of the national programme described above. Practically all component manufacturers are involved in these programmes. The PV Alliance consortium has introduced a pilot silicon photovoltaic cell production line, with an annual capacity of 25 MW. The line is designed to test innovative new processes developed at INES on a large scale. With support from the *Aides à la réindustrialisation* (ARI – reindustrialization support) scheme, a new entrant to the market was able to build a pilot crystalline silicon cell production line (capacity 30 MW) based on existing expertise in manufacturing digital disks. Other companies are involved in developing products and processes (see French National Survey Report, IEA-PVPS/Task 1). 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. At the same time, the *Institut photovoltaïque d'Île-de-France* (IPVF – Île-de-France photovoltaic institute) was under formation; drawing together several public-private research centres specializing in thin films.

INDUSTRY AND MARKET DEVELOPMENT

The French government's policy has led to growing interest in the renewable energy sector from major energy companies, many of which have created specialist renewable energy subsidiaries. Companies in the solar thermal and electricity sectors have also begun to incorporate photovoltaic technology into their business models. There is a thriving business community throughout the photovoltaic value chain, with around 15 photovoltaic module and/or cell manufacturers accounting for a total production capacity of some 1 000 MW. New building-integrated photovoltaic (BIPV) products have been awarded Technical Assessment Certificates (or green "Pass'Innovation" certificates) from the CSTB (French Scientific and Technical Centre for Building). There are also other initiatives currently in progress, focusing on concentrator systems and combined PV/T collectors.

As of 30 September 2011, the total power output of all connected photovoltaic systems in France was 2 384 MW. With an additional 1 217 MW of connections in the first nine months of 2011, the total power output of all connected photovoltaic systems has more than doubled since the end of 2010. Although there has been a general downward trend in new connections since early 2011, the number of installations above 36 kW is expanding rapidly. The growing number of new, large-scale installations has meant that the total power output connected to the grid has increased sharply.

Installations above 100 kW (i.e. 1,4 % of the total number of installations) currently account for 54 % of the total connected power output, compared with 37 % at the end of 2010. These include 63 installations equal to or above 3 MW, delivering a total power output of 421 MW.

Many new installations are due to be connected in the coming months, with 19 146 connection agreements signed as of the end of September, representing a total additional power output of 1 225 MW (source: SOeS, Department of the Commissariat General for Sustainable Development. For detailed data, see French National Survey Report, IEA-PVPS/Task 1).

The European photovoltaic industry experienced a difficult year in 2011. Many major companies and pioneers in the sector were affected by the economic slow-down, the effects of excessive capacity and a fall in photovoltaic module retail prices. In France, the revision of the government's support policy – including a reduction in purchase prices and tax credits – has had an impact on user confidence. Many small companies, which once saw the photovoltaic sector as a promising area for growth and diversification, have filed for bankruptcy.

Unions, associations and all parties involved in the French photovoltaic sector held a meeting in 2011 to discuss the consequences of the purchase price review and to prepare a series of proposals, to be submitted to the government, to improve the visibility of the industry – a key factor in securing the long-term success of the sector. Following this meeting, known as the *"États généraux du solaire photovoltaïque"* (Solar Photovoltaic General Assembly), a white paper was produced, outlining the future of renewable energy by 2020 and 2030. The white paper sets out 12 proposals, including expanding the use of photovoltaic technology in urban planning rules and thermal regulations, by encouraging the development of positive-energy buildings; incorporating photovoltaic industrial developments into public policy; creating a single market support mechanism based on purchase prices and incorporating a self-consumption bonus mechanism; and setting total installation power output targets of 20 GW by 2020 and 40 GW by 2030.

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY – STATUS AND PROSPECTS

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

Fig. 1 - In Germany, already more than one million solar systems have been installed (Photo: BSW-Solar).

GENERAL FRAMEWORK

Germany's future energy supply will be environmental friendly, reliable and economical feasible. The German Federal Government paved the way for this target when announcing the German Energy Concept in autumn 2010. Moreover, it was decided in 2011 to terminate the production of nuclear power by 2022.

Concerning 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 is expected to reach 35 % in 2020 and 80 % in 2050. The first half of 2011 showed already a share of 20 %.

Photovoltaics (PV) are part of this development. At present, a PV capacity of roughly 24,5 GW is connected to the grid meaning again an annual increase of around 7,5 GW. The installation of PV systems in Germany is still driven by the Renewable Energy Sources Act (EEG) on the one hand and a noticeable decrease of system prices on the other hand.

NATIONAL PROGRAMMES

In Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) undertakes 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) [1]. In terms of achieving expansion targets for renewable energies in the electricity sector, the EEG is the most effective funding instrument at the German government's disposal. It determines the procedure of grid access for renewable energies and guarantees favourable feed-in tariffs for them.

Research and Development (R&D) is conducted under the new 6th Programme on Energy Research "Research for an Environmental Friendly, Reliable and Economical Feasible Energy Supply" [2] 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. Main parts of the programme are administrated by the Project Management Organisation PtJ in Jülich.

RESEARCH AND DEVELOPMENT

Funding Activities of the BMU

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 2011 the BMU support for R&D projects on PV amounted to about 38,8 MEUR shared by 206 projects in total. That year, 96 (2010: 45) new grants were contracted. The funding for these projects amounts to 74,3 (2010: 39,8) 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's "Annual Report on Research Funding in the Renewable Energies Sector" [3] or via a web-based database owned by PtJ [4]. The German contributions to the PVPS Tasks 11, 12, 13 and 14 are part of the programme.

Funding Activities of the BMBF

In 2008, the BMBF published its concept paper, "Basic Energy Research 2020+," aiming for the support of long-term R&D on renewable energies which is complementary to the BMU funding. Concerning PV, currently there are three focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells.
- A call for networks aiming for the development of thin-film solar cells was initiated in 2008. First projects started in 2009, putting emphasis on topics such as material sciences including nanotechnology, new experimental or analytical methods and the usage of synergies with other fields of research such as microelectronics or bionics.
- 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.

The BMBF activities will continue under the 6th Energy Research Program.

Innovation Alliance PV – a joint initiative of BMU and BMBF

In summer 2010, BMU and BMBF initiated the Innovation Alliance PV. Under this scheme R&D projects will be funded which support a significant reduction of PV production costs in order to enhance the competitiveness of Germany's industry. Therefore, projects under industrial leadership integrating different steps of the PV value chain were sought. In particular, cooperation between PV industry and PV equipment suppliers is of importance. Together, BMU and BMBF will support this initiative with 100 MEUR. The German PV industry agreed to raise an additional 500 MEUR to accompany the Innovation Alliance.

The first R&D projects were started in 2011. Currently 19 projects are approved:

- BMU: 9 co-operative projects (38 single grants) with a total amount of funds of 32,6 MEUR.
- BMBF – Basic Research: 5 co-operative projects, total amount of funds: 20,3 MEU.
- BMBF – Optical Technologies: 5 co-operative projects, total amount of funds: 19,2 MEU.

IMPLEMENTATION

Since 2004, Germany is among the countries with the highest annual PV installation worldwide. This remarkable development is based on the "Renewable Energy Sources Act (EEG)" [1]. The EEG rules the input and favourable payment of electricity from renewable energies by the utilities. For PV, the feed-in tariff depends on the system size and whether the system is ground mounted or attached to a building. Since 2009, there is also a tariff for self consumed power. All rates are guaranteed for an operation period of 20 years, see [5].

Initially, a uniform and yearly reduction of the PV tariffs was foreseen. On the background of a constantly rising number of installations, a mechanism was introduced to adapt the EEG tariff to the market growth. Under this scheme, the reductions are increased or decreased if the market deviates from a predefined corridor. For 2010 to 2012, the corridor is currently set between 2 500 and 3 500 MW yearly. With around 7 500 MW installed in 2011, the corridor was surpassed considerably. Therefore, additional adaptations of tariffs in 2012 are under discussion.

Table 1 shows the development of the feed-in tariff for small rooftop systems (< 30 kW) since 2001.

INDUSTRY STATUS

The German PV industry showed a strong and steady growth in recent years. Today, burdens resulting from the world economic crisis and from increased competition result in a far more complex 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 manufacturer
- 70 companies with PV productions (ingots, wafer, cells, modules)
- 75 PV equipment manufacturers

and additional manufacturers of materials for PV modules and PV system components [6].

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 world-wide. At the end of 2010, around 130 000 workers were employed in the PV industry, in handcraft and trade companies [7].

TABLE 1 – DEVELOPMENT OF THE FEED-IN TARIFF FOR SMALL ROOFTOP SYSTEMS (< 30 KW)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CT*/KWH	50,6	48,1	45,7	57,4	54,5	51,8	49,2	46,75	43,01	39,14(33,03°)	28,74	24,43

**Euro cent ° from October until December 2010*

***As of January 2012*

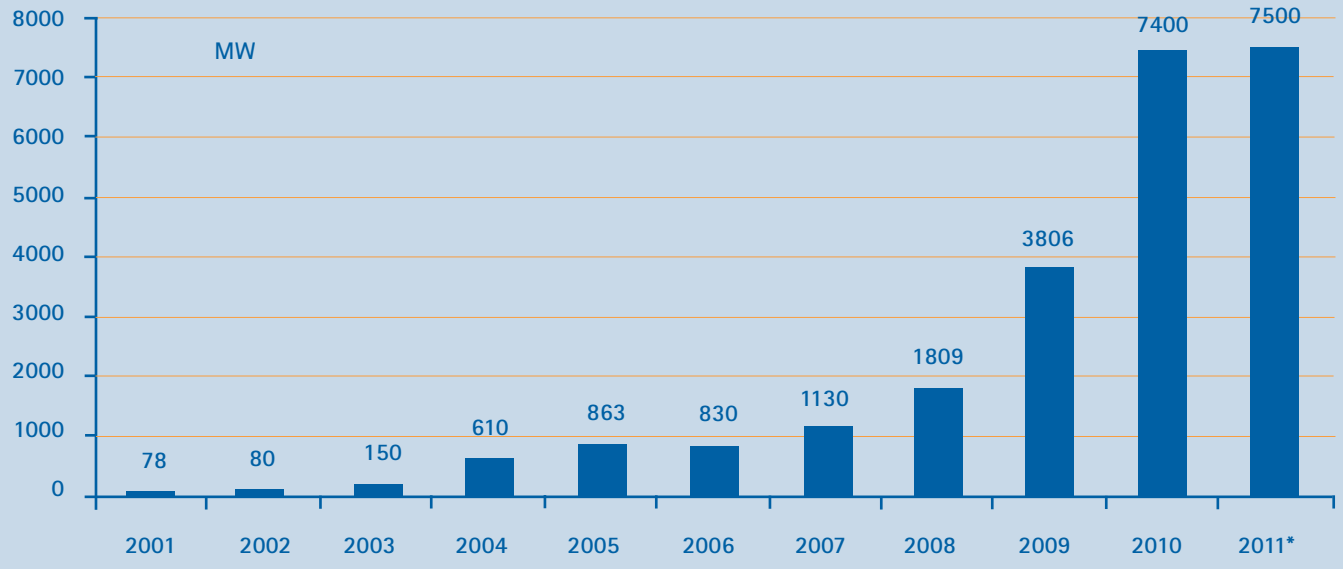

*Fig. 2 - Development of grid connected PV capacity in Germany, *first estimate as of January 2012.*

MARKET DEVELOPMENT

The EEG accelerated the installation of grid-connected PV-systems in Germany significantly. In addition, the decrease in system prices continues, which makes PV systems economically more and more attractive. An analysis published by BSW-Solar, the German Solar Industry Association, shows that the average price for PV rooftop systems of less than 100 kW arrived at around 2 080 EUR/W in the last quarter of 2011 [7]. This means, the system prices was cut in half over the last four years (i.e. since 2007).

For 2011, current estimates assume an additional PV capacity of around 7 500 MW [8]. Since the PV capacity on the grid amounted to 17 348 MW at the beginning of 2011 at the end of 2011 around 24,8 GW in total may be installed, see Figure 2.

In addition to the market of grid connected systems, there is a steady request for stand alone systems. First estimates indicate that in 2011 between 4 and 5 MW were installed mainly for industrial applications such as the automotive sector, traffic signals, etc.

FUTURE OUTLOOK

Over the last years, a significant reduction in systems prices was achieved. One main target of the members of the German PV industry association, BSW-Solar, is to constantly lower the costs of solar power. Consequently, the current technical and economical status has to be developed further. Enhancement of production efficiency and at the same time, lowered production costs are still important. For that reason, high-level R&D is needed. Here, the funding of BMU and the Innovation Alliance PV are important pillars.

The German Energy Concept aims for a 35 % share of renewable energies in the electricity sector until 2020. For PV, one assumes a future installation between 2 500 MW and 3 500 MW annually for the next years. This may lead to an installed capacity of around 40 GW in 2020. For the general strategy on the German energy concept, see [9].

REFERENCES

[1] *Renewable Energy Sources Act (EEG), http://www.erneuerbare-energien.de/inhalt/47883/*

[2] *The 6th Energy Research Programme of the Federal Government, http://www.bmwi.de/English/Navigation/Press/press-releases,did=428778.html*

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

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

[5] *For 2011 the tariffs were defined as 21.11 / 22.07* Ct/kWh for ground mounted systems (*for systems on so-called conversion areas - for example former military or industrial sites). For systems attached to buildings the tariffs are 28,74 Ct/kWh for systems smaller than 30 kW, 27,34 Ct/kWh for systems smaller than 100 kW, 25,87 Ct/kWh for systems smaller than 1 MW and 21,57 Ct/kWh for systems bigger than 1MW. For self consumption between 11,61 and 18,30 Ct/kWh are foreseen, depending on system size and fraction of self consumption. Tariffs for 2012 can be found at www.bundesnetzagentur.de.*

[6] *Germany Trade and Invest – for PV see http://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Energy-environmental-technologies/solar-industry.html*

[7] *BSW-Solar Fact Sheet "Statistic Data on the German Solar Power (Photovoltaic) Industry," January 2012, see http://www.solarwirtschaft.de/en/photovoltaic-market/*

[8] *Press release of the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway of January 9th, 2012, see http://www.bundesnetzagentur.de/cln_1932/SharedDocs/Pressemitteilungen/EN/2012/120109IncreaseNumberPhotovoltaicSystems.html?nn=48242*

[9] *German Government's Energy Concept, see http://www.erneuerbare-energien.de/inhalt/46516/3860/, and German National Renewable Energy Action Plan, see http://www.erneuerbare-energien.de/inhalt/46291/20026/*

ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE
DR H. AVRAHAM ARBIB, DEPUTY CHIEF SCIENTIST AND DIRECTOR, DIVISION OF R&D, MINISTRY OF ENERGY AND WATER RESOURCES

Fig. 1 – Prismatic Solar Curtain wall by SolarOr.

GENERAL

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. The Ministry has already approved projects for more than one third of the target installed power.

As a result of the feed-in tariffs for distributed systems that were introduced by the Public Utility Authority-Electricity in mid 2008, cumulative installed capacity has reached about 200 MW_p (25 MW_p residential, 175 MW_p commercial). Many more installations are underway. The installation cap is 310 MW_p over seven years. The tariffs are for up to 15 kW_p residential systems, and up to 50 kW_p commercial ones, are guaranteed for 20 years and are subject to updates. Additional tariffs were later introduced:

- for power plants between 51 kW_p and the largest size that can be connected to the distribution grid;
- for systems connected to the transmission grid (larger than 20 MW_p);
- for land tenders (issued by the government) - the connection is to the distribution grid; three tenders have recently been awarded, for a total of 16 MW_p.

The following table shows the present tariffs, as well as the caps (until the end of 2014):

SYSTEM	FIT [NIS/KWH]	CAP [MW]
Commercial installations	1,07	260
Residential	1,22	50
Systems connected to the distribution grid	0,90	300
Systems connected to the transmission grid/larger than 20 MW	0,98	200
Land tenders	1,025	60

It is expected that these actions will continue to influence strongly the local PV market. There is a growing interest among the general public, as well as among investors, in clean and local energy sources. The feed-in-tariffs look attractive, considering the fact that a PV installation in Israel could generate up to twice the amount of kWh as compared to installations in central Europe.

An international tender for a 30 MW_p PV power plant issued by the government in April 2008 should be 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.

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. A few start-up companies are active in the field of capital equipment and consumables, mainly for the metallization step.

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:

- At the Weizmann Institute of Science, a new type of inversion solar cell was demonstrated. It presents a significant new option to help drive down the costs of Si cells. As part of a wide survey of the state of the art of PV conversion, also basic limits to PV conversion with organic and molecular solar cells were identified and analyzed to provide realistic goals for further development.
- 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.

DEMONSTRATION AND DEPLOYMENT

- The building sector accounts for more than 40 % of total energy consumption. Integrating solar technology with building facades yields a glass curtain wall which could potentially supply most of building energy needs. SolarOr has developed the Prismatic Solar Curtain wall, based on the Low Concentration Photovoltaic (LCPV) technology and offering an architecturally appealing look resembling a honeycomb (Fig. 1). The implementation of this technology on buildings enables to produce energy close to its main consumer, without land usage. The unit functions as passive energy reducer as well, by improved insulation and light-management characterization, allowing the diffuse light to penetrate the building while blocking the direct sunlight. SolarOr is establishing its first demo site in Israel.

- Generating energy from the sun would be more practical if not for two huge drawbacks: the cost of the silicon material that converts light to electricity, and the large tracts of land needed for solar farms. By solving both problems with solar energy grids that can float on water, Solaris Synergy captured first place in the Israel National Cleantech Open IDEAS Competition in November 2010. Constructed of lightweight plastic and fiberglass, a grid of connected modules can float on any fresh-, salt- or wastewater surface. This solar-on-water platform doubles as a breathable reservoir cover that reduces evaporation and eliminates algae (Fig. 2).

Fig. 2 – Solaris Synergy's testing facility.

- Arava Power has commissioned the first utility-grade PV field in the country, covering an area of 8 hectares on the southern edge of Kibbutz Ketura in the Negev desert (Fig. 3). It is comprised of 18 500, 270 W_p polysilicon panels totaling about 5 MWp. It feeds into the medium-voltage distribution grid of the Arava district. Other ground-based PV power plants ranging in size from 2 MW_p to 10 MW_p are in various stages of pre-construction.

- Pythagoras Solar unveiled the world's first transparent photovoltaic glass unit designed to be easily integrated into conventional buildings. In June 2011, the Pythagoras Solar window won the prestigious GE Ecomagination Challenge, which recognizes the most promising innovations for capturing, managing and using energy in buildings.
- Watts & More has developed a PV panel level electronics module aimed at reducing the mismatch that causes field energy production degradation. The product line is intended for large-scale ground and roof installations.
- SolarBead is developing a novel micro-inverter, the InverBead (Fig. 4), aimed at roof-top markets as well as at power plants applications. The InverBead is based on an innovative patented algorithm that improves the system performance and enhances the energy harvesting specially in partial shading conditions, degradation of modules performance and in fast alternation of the solar radiation. The InverBead thus reduces costs of the installation and integration. In addition it provides instantaneous power factor correction. Marketing of the InverBead is planned for the end of 2012.

Fig. 4 – The InverBead.

GOVERNMENT ACTIONS

It is expected that the Government activity described above (feed-in tariffs for distributed PV and solar power plant tender) will continue to influence favorably the PV market. In addition, a number of actions are being taken to encourage the PV activity. Among them:

- Support of R&D excellence centers through selective funding of projects, including start-ups, pilot and demonstration projects. Direct expenditures in PV R&D by the Ministry of Energy and Water Resources increased fivefold in 2011, and were about USD 2 560 000 (USD 324 000 for academic research, 492 000 for start-ups, 1 742 000 for pilots and demos). In addition, USD 530 000 were invested in cooperative projects with the US. More funding is available in this area from other research foundations.
- Partial funding (up to 30 %) of innovative deployment-support projects.

ITALY

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

Fig. 1 and Fig 2 - 8,64 kWp PV shields at Sarcedo (VI), Italy.

GENERAL FRAMEWORK

The year 2011 has been characterized by an impressive growth of installations due the excellent investment conditions represented by the high incentive tariffs, alternative to «tumultuous» moments, caused by institutional measures that introduced uncertainty and discontinuity for the entire market.

A preliminary evaluation of the overall cumulative power (installed, operating and admitted to incentive tariffs) in Italy, at the end of 2011, resulted in about 12 000 MWp. Just one year ago, such cumulative power reached about 3 500 MW while a further 3 700 MW has been declared for construction completion in the framework of the "Salva Alcoa" decree. As a consequence, about 4 800 MW have been installed during 2011, while the power admitted to governmental contribution reached 7 500 MW. The amount of installation recorded in 2010 (about 6 000 MW) and in 2011 (4 800 MW) was certainly achieved with too high incentive tariffs with respect to system prices reduction.

In this framework, an impressive turnover has been generated: the budget for the 800 Italian companies operating in PV sector was very positive, even if there was some speculative and opportunistic behavior.

The barriers due to bureaucratic problems are still evident and have a high impact on PV plant costs. From the technical point of view the main barrier is represented by the electric grid that is becoming inadequate in some regions of southern Italy, where the installed power of wind turbines and photovoltaic power stations is almost the same order of magnitude of peak load. As a consequence, the growth of the photovoltaic market could be slowed down, in the absence of an adequate plan for MV and HV grid development.

NATIONAL PROGRAMME

The national market stimulation initiative in operation since 2005 is the "Conto Energia" Programme.
The first phase was completed during 2009. In this context, 5 733 plants have been installed, corresponding to a total power of around 164 MWp.

The second phase has been defined through a governmental decree issued in February 2007. This phase has been characterized by the issue of the "Salva Alcoa" decree that has extended the validity of the related tariffs from the end of 2010 to June 2011 for affirmed declarations of construction completion recorded until 31 December 2010. This phase resulted in setting more than 203 000 plants into operation, corresponding to a total installed capacity of over 6 800 MW.

In July 2010, the third phase was established: an increase of the national objective from 3 GW by 2016 to 8 GW by 2020. During the period of validity of this phase (from January to June 2011) a great amount of installations (almost 38 300) have been realized, corresponding to a total power of 1 550 MW. In fact, during this period excellent investment conditions, due to the market availability of low price photovoltaic components, caused a surge in installations.

The present ministerial decree, regulating the incentives for PV plants (fourth Conto Energia), was issued by the Minister of Economic Development and the Minister of the Environment on 5 May 2011. The most important aspects regard:

- Total spending limit for the period 2011-2016, corresponding to a total capacity of 23 GW with cap every six months;
- A reduction of the incentive tariffs starting in June 2011;

Fig. 3, Fig. 4 and Fig. 5 - 3 kWp PV rooftop at Novellara (RE), Italy.

- Higher tariffs for concentrated photovoltaic plants and for systems realized on building with innovative features;
- Two kinds of plants: The «small plants" installed on buildings not exceeding 1 MW or ground-mounted up to 200 kW and the "large plants" (all the other ones); until the end of 2012, large plants are allowed incentive tariffs in the framework of a cost limits, while small plants, can benefit from the tariff without such limits. In any case, exceeding the limit for a given period does not restrict access to the incentive tariffs, but results in an additional reduction of the next period limit;
- From 2013, an all-inclusive tariff will be introduced, to which will be added a tariff for self-consumption; moreover, from 2013, exceeding the budget limit will result in an additional reduction of the incentive for the next period;
- An increase of tariffs for plants owned by small municipalities for installation on brown-field sites, landfills, etc. for modules that replace asbestos; a further novelty regards a tariff increase for plants using components manufactured within the European Union.

In the framework of the fourth phase, about 76 150 plants corresponding to 4 100 MW have been installed during 2011.

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 promoting and supporting renewable energy sources). Additional contributions have been supplied by some Universities, CNR (the National Council for Scientific Research) and few private laboratories.

ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest regard: crystalline silicon, Cu_2O solar cells, microcrystalline Si devices, micromorph tandem solar cells, as well as concentrator 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" and SOPHIA. 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 total cumulative capacity of about 12 000 MWp were installed in Italy at the end of 2011.

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

off-grid systems:	amounting to 15 MWp;
on-grid centralized systems (>200 kWp):	reaching about 8000 MWp (*) (starting to dominate Italy's cumulative installed photovoltaic power)
on-grid distributed systems:	amounting to about 4000 MWp (*)

(*) preliminary evaluation

INDUSTRY STATUS AND MARKET DEVELOPMENT

In the year 2011, about 14 main producers of crystalline silicon cells and finished PV products have been identified in Italy. On the whole, a total production around 450 MW has been estimated. As a consequence remains still low the share of installed modules that have fabricated in Italy.

The position of Italian firms operating in the power conversion system field is different. In fact, about 50 % of the inverters installed in 2011 have been produced in Italy while a larger figure has been exported. Taking into account also exported volume, about 5 000 MW of inverters have been produced in Italy during 2011.

FUTURE OUTLOOK

Despite the tariff decrease from 2011, the return rate for solar photovoltaic investments in Italy is still higher than in other countries. In this context, the Italian national target of 23 GW could be reached in a very few years. On the other hand, the grid connection is becoming critical; especially in southern Italy and in 2012, the grid should have about 17 TWh of solar PV production; that is 5,5 % of the national electricity consumption.

Moreover, the annual cost for the incentive tariff has reached 5 500 MEUR and is quickly reaching the limit of 6 000 MEUR, fixed by the fourth phase of the "Conto Energia" programme.

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

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OSAMU IKKI, RTS CORPORATION

Fig. 1 - Tokyo Institute of Technology Ookayama Main Library (Ookayama, Meguro-ku, Tokyo). Louver: 12 kW, CIS PV module (by Solar Frontier).

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 three principles of 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. Furthermore, the "Basic Energy Plan" was formulated in order to materialize a basic direction of Japan's energy policies.

2) Direction for dissemination of new and renewable energy: Law Concerning Special Measures to Promote the Use of New Energy (New Energy Law, enacted in 1997)
   This law stipulates responsibilities of the national government, local governments, energy consumers and suppliers, as well as manufacturers of energy equipment for dissemination of new and renewable energy.

3) Enhancement of 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 Basic Energy Plan that stipulates direction of Japan's energy policy toward 2030 was formulated in 2010 by reviewing the New National Energy Strategy formulated in 2006. 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.

5) Short- to mid-term strategy for technology development of PV systems: "PV2030+ (Plus)" roadmap for technology development of PV systems (formulated in 2004 as PV Roadmap Toward 2030 (PV2030), reviewed and revised in 2009 as PV 2030+ (Plus)).
   Goals for technology development of PV cells/ modules and systems were set, five years ahead of the original schedule, from a mid-term perspective for the period up to 2030, with a longer-term perspective towards 2050.

6) Long-term strategy for technology development of PV systems: Cool Earth Energy Innovative Technology Plan (formulated in 2007)
   "Innovative PV power generation" was selected as one of the 20 topics of innovative technology development which will 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 reduce the cost of PV power generation from the current level of 46 JPY/kWh to 7 JPY/kWh.

7) Target 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 Non-fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers" (enacted in 2009)
The basic purchase price of surplus electricity generated by PV systems for FY 2009 and FY 2010 was set at 48 JPY/kWh. For FY 2011, the purchase price is 42 JPY/kWh.

9) Obligations to purchase the entire electricity generated by renewable energy at fixed rates for the Feed-in Tariff (FIT) program: Renewable Energy Law (enacted in 2011)
METI is preparing for the enforcement of the law in July 2012, including stipulation of tariffs, terms of purchase, etc.

10) Cultivation of the PV industry: the New Growth Strategy and the Industry Structure Vision 2010 (both formulated in 2010), and Realizing the New Growth Strategy 2011 (formulated in 2011)
The sectors that Japan will strategically promote the growth are identified. "Japan as a global power in the environment and energy sector with green innovation" as one of the core strategies and "Establishment of an environment related new market with the size of over 50 trillion JPY" and "Creation of 1,4 million jobs in the environment sector" and other targets are listed. The PV industry is positioned as one of the industries to support this sector.

11) Support programs for dissemination: METI, the Ministry of the Environment (MoE) 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, a project to accelerate introduction of new and renewable energy, technology development of PV power generation and a project to establish Eco Schools, etc.

NATIONAL PROGRAM

The Japanese government has been promoting measures for further deployment of PV systems and the Ministry of Economy, Trade and Industry (METI) has been taking a major role to implement research and development (R&D) programs, demonstrative researches, model projects, dissemination measures, laws and regulations. METI restarted the subsidy program for residential PV systems from January 2009 with the supplementary budget of FY 2008 and continued the program in FY 2011 with a budget of 34,9 BJPY. In the area of R&D, METI continuously promotes technology development of PV systems for cost reduction and dissemination of PV systems and demonstrative researches. The Ministry of the Environment (MoE) promotes countermeasures for global warming as one of the efforts to create a low-carbon society and offered subsidy for interest rate to eco-friendly leasing businesses which conducts leasing of PV modules and other low-carbon equipment in FY 2011.

In the 3rd supplementary budget passed by the Diet on November 21, 2011, the government allocated the budgets for the programs or projects promoting PV power generation. "Subsidy for introducing residential PV systems as restoration measures" (86,99 BJPY) and "Projects for establishing a fund for high penetration of residential PV systems as restoration measures" (32,39 BJPY) were established as a fund and will be utilized this fiscal year (FY 2011) and until FY 2013 to promote installation of residential PV systems. "Subsidy for introducing renewable energy systems as part of restoration measures" was established as a measure to subsidize introduction of renewable energy power generation systems including PV systems and wind power generators as well as storage batteries for this equipment in the areas damaged by the Great East Japan Earthquake, which occurred on March 11, 2011. In addition, the budgets were requested to establish an R&D base for renewable energy in Fukushima Prefecture responding to Fukushima nuclear power plant failures.

The major national PV programs implemented FY 2011 regular budget are as follows;

1) Subsidy for measures to support introduction of residential PV systems: 34,9 BJPY
2) Technology Development of Innovative Photovoltaic Power Generation: 8,04 BJPY
   - R&D for High Performance PV Generation System for the Future: 5,98 BJPY
   - R&D on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program): 2,06 BJPY
3) Demonstration project on developing forecasting technology of PV power generation: 0,10 BJPY
4) Development of electric energy storage system for grid-connection with new and renewable energy resources: 2,0 BJPY
5) International collaboration project on efficient use of energy consumption (Japan-U.S. Smart Grid Collaborative Demonstration Project in New Mexico, USA): 1,0 BJPY
6) Project supporting acceleration of the local introduction of new energy: 13,0 BJPY
7) Eco lease business promotion project for household and business (Subsidy for lease interests by entities who lease low-carbon devices such as PV modules (3 % of the price of low-carbon devices)): 2,0 BJPY

The budget for item 4) - 7) includes those for PV and other types of new and renewable energy. Major national PV programs implemented in the FY 2011 3rd supplementary budget are as follows:

1) Subsidy for introducing residential PV systems as restoration measures: 86,99 BJPY
2) Projects for establishing a fund for high penetration of residential PV systems as restoration measures: 32,39 BJPY
3) Project to establish an R&D center on renewable energy in Fukushima Prefecture: 5,0 BJPY
4) Project for R&D on renewable energy in Fukushima Prefecture: 5,1 BJPY (3,0 BJPY is allocated for photovoltaics)
5) Subsidy for introducing renewable energy systems as part of restoration measures: 32,6 BJPY

The budget for item 3) - 5) includes those for PV and other types of new and renewable energy.

Fig. 2 - Odaiba Gasshukoku summer amusement park at Fuji Television Network, Inc. (Daiba, Minatoku, Tokyo), installed for a temporary use. CIS PV modules by Solar Frontier: 50 kW , CIS PV modules by Honda

R&D, D

R&D

"R&D for High Performance PV Generation System for the Future," which started in FY 2010 as a 5-year R&D program to mainly achieve the technological target of "PV power generation cost of 14 JPY/kWh" has been continued by New Energy and Industrial Technology Development Organization (NEDO). The program consists of the following technological development projects for the pursuit of higher conversion efficiency, highly-functional materials and components, longer lifetime of PV modules, evaluation technology of performance and durability: i) total 7 projects conducted by academic-industrial consortium covering crystalline silicon, thin-film silicon, thin-film CIGS, and organic thin-film solar cells; ii) 6 technological development projects proposed by industrial players; and iii) R&D projects for common fundamental technologies on evaluation technologies for PV cell/ module performance and reliability issues. In the 3rd supplementary budget finalized in November 2011, the establishment of a new research institute in Fukushima Prefecture to mainly support renewable energy related industries was decided in relation to the project for restoration from the Great East Japan Earthquake, and the preparation is underway mainly for the technological development on crystalline silicon solar cells.

Research and Development on Innovative Solar Cells (International Research Center for Innovative Solar Cell Program), a 7-year R&D program that has been continued since FY 2008, is a seeds-seeking research program aiming at drastically improving performances of solar cells (target conversion efficiency: 40 % and above). While some sub-theme projects were discontinued based on the mid-term evaluation conducted in 2010, 3 projects are continued: i) research and development project of ultra-high efficiency post-silicon solar cells led by the University of Tokyo; ii) research and development project for thin film multi-junction solar cells with highly ordered structure, led by National Institute of Advanced Industrial Science and Technology (AIST); and iii) research and development project of thin film full spectrum solar cells with low concentration, led by Tokyo Institute of Technology (TIT).

In the field of fundamental research, the following 2 R&D programs under the control of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) have been continued and new proposals were called (final call): i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells (an individual proposal-oriented program with a research term of 3 to 5 years); and ii) Creative Research for Clean Energy Generation using Solar Energy (a team proposal-oriented program with a research term of 3 to 5 years). Under Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells, 36 projects including 12 new projects have been conducted to study various PV elemental technologies and develop novel materials. Creative Research for Clean Energy Generation using Solar Energy has been conducted with a total of 14 projects, including 3 new projects such as a project on optical management technology. Development of Organic Photovoltaics toward a Low-Carbon Society conducted by University of Tokyo has also been continued. Furthermore, R&D for high performance solar cells will be conducted in a newly established R&D program on next-generation energy for reconstruction of Tohoku (quake-stricken) area.

Demonstration

Demonstration projects were implemented in Japan and overseas mainly on smart community in FY 2011, and PV systems were installed in the projects in a large volume. Overseas, smart community demonstration projects have been planned and implemented in New Meixco and Hawaii in the USA, Lyon in France, Malaga in Spain, Gongqingcheng, Jiangxi Province in China and Java Island in Indonesia. In addition, a comprehensive joint project in solar energy area has been promoted in Morocco.

(1) Demonstration Project of Next-Generation Energy and Social Systems

Demonstrative research on a next-generation energy and social system with the installation of PV, storage battery and other systems has been conducted in 4 cities: Yokohama City, Kanagawa Prefecture; Toyota City, Aichi Prefecture; Keihannna Science City, Kyoto Prefecture and Kitakyushu City, Fukuoka Prefecture. The objectives of the demonstration projects in each city are as follows: i) Yokohama City is for the comprehensive demonstration in a metropolis, ii) Toyota City is for the demonstration focusing on the next generation vehicles, iii) Keihannna Science City is for the demonstration in an area where homes and research institutes are dispersed into relatively large area, iv) Kitakyushu City is for the regionally specific demonstration. The term of this project is from FY 2010 to FY 2014.

(2) Verification Test of a Micro Grid System for Remote Islands

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

(3) Japan-U.S. Smart Grid Collaborative Demonstration Project in New Mexico, USA

This is a Japan-US joint demonstrative research implemented in Los Alamos County and Albuquerque City in the State of New Mexico. Demonstrative project on smart grid, smart house and others has been conducted in residential and commercial areas. The term of the project is from FY 2009 to FY 2013, and the overall budget scale is approximately 4 BJPY.

(4) Verification Test of a Smart Grid System for Remote Islands in Hawaii, USA

Verification tests on smart grid in remote islands have been implemented in Maui Island in the State of Hawaii using renewable energy and electric vehicles (EVs). The term of this project is from FY 2011 to FY 2014, and the overall budget scale is approximately 3 BJPY.

(5) Smart Community Demonstration Project in Lyon, France

Introducing Japan's cutting-edge technology, this demonstrative project is to contribute to sustainable development of the Lyon redevelopment district. The plan to build a positive energy building as a model building, establish EV car-sharing service, introduce "Energy Box" to control energy at home, and set up a community management system (CMS) to control energy in the whole community has been under consideration. The overall budget scale is approximately 5 BJPY and the term of this project is scheduled to be from FY 2011 to FY 2015.

(6) Technology Demonstration Project utilizing Large Scale PV System in India

This project was agreed in a Japan-India joint project, the «Delhi-Mumbai Industrial Corridor» (DMIC) for the joint development of smart community. Utilizing a MW-scale PV system and others, the two countries will start a demonstration project combining supply-demand monitoring for micro grid in industrial complex with technology for stable supply of grid electricity of the same quality. The term of this project is from FY 2010 to FY 2013, and the overall budget scale is approximately 4 BJPY.

(7) Smart Community Demonstration Project in China

This demonstrative project on smart community has been started in Gongqing City, Jiangxi Province in China. In a smaller city in inland China where tremendous population increase is observed, the project is to build and demonstrate an energy management system with the introduction of low-carbon traffic management system, smart grid and others in addition to energy conservation and renewable energy technologies. The total budget of the project is approximately 3 BJPY and the term of the project is scheduled to be from FY 2011 to FY 2013.

(8) Demonstration Project for Smart Grid-related Technology in Malaga, Spain

In collaboration with the "Malaga Smartcity Project" in the city of Malaga, Spain, this project is to promote joint research and demonstration in the technology areas relating to smart community. The plan includes large-scale introduction of renewable energy and electric vehicles (EVs). The term of this project is from FY 2011 to FY 2015, and the overall budget scale is approximately 5 BJPY.

(9) Smart Community Demonstration Project in an Industrial Complex in Java Island, Indonesia

This project conducts a feasibility study for the introduction and demonstration of smart community-related technology in order to achieve stabilized electricity and establish an eco-friendly low-carbon society at the same time.

(10) Collaborative Projects in the Solar Energy Field with Moroccan Government

This was agreed with the Moroccan government to promote comprehensive collaboration on the solar energy area in December 2010. Under the agreement, the project conducts baseline examination of grid stabilization technology related to PV systems in a large scale. According to the plan by the Moroccan government, a total capacity of 2 000 MW of solar energy power generation will be introduced by 2019.

IMPLEMENTATION

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

METI is leading dissemination of PV systems for residential houses and public and industrial applications. Besides the subsidy for installation of facilities, METI is implementing the program to purchase surplus PV power. METI also supports local governments to

introduce new and renewable energy. Through related organizations, METI also offers some programs such as low-interest loans and tax credits.

1) Subsidy for Measures to Support Introduction of Residential PV Systems

METI implements the subsidy program for the individuals and companies who install residential PV systems. The amount of subsidy for the FY 2011 is 48 000 JPY/kW. There are requirements for the subsidy such as maximum output capacity must be less than 10 kW and the price of the system is equal to or less than 600 000 JPY/kW. It is expected that the number of PV system installations supported by the subsidy with an initial budget of 34,9 BJPY for FY 2011 will reach approximately 170 000. The number of applications for the subsidy exceeded 200 000 in December 2011. In addition, Subsidy for introducing residential PV systems as restoration measures was introduced following the Subsidy for measures to support introduction of residential PV systems, with the third supplementary budget.

2) Program to Purchase Surplus PV Power

Based on the "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers," METI has been implementing the program to purchase surplus PV power since November 2009. Purchase prices for FY 2011 are 42 JPY/kWh for residential PV systems with less than 10 kW (1,7 times as much as the typical retail price for household) and 40 JPY/kWh for non-residential (less than 500 kW) and residential applications with more than 10 kW of output capacity. Purchase term is 10 years and all electricity users share the purchase costs evenly. This program, coupled with the subsidy program for residential PV system, is the powerful driving force of the PV demand.

3) Project for Promoting the Local Introduction of New Energy

This program aims at accelerating the introduction of new and renewable energy by local public organizations and non-profit private organizations. New and renewable energy installation projects which are locally integrated and collaborative work of local public organizations and private institutions are also eligible for this program. 4 PV projects continued in FY 2011, however, a call for new application was not conducted for PV system in FY 2011. Subsidy is delivered to the PV system with output of 10 kW or above, and the grant rate is the lower amount of either up to half of the installation cost, or 400 000 JPY/kW. From the initiation of the program in FY 1997, the cumulative number of qualified systems and installed capacity were 1 300 systems and 116 MW respectively.

4) Project for Supporting New Energy Operators

This program aims at accelerating the introduction of new and renewable energy by supporting private institutions which install facilities using new and renewable energy. 5 PV projects continued in FY 2011, however, a call for new application was not conducted for PV in FY 2011. Under the condition that the PV system output is equal to or more than 50 kW, the amount of subsidy is the lower amount of either up to one third of the installation cost or 250 000 JPY/kW. From the initiation of the program in FY 1997, the cumulative number of qualified systems and installed capacity reached 1 200 systems and 90 MW respectively. The installations of MW-scale PV power plants is installed mainly by utilities and large scale factories taking advantage of this program and the above-mentioned "Project for Promoting the Local Introduction of New Energy."

(2) The Ministry of the Environment (MoE)

MoE is promoting projects to reduce CO2 emissions by the use of natural energy under the "Law Concerning the Promotion of Measures to Cope with Global Warming." In FY 2011, subsidy for lease interests by entities who lease low-carbon devices such as PV modules was granted (3% of the price of low-carbon devices). In addition, MoE introduced the higher rate of 10 % for the entities in Iwate Prefecture, Miyagi Prefecture, and Fukushima Prefecture in the Tohoku region from November 1, 2011. The budget of 6,2 BJPY was allocated in FY 2011 for "Project for developing technology to prevent global warming (competitive funds)" to support private companies, public research institute, and universities which conduct technology development of leading low carbon transportation and technology development of leading low carbon houses and offices utilizing new and renewable energy including PV. Besides, MoE implements supports of Eco-Renovation of Schools under "School Eco-Renovation and Environmental Education Program".

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

Construction of green government buildings equipped with PV systems and other new and renewable energy systems has been promoted for central ministries and agencies and government offices in local region. For the private sector, MLIT subsidizes a fixed amount of grant or a part of maintenance cost to the projects which contribute to the implementation and enlightenment towards dissemination of renovation for longer operation life and CO_2 reduction at houses and buildings. For the introduction of technologies such as PV systems to reduce CO_2 emissions, MLIT provides subsidy for private institutions who conduct projects which are highly effective as model projects. MLIT also considers leasing of nationally-owned land such as road space to the private institutions to install commercial facilities and PV systems.

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

MAFF implements a subsidy program to install PV systems at facilities for agriculture, forestry and fisheries, in order to promote introduction of renewable energy into these industries. Introduction of PV systems are also included for the comprehensive maintenance supports of living environment in villages dependent on the primary industries. In order to strongly support introduction of PV and other renewable energy facilities in those villages, MAFF implements study on installation potential of these facilities in discarded land for farming.

Fig. 3 - JR Osaka Station (Osaka Station City) (Kita-ku, Osaka City, Osaka) Multicrystalline silicon PV module.

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

In cooperation with MAFF, METI and MoE, MEXT has continued the "Eco-school Pilot Model Project" and is promoting the introduction of new and renewable energy systems such as PV systems, facilities for energy conservation as well as locally-supplied building materials at kindergartens, elementary, junior high and high schools across the nation. By FY 2011, MEXT certified 1 235 schools as Eco School Pilot Model Projects. Of the 1 235 schools, installation of PV systems has been promoted at 840 schools. Under the School New Deal Concept formulated in 2009, MEXT is forwarding the installation of PV systems in public elementary and junior high schools nationwide. Moreover, MEXT implements the subsidy program intended for the national universities and private schools.

(6) Local Governments and Municipalities

The movement to actively work on environmental issues has been spreading among local governments and municipalities year by year. 875 local governments and municipalities established subsidy programs for residential PV systems. Support projects are undertaken in 53 municipalities in Hokkaido, 52 municipalities in Saitama Prefecture, and 49 municipalities in Aichi Prefecture. Most of the programs provide subsidy ranging from 20 000 JPY/kW to 50 000 JPY/kW. Tokyo Metropolitan Government (TMG) set a target to reduce CO2 emissions by 25 % in 2020 compared to that of 2000 under the "Tokyo in 10 years" plan and announced a plan to introduce 1 GW of solar energy. Accordingly, TMG decided to provide subsidy of 100 000 JPY/kW in FY 2009 and FY2010. For FY 2011, TMG continues subsidy of 100 000 JPY/kW in order to support the securing of electricity after the earthquake.

(7) Utilities

Voluntary programs to purchase surplus PV power that electric utilities was replaced by a program to purchase surplus PV power from November 2009, based on a newly-enacted "Act on the Promotion of the Use of Nonfossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers." Under the new program, the purchase price of surplus PV power was set at 48 JPY/kWh, twice as much as the current retail price of electricity. Electric utilities established the "Green Power Fund" in October 2000, aiming at disseminating PV systems and wind power generators. From FY 2001 to FY 2010, 1 568 public facilities including schools across Japan were subsidized by the fund and the total installed capacity reached 27 594 kW.

Electric utilities achieved the obligation amount of purchasing electricity generated from new and renewable energy for FY 2010 designated under the RPS Law that was enforced in FY 2003. Usage of electricity generated by new and renewable energy by utilities in FY 2010 was 10 246 TWh in total, including 1 336,9 TWh from specific PV power plants (facilities intended for "New PV Power Purchase Program") which is not counted as the obligated amount. The obligation amount of 989,1 TWh was completed. The accredited facilities for power generation using new and renewable energy under the RPS Law was 720 587 systems totalling 7 594,9 MW cumulatively, of which PV systems accounted for 114 systems and 49,7 MW and specific PV power accounted for 719 188 systems and 2 728 MW respectively.

Electric utilities continue the introduction of PV systems in their own facilities, which represent their commitment to taking the initiative in introducing PV systems. Federation of Electric Power Companies (FEPC) also announced a plan to construct 30 PV power plants with a total capacity of 140 MW across the nation by 2020 by 10 electric utilities. Most of these projects were conducted with the aim to initiate their operation by 2012, but the construction projects of MW scale PV power plants were developed ahead of schedule, thus a great number of PV plants have completed across Japan. Besides, through affiliate companies, some utilities started the on-site generation business utilizing the customer's roof and rooftop space.

(8) Financial Institutions

Some financial institutions such as banks provide loan programs for individual customers at low interest rates for the introduction of residential PV systems and houses equipped with PV systems. The number of such financial institutions has been increasing year by year. There is also an emerging trend of expanding environmental financing for the projects actively working on environmental issues. Besides, environmental investment in foreign countries as well as support and coalition in the field of environmental business have been initiated with emphasis. The sales of insurance products were also started, covering indemnification risk which was a source of concern to renewable energy related companies.

INDUSTRY STATUS

In the Japanese PV industry, the residential PV market continued growing steadily. For development of MW-scale PV power plants, electric utilities and others started construction ahead of schedule. Industrial players made active efforts to expand sales and add high values to PV products focusing on the domestic PV market. Demand in overseas PV markets which was stagnant in the beginning of 2011 recovered toward the end of the year. However, unfavorable conditions such as continued price reduction of PV products and the yen's extraordinary appreciation resulted in squeezing profits of manufacturers. PV manufacturers and manufacturers of materials are dispersing their production bases in different locations of

Fig. 4 - Miyako Island Large-Scale Solar Demonstration Research Facility Miyakojima City, Okinawa Prefecture Total 4 MW. Microcrystalline thin-film silicon PV module (by Kaneka). Multicrystalline silicon PV module (by Sharp, Kyocera).

the world depending on the locations of suppliers. Also, a growing number of overseas manufacturers are entering the Japanese PV market and increasing their market share.

In 2011, each PV manufacturer conducted its own business development in response to rapidly changing PV markets home and abroad. Sharp started production of a thin-film silicon PV module plant in Italy, as a joint venture. Domestically, Sharp focused on back-contact crystalline silicon PV modules in order to differentiate itself from competitors. Having entered the power generation business, Sharp aims to establish an integrated PV business framework. Kyocera emphasized receiving orders for PV systems home and abroad in expectation for 1 GW production in FY 2012. Panasonic/ SANYO Electric unified the corporate brand to "Panasonic" and decided to extend its PV production capacity for the next phase in Malaysia instead of Japan, which was originally planned. Domestically, SANYO Electric has been promoting PV systems for houses and buildings as well as smart communities, while it has been promoting development of large-scale PV power plants and conducting leasing business overseas. Mitsubishi Electric has been strengthening its monocrystalline silicon PV business. An increasing number of new entrants started full-scale production or increased production volume of PV products, such as high efficiency PV cells/ modules by Choshu Industry and PVG Solution and PV modules by Noritz.

Solar Frontier increased production of its third manufacturing plant to a full capacity of 900 MW/year by the summer of 2011. The company has been expanding sales taking advantage of its distribution channels while continuously focusing on establishing sales collaboration for PV systems with its sales companies home and abroad. Meanwhile, Mitsubishi Heavy Industries (MHI) producing thin-film PV products announced that it would transfer its PV manufacturing lines to Auria Solar in Taiwan as part of business restructuring. Overseas PV manufacturers have been actively launching new products for the growing Japanese residential PV market and promoting sales for the MW-scale PV system market, which is expected to expand. Market share of overseas manufacturers has been largely increasing in the domestic shipment statistics. In the area of silicon feedstock, prices of both polysilicon and silicon wafers have been sharply dropping due to wide gaps between supply and demand, a similar trend of that of PV cells/ modules. M.SETEK resumed the polysilicon production hit by the Great East Japan Earthquake and halted its operation. Tokuyama and Ferrotec announced a plan to increase production ahead of schedule and a plan to further increase production, with an aim of increasing their global market share taking advantage of their technical edges and superior quality.

In the area of PV components, manufacturers are actively increasing production of backsheets, encapsulants and raw polymers in order to deal with GW production by global PV manufacturers, while suffering from deteriorating market conditions. For every component ranging from materials for electrodes, connectors, junction boxes to TCO glass, functions have been improved and applications have been diversified. Manufacturers have been increasing their production capacity for PV applications and a number of companies are entering the PV market one after another. Furthermore, along with production expansion of thin-film PV products, manufacturers of special gas for semiconductors such as hydrogen selenide started competing with each other in expanding their production.

In the area of Balance of Systems (BOS), launching of large-sized power conditioners for large-scale PV systems home and abroad has been intensified. With product development of Home Energy Management Systems (HEMS) and Building Energy Management Systems (BEMS), combination of products such as PV with storage batteries and other new and renewable energy devices is on the rise. Efforts on introducing PV in smart communities also started expanding across industries. Manufacturers of steel and roof materials are stimulating the market of supporting structures for PV systems through expansion of business and development of new products such as simple supporting structures.

In the area of PV manufacturing equipment, demand for quartz crucibles, special carbon (isotropic graphite), saw wires (those with fixed abrasive process, in particular) and wire saws has been expanding particularly due to production increases of crystalline silicon PV products worldwide. For thin-film PV applications, products such as laser patterning devices have been launched. In the PV module manufacturing process, there is a clear phenomenon that manufacturers are shifting their production to China. The market for evaluation and measurement devices remained brisk.

In the area of utilizing PV systems, the residential PV market continued growing and MW-scale PV systems increased, and more PV systems were integrated with smart grid. Accordingly,

an increasing number of businesses are entering the market and enhancing the PV business.

System integrators are strengthening efforts in the domestic market for public and industrial PV systems while developing large-scale PV systems through tie-ups and acquisitions in overseas markets in expectation for the start of the new Feed-in Tariff (FIT) program in the summer of 2012.

In the housing, real estate and construction industries, installation of PV systems in newly-built houses as standard equipment and expansion of installed PV capacity in existing houses have been further advanced. They are also focusing on installing PV systems in collective housing.

In the distribution and sales industries, companies have been aggressively expanding their lineups of products by commercializing PV products from emerging countries and increasing the number of suppliers.

In the finance and insurance industries, the number of large-scale PV system projects has increased and financing for expansion of production capacity and provision of risk compensation have been improved. Furthermore, services to support PV businesses such as product evaluation services, monitoring systems, quality management and provision of meteorological data have been more and more diversified.

MARKET DEVELOPMENT

PV installed capacity in Japan in 2011 is expected to exceed 1 GW for the first time. Cumulative PV installed capacity at the end of 2011 is expected to be 4 GW level.

In the newly-built residential house market, major pre-fabricated house manufacturers supply energy-saving houses equipped with PV systems as well as houses with environment-friendly functions. In addition to the conventional distribution channels of residential PV systems developed by PV manufacturers which consist of local builders, electric contractors, electric appliances stores and roofers, large-scale home electric appliances stores and large-scale retail stores entered the PV market for existing houses. In 2011, a great number of overseas PV manufacturers entered the Japanese residential PV market. Accordingly, market share of imported PV products increased in Japan.

As for medium- to large-sized PV systems for public and industrial facilities, there were no more new projects selected under the Project for Promoting the Local Introduction of New Energy and the Project Supporting New Energy Operators, which means there was no national support program in FY 2011. In preparation for a new Feed-in Tariff (FIT) program scheduled to be enforced in July 2012, a large number of entities are working on market development of a wide variety of PV systems including MW-scale PV power plants in order to enter the power generation business taking advantage of the FIT program.

FUTURE OUTLOOK

The Japanese government has started formulating its new energy strategy in the wake of nuclear power plant failures caused by the Great East Japan Earthquake. The government is formulating the energy strategy from the viewpoint of both the basic energy plan and measures against global warming. As the perspectives required for formulating a new basic energy plan, the government listed the following: 1) sustainable policy under which the citizens feel safe; 2) focus on the "demand side;" 3) focus on consumers and citizens as well as local communities; 4) energy policy which supports the national power and contributes to the international community; and 5) utilization of a variety of power and energy sources. The government has been reviewing its energy strategy by focusing on the following as a desirable energy mix: 1) drastic enhancement of energy conservation and power saving measures; 2) maximum acceleration of development and utilization of renewable energy; 3) clean utilization of fossil fuels (e.g. shifting to natural gas); and 4) reduction of dependence on nuclear power generation as much as possible. Furthermore, as a direction of reforming the energy policy, the government listed the following: 1) realization of an energy saving society with cutting edge technologies (reform of demand structure); 2) realization of a distributed next-generation energy systems (reform of supply structure); and 3) significance of technological innovation. As the new energy strategy is scheduled to be officially formulated in the summer of 2012, it is expected that efforts for dissemination of renewable energy will be further strengthened.

With the enactment of the Renewable Energy Law in August 2011, Japan's Feed-in Tariff (FIT) program will be enforced in July 2012. Under such circumstances, the Japanese residential PV market is expected to continue growing with the following support measures: 1) subsidy for installation of residential PV systems; 2) continued and expanded support programs for residential PV systems by local authorities; 3) continued program to purchase surplus PV electricity at preferential rates; 4) price reduction of PV systems; 5) heightening awareness of users for installation; 6) enhancement of sales capabilities by distribution and installation companies, and so on. On the other hand, the non-residential PV market including PV applications for public, industrial and commercial facilities as well as power generation business is expected to be established full-scale upon the enforcement of the Renewable Energy Law. Consequently, the Japanese PV industry will depart from extremely depending on the residential sector. Enforcement of the new renewable energy law will lead to broadening and transforming it to a well-balanced one. It is also assumed that price reduction of PV systems and participation of industries utilizing PV systems will create new markets and new business models, diversifying components of the PV market. The PV industry in Japan as a nation with a sustainable market of GW-level PV installation, backed by the governmental support and market expansion will contribute to expanding PV power generation across the globe. This will be achieved by the participation of a large number of related industries and establishment of a production framework for the domestic market size exceeding 1 GW, as well as distribution, sales and installation frameworks.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DONGGUN LIM, KOREA NATIONAL UNIVERSITY OF TRANSPORTATION

Fig. 1 – 100 kW PV power plant on the water surface at Hapcheon Dam, South Gyunsang Province.

GENERAL FRAMEWORK AND IMPLEMENTATION

The Korea government has been pushing "low carbon, green growth" as a major agenda, holding campaigns to reduce Asia's fourth-largest economy's dependence on oil and gas imports and tackle greenhouse gas emissions. Also the government mapped out a plan to raise its renewable energy sector as a key exporting industry to add exports of 40 trillion KRW (Korean Won, 1 100 KRW/USD) and create 110 000 jobs. The total budgets for new and renewable energy programs amounts 993,4 BKRW in 2011 and PV Korea's national PV programs have been based on the 2nd 10-year basic plan for new and renewable energy R&D established to enhance the level of self-sufficiency in energy supply, to meet the challenging of climate change and to consolidate infrastructure of new and renewable energy industry. Korea's PV programs are categorized into four major sub-programs; PV R&D programs, PV infrastructure establishment & human resource education program, PV international cooperation programs, and PV dissemination programs. Under the PV R&D programs, various types of R&D projects have been allocated to industries, research institute and university. Five main programs are operating under the PV dissemination programs; PV subsidy, 1 million Green Homes, public building obligation, regional dissemination and feed-in-tariff programs.

Recently the Korea government released its Green Energy Strategy Roadmap 2011 for growth of the green energy industry. It is a second version, following the first from 2009. According to the plan, Korea is aiming to expand the global green energy market share to 18 %, and reach 328 trillion KRW 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.

Since the installation of 276 MW in 2008, the PV installation continues to decrease; about 154 MW was installed in 2011. This is mainly due to the limited FIT scheme. About 154 MW were installed in Korea during 2011, and the cumulative installed PV power was about 800 MW. The main applications for PV in Korea are grid connected centralized systems. It has amounted to much more than 70 % of the total installed power.

NATIONAL PROGRAMME

Korea has been making a strong effort to increase the renewable energy portion of the "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, renewable energy is estimated to account for about 2,6 % of total primary energy consumption. This plan includes the construction of "One Million Green Homes" and "200 Green Villages" until 2020. It was also planned that the RPS will replace the existing "Feed-in-Tariff" scheme from the year 2012.

One Million Green Homes Program: This program which merged the 100 000 rooftop PV systems aims at the construction of one million green homes utilizing PV as well as solar thermal, fuel cells, wind, bio-energy and geothermal until 2020. In general single-family houses and multi-family houses including apartments can benefit from this program. The government provides 60 % of the initial PV system cost for single-family and private multi-family houses, and 100 % for public multi-family rental houses. Until the end 2011, about 83 MW capacity and about 78 000 households benefited from this program. In 2011, the number of households that benefited was 12 810 and the installed capacity was about 17 MW.

General Deployment Subsidy Program: The government supports 50 % of installation cost for PV systems with a capacity below 50 kW. In addition, the government supports 80 % of the initial cost

Fig. 2 - 100 kW PV power plant installed at Daegu.

Fig. 3 - 1,5 MW water purification plant in Kimhae, South Gyunsang Province.

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 end 2011, about a 13 MW capacity and 564 PV systems benefited from this program. In 2011, 64 PV systems with a total of 1,1 MW were installed. Various grid-connected PV systems were installed in schools, public facilities, welfare facilities and universities.

Regional Deployment Subsidy Program: The government supports 50 % of installation cost for PV systems owned and operated by local authorities. Until end 2011, about 40 MW benefited from this program. In 2011, the installed capacity was about 10 MW.

RPS Demonstration Program: Before starting the RPS from 2012, the Government initiated its RPS demonstration program for three years, from 2009 until 2011. Six electricity companies construct their own PV plants or purchase PV electricity from private. In 2010, about 6 MW was installed under this program.

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

YEAR	2012	2013	2014	2015	2016
CAPACITY (MW)	200	220	240	260	280

Public Building Obligation Program: New public buildings larger than 3 000 sq meter must spend 5 % of total construction budget in installing renewable facilities. As the government pursues its course for the "New Administration-Oriented City Plan" and the "Plan for Public Enterprise Relocation," new public buildings are planned all over Korea and thus this program will contribute to the expansion of Korea's PV market. In 2011, approximately 12 MW was installed under this program.

R&D, D

The government budget in 2010 for PV R&D was 202,551 BKRW, which is a 22,4 % increase from previous year. The program mostly consists of industry-oriented research works. For the short- term commercialization, so 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 goal, many projects have been implemented in the area of quantum dot, organic, and dye-sensitized solar cells.

TABLE 2 – ANALYSIS OF PV R&D BUDGET IN KOREA (2009~2010)

CELL TYPE	2009		2010	
	R&D Budget (Billion KRW)	Share (%)	R&D Budget (Billion KRW)	Share (%)
C-Si	53,120	33,8	70,344	34,7
Si thin film	24,538	15,6	33,586	16,6
CIGS thin film	17,907	11,4	25,155	12,4
CdTe thin film	0,646	0,4	1,200	0,6
Concentration	5,505	3,5	7,737	3,8
Dye-sensitize	17,056	10,9	25,123	12,4
Organic	19,313	12,3	22,439	11,1
Quantum dot	3,884	2,5	6,631	3,3
Others	15,122	9,6	10,334	5,1
Total	157,092	100,0	202,551	100,0

INDUSTRY AND MARKET DEVELOPMENT

Recently Korea has rapid growth in the PV industry. The total solar cell production capacity in Korea has reached more than 1,6 GW in 2011. As the result, supply chain of crystalline silicon PV has completed from feedstock materials to system installation.

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 1,8 GW in 2011 for silicon wafers.

Hyundai Heavy Industry expanded their capacity up to 600 MW in c-Si solar cells. Shinsung Solar Energy expanded their capacity up to 330 MW in c-Si solar cells. STX Solar also expanded capacity their capacity up to 180 MW in the c-Si solar cells. Hanwha SolarOne (located in China) expanded their capacity up to 1,3 GW in c-Si solar cells. And the capacity is expected to ramp up to 2,2 GW in 2012.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS

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

GENERAL FRAMEWORK AND IMPLEMENTATION

Year 2011 marks a historical milestone when the Malaysian Government's long term pledge to implement a renewable energy (RE) policy in the country was realized. The Government, on 2 April 2010 had approved the National RE Policy and Action Plan and this solidifies the foundation for solar PV growth. The overall policy framework on Feed-in-Tariff (FiT) and also with the introduction of the Economic Transformation Programme (ETP), Malaysia has set its sights to achieve a total of 1 250 MW of grid-connected RE by the year 2020.

By end of April 2011, the Renewable Energy Bill 2010 and the Sustainable Energy Development Authority Bill 2010 were finalized and subsequently passed by the Parliament. On 1 September 2011, the Sustainable Energy Development Authority of Malaysia (SEDA Malaysia) was officially established. Its main responsibility was to administer and monitor the implementation of the FiT mechanism. The FiT was then rolled out on 1 December 2011 with the enforcement of the Renewable Energy Act 2011.

NATIONAL PROGRAMME & MARKET DEVELOPMENT

The RE market development in Malaysia would be largely driven by the feed-in tariff and the enforcement of the RE Act 2011. On 1 December 2011, Malaysia rolled out the world's first electronic FiT application system, enabling eligible producers to apply and submit applications online. This on-line system or e-FiT, is complex in design, being developed in accordance to the RE Act 2011, including its rules and regulations as stipulated in the subsidiary legislations and guidelines. The e-FiT features first tier verification, project tracking and monthly energy performance over the entire lifetime of the FiT tenure.

Quotas for PV starting from year 2012, 2013 and 2014 were opened for applications on 1 December 2011. By 31 December 2011, a total of 173,85 MW or 3 years quota have been taken up. Currently only 5,22 MW and 2,36 MW are available for the individual and non-individual categories respectively (subject to change). Latest up-to-date information on quotas and the e-FiT online system can be accessed through internet via www.seda.gov.my.

INDUSTRY DEVELOPMENT

On PV manufacturing front, Malaysia is one of the largest solar PV producers in the world with a total combined production capacity of 3 693 MW for wafers, solar cells and PV modules. This is largely due to concentrated Government efforts in providing attractive incentives such as a 15-year tax holiday for solar company profits. Other attractive features that Malaysia had offered include low loan interest rates, clear regulations and good infrastructures. As of June 2011, the total investment in Malaysia's solar energy industry has hit 3,86 BEUR which translated to 14 300 jobs. Of the 3,86 [1] BEUR solar related investments, 3,59 BEUR came from foreign direct investments.

In 2011, three (3) local PV assembly plants in Malaysia (SolarTIF Sdn Bhd, PV Hi-Tech Solar Sdn Bhd, and Malaysian Solar Resources Sdn Bhd), with a combined total production capacity of 90 MW, had set up their businesses here. Combined production capacity is also expected to increase to 136 MW by 2012. These plants had 148 employees in 2011 and are expected to increase their workforce to 275 by 2012.

Within the PV industry, there are approximately 40 PV service providers currently active in the market. The total estimated manpower involved in the PV service industry is between 235 to

COMPANY	PRODUCT	NAMEPLATE CAPACITY	EMPLOYMENT/ JOB CREATION	STATE	STATUS
AUO-SunPower	Solar wafering& cells	350 MW (2011) 700 MW (2012)	2 600 (2011) 3 000 (2012)	Malacca	Up scaling operation
Robert Bosch	Solar wafering& cells	800 MW (wafers, 2013) 620 MW (cells, 2013)	1 (2011) 50 (2012)	Penang	Operational 2013
First Solar	CdTe Modules	1 514 MW (2011) 1 680 MW (2012)	3 500 (2011) 3 500 (2012)	Kedah	Up scaling operation
Flextronics	PV module assembling	469 MW (2011) 469 MW (2012)	1 160 (2011) 1 160 (2012)	Johor	In full operation
MEMC	Solar wafering	600 MW (2011) 300 MW (2012)	500 (2011) 350 (2012)	Sarawak	Downsizing operation
Q-Cells	Solar cells	670 MW (2011) 850 MW (2012)	850 (2011& 2012)	Selangor	Up scaling operation
Tokuyama	Polysilicon	6 000 tons (2013)	112 (2011) 380 (2012)	Sarawak	Operational 2013

Fig.1 - Major PV FDIs in Malaysia.

[1] 1,0 EUR = 4,0945 RM (2011-12)

Fig. 2 - 470 kWp, Macglo Steel Service Center, Shah Alam.

260 people. The list of these service providers can be referred to in www.seda.gov.my and www.mpia.org.my.

R&D, D

R&D on solar PV in Malaysia has yet to meet a major breakthrough in the technology. However, Strategic Thrust 4 of the National Renewable Energy Policy and Action Plan (which is implemented under the 10th Malaysia Plan period from 2011 to 2015) aims to further enhance R&D in renewable energy sector. The focus is on technology innovation rather than invention. Systematic R&D programme will be implemented under this thrust to accelerate innovative RE products and services aiming mainly to further reduce the cost of RE technology deployment. Although this Strategic Thrust is helmed by SEDA Malaysia, the institutional arrangement to implement this thrust effectively requires the collaboration of Ministry of Science, Technology and Innovation, Ministry of Higher Education and other relevant Government agencies.

FUTURE OUTLOOK

The Government of Malaysia is committed to develop the solar PV market as well as the solar industry for the dual purposes of achieving energy security and economic growth. The target set for solar PV for 2015 and 2016 is estimated to be 70 MW respectively. In the manufacturing front, the total annual PV production capacity is estimated to reach 4 185 MW (wafer, solar cell and module) for 2012 and 6 000 tonnes (polycrystalline silicon) will come on board by the year 2013. With these targets, solutions to both energy security and economic issues have simultaneously been addressed. More importantly, solar can play a significant role in contributing the conditional commitment made by the Prime Minister of Malaysia in December 2009 to reduce the country's carbon intensity by up to 40 % to the GDP by 2020 (compared with 2005 levels).

MEXICO

PV TECHNOLOGY: STATUS AND PROSPECTS IN MEXICO

JAIME AGREDANO, J. M. HUACUZ, ELECTRICAL RESEARCH INSTITUTE (IIE)

Fig. 1 - 81 kW two axis tracking system (Photo: ERDM).

GENERAL FRAMEWORK

Times of enhanced growth in PV activity in Mexico are coming. This is a forecast derived from the PV arena dynamics observed during last year both inside the country and internationally.

Nationally, several factors can be listed. First, the Mexican official sector is trying to launch programs for massive deployment of grid-connected PV systems. In particular, the national utility, that is CFE, is working out plans and projects to introduce PV technology as an alternative for distributed generation. Another case is the fact that State governments are pushing to include it as a mean to partially meet the electricity needs for services such as water supply and street lighting. The National Regulatory Commission is also doing its job to fit the regulatory framework to a higher scale of capacities. With respect to human resource formation in PV technology, the offer is increasing notably; worth mentioning is also the training program that historically the Electrical Research Institute has promoted. Mexican PV industry is also playing its game towards quality through a growing standardization of products and services. On the other hand, the PV international panorama undoubtedly drives the PV national market. As PV is the driving motor we can address the module price behavior. In 2011, the ever awaited dollar per watt-peak reached its historical low record and still a higher reduction for the near term is anticipated. Inverter price trends can also be mentioned as a positive factor due to a net reduction, although at a lower rate than what occurs with PV modules. What happens with the rest of BOS components must also be mentioned due to an observed higher availability of standardized solutions. In summary, all the actors are working together to make photovoltaic technology a viable option for energy diversification in Mexico.

NATIONAL PROGRAMME

Although, a national program for the deployment of PV Technology has not been implemented, the Federal Government created the Fund for the Energy Transition and the Sustainable Use of Energy

Fig. 2 - 176 PV roof mounted system at The CINVESTAV –IPN research center unit in Zacatecas city (Photo: Conermex).

during 2009, whose objective is to use the economic resources to foster the national energy sector through actions and programs focused on the achievement of a better and broader use of renewable energy resources and clean energy technologies. PV is one of the technologies included by the fund. Additionally during 2011, the Federal Electricity Commission (CFE) made a call for constructing a one-MW centralized grid-connected PV system in the Peninsula of Baja California. This PV power plant will be the first one to be operated by CFE. The plant will be commissioned during the first quarter of 2012.

After a lengthy delay, it is expected that during the present year the rural electrification program can be re-launched. This program is focused on delivering electricity to communities with a population over 100 inhabitants. The technological solution for these communities was the implementation of the so called "Solar village," consisting of centralized photovoltaic systems coupled to a mini distribution network. The first two villages were put into operation in late 2011. Several State governments are analyzing business plans to deploy centralized PV plants in their localities. The National Housing Fund for Workers (INFONAVIT by its Spanish acronym) is

Fig. 3 - 145 kW Roof Mounted PV system (Photo: ERDM).

studying the alternatives for incorporating photovoltaic generators of small capacity around 1 kW capacity in houses for low and medium –low income families. If this project matrializes, it will represent a huge potential market of several tens of thousands of houses with PV systems tied to the national low-voltage network.

R&DD

As mentioned in the previous section, the Energy Transition fund has, among other objectives, the support of renewable energy technology development. Academic and R&D institutions are main recipients of this fund. In 2011, the fund granted support for PV research in the following areas: (1) development of materials for thin film PV cell technology, and (2) two projects to build up a test bench for small PV systems, and a test bench for mini-grids and hybrid systems. Also, the R&D effort has continued to develop inverter technology for grid-connected PV systems. In another way, the Electrical Research Institute has been preparing the guidelines for inspection and diagnosis of grid connected residential PV systems. It is expected that this methodology can be used by incentive programs in the acceptance/rejection process of projects. The tool will provide the metrics to assess the quality, reliability and durability of PV systems in urban areas.

Some initiatives are been studied by the National Regulatory Commission. The most important for PV is related to the possibility that PV residential clusters can operate through a unique interconnection contract – as a centralized system –, and can receive proportionally the benefits of the energy exchange with the utility. This change in the regulatory issue will have a very positive impact on PV cost reduction for residential areas.

INDUSTRY AND MARKET DEVELOPMENT

Mexican PV companies declared 2011 as a very good year. The best estimation for the Mexican market is around 6,5 MW, which is consistent with the predictions and estimations made at the beginning of the year. Mexican PV module assemblers reported sales of around 3 MW; part of this production was commercialized in Latin-American countries. The presence in the local market of cheap Chinese PV modules is remarkable. A Spanish PV cell and module

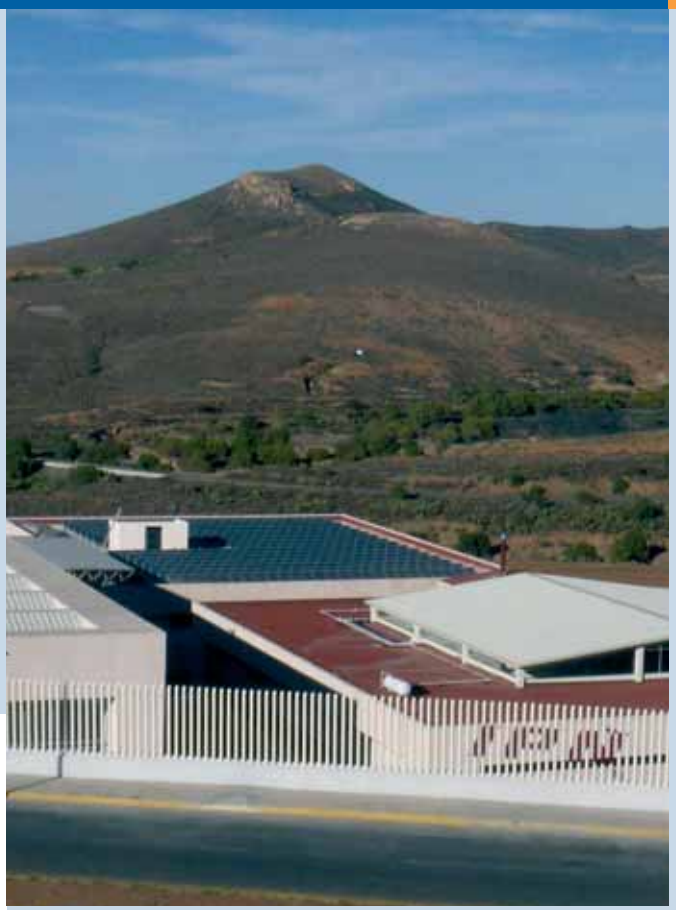

Fig. 4 - 176 PV roof mounted system at The CINVESTAV – IPN research center unit in Zacatecas city (Photo: Conermex).

maker established an assembling plant in the northwestern city of Tijuana, whose production is mainly exported to the US market. During this year, the technology transfer for the production of an inverter for PV grid connected systems was concreted between the Electrical Research Institute and a local company.

On the business side, some alliances among Mexican and foreign companies were announced to develop PV systems packs customized for the local market.

The 2011 historic low price of PV modules had a very positive impact on the PV installed capacity. As in previous years, the expectation in PV market growth for next year is encouraging.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS

OTTO BERNSEN, NL AGENCY, DIRECTORATE ENERGY AND CLIMATE

Fig. 1 - Close up installation of nominal DC output 264,74 kWp, Yingli panels, at the district building of the water board Velt & Vecht in Sleen; Project Developer DEC (Photo: Ecofys).

Fig. 2 - Overview same system installation and rooftop Velt & Vecht. Project start November 2010. The performance of the system can be monitored online at https://www.solar-monitoring.net/ssp/anlage/anlageninfoStatisch.php (Photo: Ecofys).

GENERAL FRAMEWORK

In 2011 the general framework was set by major policies changes already announced in 2010. The new policy directives focused on clean, reliable and affordable energy supplies, cutting back government spending and taking advantage of economic opportunities. The national goal remained the achievement of 14 % of renewable energy production by 2020 and 20 % of carbon dioxide reduction, which is well within the EU directive. No technology specific targets were set and market forces are supposed to promote the most suitable and cost effective renewable technologies. In this scheme, solar PV still has an important role to play, especially in the mid and long term. A special program called «Green Deal,» was set up with the aim of achieving major energy efficiencies, less administrative obstacles and to explore new roles for government and stakeholders. Direct subsidies for R&D in solar technology and the market incentive (SDE) for solar stopped altogether in 2011. The former are to be replaced by an «innovation contract,» to be negotiated between industry and government as a public private partnership and concluded in 2012. The later was already replaced by a general scheme for all renewable energy sources (SDE plus) 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. An amount of approximately 50 MWp was granted under this new scheme for larger systems, with a shift to the agricultural sector. Although no definite data is available yet, the estimates point towards a similar modest growth in 2011 of the domestic market as in the previous years. This continuity is due to the earlier SDE grants still in the pipeline and in a large measure to the combination of lower PV modules prices and rising energy prices that may have compensated for the lack of specific incentives for smaller households. These price developments, especially at the end of 2011, have brought solar PV an important step closer to becoming a competitive energy source for a larger customer base with a return on investment below 10 years. In addition, some social innovation in the market took place as consumers increasingly organised themselves to have a better position in the marketplace. This trend went hand in hand with discussions about the limitations of the regulatory framework that allows consumers with solar panels to settle the electricity fed into the grid and distracted from the grid. With this instrument, small scale electricity production for own use, for instance with solar panels, is effectively exempted from energy taxes. The discussion focuses on general aspects, such as the 5 000 kWh upper limit per household and on specific target groups, such as for cooperative constructions with self delivery, households under one roof, such as apartment blocks, but with a shared grid connection and some energy companies that read the law differently, as not to be limited to 5 000 kWh for small connections.

The international consolidation in the PV sector, noted in previous years, continued in 2011 with shake outs and mergers in a race to keep up margins, while under pressure of falling prices. One of the major Dutch players, Solland Solar, opted for a management buyout from its former shareholder the energy company Delta and attracted new investors. The layoff of the major part of its workforce hit home hard in the southern part of the province of Limburg were most of the solar factories are located. Another energy company, NUON, recently acquired by the Swedish Vattenfall, also stopped investments in the thin film producer Helianthos at Arnhem which was not able to attract new investors. However the thin film technology developed by Helianthos with its many partners over the years remains a valuable asset for the Netherlands.

Fig. 3 - Solar Park Azewijn (1,620,000 KWh/year) by project developer Pfixx, on top of a former waste dump.

Fig. 4 - Solar modules(189 kWp) on an historical railway workshop in Tilburg. Project Developer: DEC (Photo: Project Developer DEC).

In 2011 only national R&D projects were granted that were already in the pipeline in anticipation of the "innovation contract," to be concluded in 2012. A major (5 MEUR) research program concerning «Light Management in Photovoltaic Materials» was initiated in 2010 and granted in 2011. The project is executed by the AMOLF research institute of the Foundation of Fundamental Research on Matter. Also in 2011, the Belgium research centre IMEC joined the Dutch research alliance Solliance in Eindhoven city. Solliance aims to be an excellent R&D cluster with critical mass and bring solar thin film technology to the forefront. In the national innovation program for solar PV, four companies entered the second phase of the small business innovation research program (SBIR) for building integrated photovoltaic systems. The third and last phase is about market introduction without government support. The Dutch companies and start ups keep adding value in this segment and look for an increasing market share in Northwestern Europe.

NATIONAL PROGRAMMES

The national program for the implementation of renewable energy sources (DEN) continued in 2011 with the activities focused on the quality and ease of installation, permits, certification and public information about the realities of solar PV in the marketplace. To this end a foundation saw the light, supported by this program, with the aim of supplying the public at large with independent information about prices and performance of the solar panels, inverters, its components and suppliers. Other supporting activities, such as the yearly "Sunday" congress and the informative "Solar Tours," visiting companies and installation sites all around the Netherlands, have become well attended and established landmarks in the national solar agenda.

Within the same mind set a "green deal" was made between the national trade organisation Holland Solar and the government in order to simplify procedures for permits and lower the administrative barriers in general.

The SDE incentive was replaced by the SDE plus 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 wind energy and biomass projects but an amount of approximately 50 MWp 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 energy reduction (EIA) and small investment reduction KIA.

For solar PV in the Netherlands the direct government funded R&D programs for energy gave way to a public /private partnership called the "innovation contract," to be negotiated and concluded during spring in 2012. Actually there are two innovation contracts dealing with solar PV, one in the energy sector itself and another one from the sector high tech and materials. The first draft was submitted in December 2011 and under review.

In the national innovation program for solar PV (IPZ) the original eleven awarded companies in the first feasibility phase had to compete to enter the second phase of research and development. Only four consortia succeeded:

1. Movares/BRS/ECN project about integrating cold bended PV modules in glass roofs.
2. Femtogrid is boosting performance of PV modules in the built environment with "smart" electronics.
3. Dimark developed integrated roofing's using both solar thermal and solar power for traditional prices.
4. Peer+, a university start up, is producing smart energy glass with flexible settings.

In the third phase in 2012 market introduction is being sought after without government support.

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2011 the research program concerning "Light Management in Photovoltaic Materials" was granted. This program aims at light management: the control of the collection, guiding, concentration and conversion of light at the nano scale. Its focus lies in the development of new materials and new solar cell architectures. ECN is a partner in the program and the cooperation brings synergy and new opportunities to strengthen the patent portfolio. In charge at AMOLF is director Albert Polman who has a long track record in photonic materials.

ECN was also involved together with TNO and the academy "Hogeschool Zuyd" in setting up the Solar Application Centre. Its focus on BIPV, grid integration, aesthetics, pre-fab modules and combined solar/thermal systems is very much in line with the national IPZ program and current SBIR.

Fig. 5 - Professor Wim Sinke receiving the Becquerel Prize 2011 (Photo: Axel Schönecker).

In order to represent industry and draw up the first "innovation contract" for solar PV from the energy sector, Wim Sinke (ECN and professor at the University of Utrecht) was called once more unto the breach. This public private partnership is intended to replace the direct R&D funds from the government for solar PV which was stopped in 2011. Since October 2011, representatives from industry, science and government have worked on a national roadmap for solar that will be part of this "innovation contract."

It is no coincidence that Wim Sinke was also awarded the prestigious "Becquerel Prize" at the 26th European Solar Energy Conference and Exhibition in Hamburg. Especially his work in wafer based sillicium photovoltaic cells and modules was mentioned which has become mainstream technology. Added to that was his contribution to the European Strategic Research Agenda, which has been widely copied internationally.

The academic organisations STW (Dutch Technology Foundation) and the national science foundation (NWO) did launch new research projects in solar cells; for example, the project by Prof. Tom Gregorkiewicz on "Spectral Shaping for Smart Photovoltaics." In 2011, NWO also awarded ten research proposals in the program "Towards Biosolar Cells." This concerns fundamental research into artificial photosynthesis with a budget of 7 MEUR. The entire program is part of the Bio Based Economy (BBE) but has a strong overlap with research in the photovoltaics, especially on the conversion from photon to electron and light management side. The Netherlands are still relatively strong in R&D with over 200 FTE employed in high value research jobs. The effects of sudden dips in research will not be visible until after typically 3 to 4 years (the length of a PhD).

INDUSTRY STATUS

The international consolidation in the PV sector continued in 2011 with shake outs and mergers in a race to keep up margins, while under pressure of falling prices. Most solar cell and module manufacturers have adapted their strategies and product range accordingly. The major solar module manufacturer, Scheuten Solar, has expanded into BIPV and PV on industrial buildings or infrastructures. Another major manufacturer, Solland Solar, was hard hit and had to focus on the production of the high efficiency Sunweb cells and halted production of other solar cells; laying off the better part of their workforce. After the management buyout from their former majority shareholder energy company Delta, Solland Solar started looking for other investors abroad. Another energy company NUON, recently acquired by the Swedish Vattenfall, also stopped investments in the thin film producer Helianthos at Arnhem which was not able to attract new investors by the end of the year. Here the possibility of a public auction came into play. However the thin film technology developed by Helianthos with its many partners over the years remains a valuable asset for the Netherlands. Other companies such as OM&T, purchased by Indian MoserBaer from Philips in 2007 for their optical disc technology, seemed to have found their place in this international turmoil and contribute both to the cost reduction of the production of solar cells and the development of organic LED lights. The Thin Film Factory in the northern province of Frisia has made a similar shift over the years towards LEDs. In 2011, the importance of an international strategy and the value of an international network were emphasized again. The company Solar Modules Nederland (SMN), also located in the southern province of Limburg, signed an agreement with Canadian Day4 Energy to upgrade their 25 MW production facility for the production of Day4 DNA PV cells. Also based in Limburg, Hauzer Techno Coatings in Venlo expanded production and opened a test facility in Japan. The company specialises in supplying plasma coating technology (PVD coating and PACVD coating) and vacuum coating equipment to worldwide markets.

Added to the consolidation in the sector that took place over the last few years, it seems safe to say there are very few Dutch solar manufacturers left that are not incorporated into a larger holding, be it national or international. Still there were also start ups in this dynamic industry that reinvents itself every few years now. Prominently among these is Frans van den Heuvel (former CEO Scheuten Solar), who embarked on a new venture with ProxEnergy that specialises in decentralised energy systems, including solar PV, but also sets out to close the business concepts from an energy demand point of view, being very much customer oriented and also looking into transportation.

The industry has organised itself in a new Solar Industry Platform at the initiative of ECN, TNO and the development agency of the province of Noord Brabant. It represents more the production side of the value chain while Holland Solar has more installation companies and project developers among its members. Moreover it also represents the smaller section of CPV in the Netherlands. The first twelve members of the industry platform are: Avantor, Eurotron, Mastervolt, OTB Solar, Scheuten Solar, Smit Ovens, Helianthos, SMN, Sunenergy, Tempress Systems, Solland Solar, Ubbink Solar and quests members Oskomera, Ecostream. This list already shows there is some overlap and there exists close ties between the two organisations, but nevertheless it will be a clear contact point for the government and the public at large.

Another important milestone in 2011 was the participation of the Belgium IMEC in Solliance which reinforces the already existing cooperation between the European regions. An extra advantage

Fig. 6 - City of Doesburg, private car park by module producer Ubbink Solar.

Fig. 7 - Village of Kollum, House with BIPV, amorph Si.

would be the addition by IMEC to the research agenda; especially in the area of organic solar cells and new materials. The initiative offered a more adequate and timely perspective on the international competition and possible the necessary critical mass.

DEMONSTRATION PROJECTS

Last year, the DEN program organised well received "Solar Tours" around various production sites and PV installations all around the Netherlands. For a detailed description of the Solar Tours, in Dutch, as well as photos, see web link http://www.solartour2011.nl/solartour/?page_id=49

The original PV pilot projects in, for example, the cities of Heerhugowaard en Amersfoort, are now joined by a multitude of cities and villages with their own solar PV projects. The reasons and policies differ somewhat but all municipalities want to stimulate green economic growth. Typically, the solar PV projects are being expanded into being part of the local energy system using monitoring systems, smart grids, integration with solar thermal, CHP and/or storage. In case of newly built neighbourhoods this seems easier to realise.

While solar PV is becoming rapidly more affordable, the upper market segment can be observed moving into the usually more expensive and design solutions, as well as custom made applications.

IMPLEMENTATION AND MARKET DEVELOPMENT

In 2011, the incentive for PV installations was replaced by a general scheme for all renewable energy sources (SDE plus) which favours 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. The amount of approximately 50 MWp was granted under this new scheme for larger systems and will have to be installed in the next few years. The new scheme worked in favour of larger systems with a clear shift to the agricultural sector and public buildings. This scheme is in addition to the already existing tax incentives for companies, such as the energy reduction (IEA) and environmental reduction (MIA/Vamil).

Although figures were not yet published at the time of this publication, the first indications are that the amount of installed capacity remained stable over 2011, compared to the previous years. This is perhaps remarkable since the SDE scheme for smaller household systems was cancelled but at the same time the steeply falling prices of solar modules especially in the last months of the year may have compensated in some measure for this. In addition, there were many initiatives in the market for buying solar panels collectively, and supposedly cheaper, and also a number of provinces and cities had separate supporting schemes. Interesting to mention was the scheme from the province Overijssel, where 115 farmers received a total of 3,5 MEUR to replace the roofs of their barns that contained asbestos with solar PV modules. Many other provinces followed suit with tailor made programs.

FUTURE OUTLOOK

After the steady and modest growth of the Dutch home market over the last few years, the market conditions are ripe for an independent take off of solar energy in the Netherlands. The quality of the installations has improved over the years and so has the performance of the modules, while prices have dropped dramatically.

Although these are harsh conditions for the PV producing industry, where smaller margins, economies of scale and deep pockets will dominate the international consolidation in 2012, for a larger portion of the public it means solar energy may become a commodity as of 2012. Still there remain some obstacles in the Netherlands, such as the upfront financing and the poor aesthetics of roof top applications. Nevertheless, 2012 might see an uptake and widening of the solar market in the Netherlands. Especially townships and other local public entities, far removed from national politics, see themselves confronted with rising energy costs and public pressure to do something about it. Estimates for the growth rate are hard to give since the economic crisis has, on the one hand, a negative effect on spending of households but on the other, it makes more sense now to invest in solar panels, and cut the energy bill, in the long run. In a report written by Ecofys, it is stated that the sharp price drop in 2011 has pushed the Dutch market 5-7 years forward, meaning predictions originally for 2018 may come already true in 2012 or shortly after. At the same time the market is becoming more diverse with more pronounced products for specific market segments.

The main question for 2012 seems to be if the increase in the total installed capacity will grow at a steady constant pace or accelerate? Combining the above statements it seems likely that PV demand will pick up but not evenly spread over all market segments. The PV industry will still continue to consolidate itself into global players but with room still for innovative players along specific parts of the value chain.

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

TROND MOENGEN, THE RESEARCH COUNCIL OF NORWAY

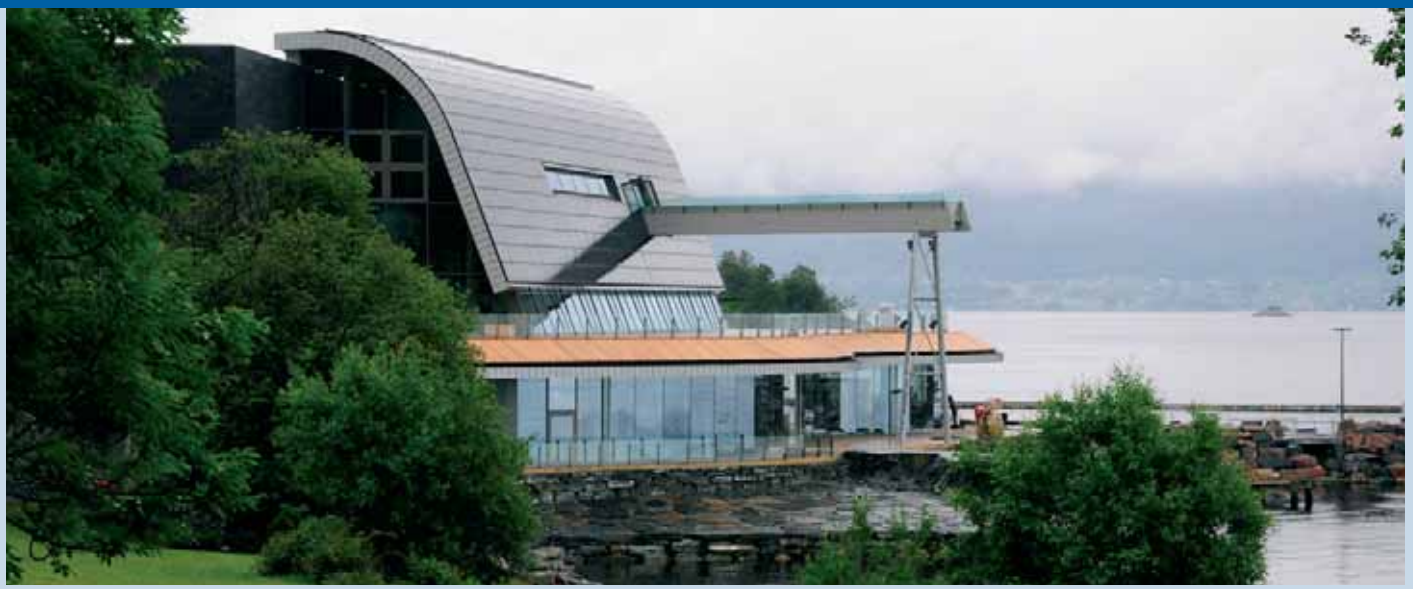

Fig. 1 - Oseana: Inaugurated in June 2011. The building has the largest BIPV system (60 kWp) in Norway so far. The curved wall-roof construction is covered with PV modules (Photo: P. Bernhard).

GENERAL FRAMEWORK

The Norwegian electricity system is mainly supplied by hydropower, but at the same time highly integrated in the Nordic power market. Despite a net population increase in recent years, the power consumption is relatively stable, due to energy efficiency measures and reduced activity in the 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. Throughout 2011, a common Swedish-Norwegian elcertificate market has been planned. The elcertificate market is a technology neutral, market-based support scheme for power generation from renewable energy sources. It will be in operation from 2012, aiming to increase power generation from renewable energy sources in the two countries with 26,4 TWh before 2020.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001. With annual budgets of about 120 MEUR in 2011, Enova is the main instrument with regard to improving energy system efficiency and increasing renewable energy production.

Norway has still no public schemes for supporting PV systems. Consequently, there are few large PV systems, and the main market for PV in Norway continues to be related to off-grid recreational applications and special areas such as lighthouses and telecom. 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 PV projects in Norway.

The state owned company Innovation Norway promotes nationwide industrial development, and helps release the potential of different districts and regions by contributing towards innovation, internationalization and promotion. During the last years, Innovation Norway has contributed with approximately 12 MEUR to the establishment of several PV-related industries. The NorSun wafer production facility in Aardal is among the recipients, but several companies within the "Norwegian Solar Cluster" are on the list and developing new solutions to enter the international market.

NATIONAL PROGRAMME

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

RESEARCH AND DEVELOPMENT

The energy research programme RENERGI in the Norwegian Research Council (NRC) funds industry oriented research, basic research and socio-economic research within the energy field, including renewable energy sources. Another NRC programme within new materials and nano technology, NANOMAT, also supports fundamental research tied to development of new materials of relevance for future PV solutions. Finally, there is also the BIA programme – User-driven Research Based Innovation Funds Projects within the field of photovoltaics. The focus in the latter programme is improvement and optimization of fabrication and processes for manufacturing PV cells.

The total funds for PV-related R&D projects were approximately 144 MNOK (18,5 MEURO) for 2010 and at the same level in 2011. 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 taking filling out the portfolio of projects.

The Norwegian Research Centre for Solar Cell Technology has completed its second year of operation (http://www.solarunited.no). All of Norway's leading research groups and industrial partners in solar cell technology participate in the centre. The research activities are grouped into six work packages, five of which involve competence-building: mono- and multi-crystalline silicon, next-generation modeling tools for crystallizing silicon, solar-cell and 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).

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 weakened in 2011. Falling unit prices and over capacity on the supply side has led to corresponding production reductions for the major Norwegian PV-actors. During 2011, the number of employees in the Norwegian solar industry has dropped by close to one thousand, permanently and temporarily. This means that the work force in the Norwegian solar industry was almost halved in 2011, compared to previous years.

Renewable Energy Corporation (REC) REC – Renewable Energy Corporation, is involved in the whole value chain of solar cells, from raw materials to complete modules. More than 3,900 employees work in REC's worldwide organization. The production facilities include the silicon materials plants in Moses Lake, Washington and Butte, Montana in the USA. The wafer production sites are located in Glomfjord and Herøya, in Norway and Tuas Singapore. The solar cell production is in Narvik, Norway and Tuas, Singapore, and solar modules are produced in Tuas, Singapore. The headquarters are located in Oslo.

REC has reduced its production in Norway in three steps during 2011. The last step, (November 29), the company announced the temporary halt of 60 percent of its production at the 650 MW multicrystalline wafer facility at Herøya, Norway. After these adjustments, REC expects to produce approximately 105 MW of multi- and monocrystalline wafers in Norway in the first quarter 2012.

The integrated wafer, cell and module facility in Singapore (700 MW annual wafer to module capacity) and the polysilicon facilities in the US (19.000 MT annual polysilicon capacity) continues to operate at full capacity.

Elkem Solar is based on the so called metallurgical route. Elkem Solar invested more than 4,2 BNOK in its silicon production plant in Kristiansand, in southern Norway. The plant started ramp up production during 2009. The plant has a design capacity of 6 000 tons of solar grade silicon per year. In January 2011, Elkem Solar, along with the other parts of Elkem ASA, was sold from Orkla ASA to China National Bluestar (Group) Co., Ltd.

NorSun AS manufactures and markets high performance mono-crystalline silicon ingots and wafers. Annual production capacity at the company's modern production facilities in Årdal, Norway and Vantaa, Finland exceeds 200 MWp. By December 2011, about 70 out of 200 employees will be affected by temporary layoffs in Norway.

Several other Norwegian key players in the PV market are Metallkraft AS, Innotech Solar AS (ITS), CruSiN AS, SIC Processing AS, and Fesil Sunergy AS.

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 represent a significant market. The Norwegian Coastal Administration (NCA) operates a total of 3 083 PV installations. The average is 110 Wp per installation, yielding a total installed PV capacity of 338 kW.

Norway's largest building integrated PV project so far is called "Oseana"; a combined culture- and arts centre located in Os, 30 km south of Bergen. The 60 kWp, 470 sq metre PV system is integrated as part of the roof and southern wall, facing towards the beautiful Bjoernafjord. The building represents the latest in modern architecture, combined with energy efficient building principles. The landmark and a major tourist attraction opened in June 2011. Annual sales of PV capacity in Norway are estimated at 300-400 kWp, mostly as stand-alone systems. The total installed PV capacity is approximately 9 MWp.

PORTUGAL

PV TECHNOLOGY STATUS AND PROSPECTS

PEDRO SASSETTI PAES AND JOÃO MACIEL, EDP

Fig. 1 - 480 kW CPV installed in MARL- Lisbon Wholesale Market (Photo: MagPower).

GENERAL FRAMEWORK AND IMPLEMENTATION

In 2011, the political and financial Portugal's crisis reached a critical level, leading to the government fall and the need to have a financial bailout from the so-called Troika (IMF, EC and ECB) – the International Monetary Fund (IMF), the European Commission (EC) and the European Central Bank (ECB). In June, the elections dictated a change in Government and the enforcement of a Memorandum of Understanding with the Troika. The Troika recommendations were clearly biased towards energy efficiency measures, whereas caution was recommended for the further support of renewable energy generation and co-generation, under the special regime.

For renewables, the following recommendations were issued:

- For existing contracts in renewables, assess the possibility of agreeing a renegotiation of the contracts in view of a lower feed-in tariff.
- For new contracts in renewables, revise downward the feed-in tariffs and ensure that the tariffs do not over-compensate producers for their costs and they continue to provide an incentive to reduce costs further, through digressive tariffs. For more mature technologies, develop alternative mechanisms (such as feed-in premiums).
- Decisions on future investments in renewables, in particular in less mature technologies, will be based on a rigorous analysis in terms of its costs and consequences for energy prices. International benchmarks should be used for the analysis and an independent evaluation should be carried out.
- Reduce the delays and uncertainty surrounding planning, authorisation and certification procedures and improve the transparency of administrative requirements and charges for renewable energy producers (in line with Article 13 and 14 of EU Directive 2009/28/EC).

As far as energy policy instruments and taxation were concerned, the Troika recommended to:

- Review existing energy related instruments, including taxation and energy efficiency incentives. In particular, evaluate the risk of overlapping or inconsistent instruments.
- Based on the results of the review, modify energy policy instruments to ensure that they provide incentives for rational use, energy savings and emission reductions.

The year of 2011 must be approached in two parts, mediated by the June elections. During the first half of 2011, the National Energy Strategy and the associated Renewable Energy Action Plan (REAP), was fully in force, after its approval in 2010. In this context, and as expected, the revised micro-generation regime was extended in March to higher capacity installations under the so-called mini-generation framework (Decree-law 34/2011). Under this scheme, implemented according to a demand-side philosophy, systems up to 250 kW can be installed if associated to a consumption point. The licensing process started in June.

Because the micro and mini-generation regimes fall within the special regime, doubts of its continuity were raised. In October though, the continuity of these schemes in 2012 were ensured, even if with a reduction of 46 % of the annual installation cap and cuts in the associated feed-in tariffs.

The government is currently preparing the new energy policy framework, which will have to comply, on one side, with the Troika recommendations and, on the other side, with the commitments already assumed under the European legislation (20-20-20 climate-energy package), namely the REAP. 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.

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).

Besides the feed-in tariff schemes, investors in renewable equipment may deduct 30 % CAPEX on income tax up to about 800 EUR. On the other hand, VAT rate on renewable equipment changed from 12 % to 23 %.

TABLE 1 – CURRENT 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; 10,04 kW 3-phase in condominiums
Starting Tariff	**Building integrated** • Less than 5 kW – 0,469 €/kWh • 5 kW to 150 kW – 0,354 €/kWh **Ground based** • Less than 5 kW – 0,447 €/kWh • More than 5 kW – 0,317 €/kWh	**Premium tariff – 0,25 €/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** – 0,40 €/kWh (in 2011) applicable to • Up to 3,68 kW production capacity or 10,04 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 0,02 €/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 2011: 0,40 €/kWh (-0,02 €/kWh/year for subsequent years) • Fixed for the next 7 years of operation. Starting tariff in 2011: 0,24 €/kWh (-0,02 €/kWh/year for subsequent years), **General regime (Regular tariff)** -Annually set at LV regulated tariff
Time frame	Tariff secured for 15 years or 21 MWh/kW capacity (becomes active for +1,400 hours annual load factor)	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)	50 MW per year	25 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 2m^2 solar water heating system installed or equivalent biomass boiler • 30 % CAPEX deductible on income tax up to 800 €

RESEARCH, DEVELOPMENT AND DEMONSTRATION

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

Applied research, demonstration and dissemination are performed in several institutions such as Public Research Institutes (LNEG – National Laboratory for Energy and Geology; IN+ - Centre for Innovation, Technology and Policy Research), Energy Agencies (ADENE and regional agencies), utilities (EDP, the largest national energy company) and private research institutes (INESC Porto - Institute for Systems and Computers Engineering).

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

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

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 of the correlation between climatic variables, module position and energy production in different sites and for different PV technologies, along Portugal. EDP
- "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.

INDUSTRY AND MARKET DEVELOPMENT

There are currently 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.

Despite the financial crisis, the Portuguese PV market grew 9 % in 2011, achieving a total cumulative PV capacity of about 144 MW (see Table 3 and Figure 2), 98 % of which are grid-connected. The new additional capacity in 2011 came mainly from the micro-generation scheme (9 MW), which has reached a total cumulative capacity of about 42 MW, representing more than 10000 PV microgenerators.

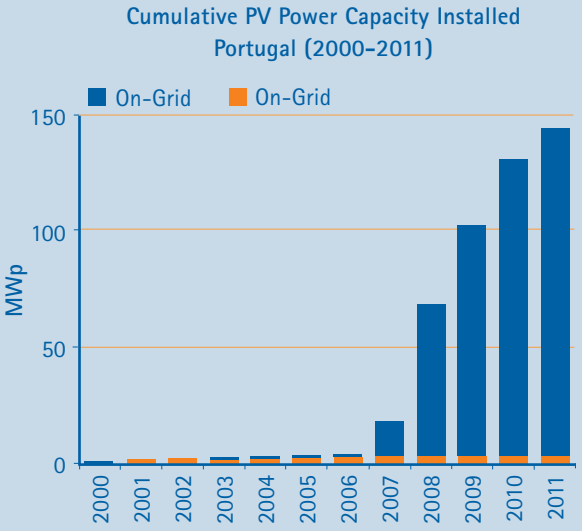

Fig. 2 – Cumulative PV power capacity installed in Portugal (2000-2011).

TABLE 2 – PV MODULE MANUFACTURERS

COMPANY	MAXIMUM CAPACITY (MW)	CURRENT CAPACITY (MW)	PRODUCTION 2011 (MW)	TECHNOLOGY
Open Renewables	65	65	34	c-Si (77 % mono, 23 % poly)
Martifer Solar	50	25	21,3	c-Si (poly)
SolarPlus	10	10	~5,5	a-Si (double junction)
Goosun	10	10	n.a.	c-Si (poly)
Fluitecnik	50	50	25	c-Si (15 % mono, 85 % poly)
WS Energy	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)

TABLE 3- ANNUAL AND CUMULATIVE PV POWER CAPACITY INSTALLED IN (2000-2011)

YEAR	OFF-GRID (MWP)	ON-GRID (MWP)	TOTAL ANNUAL POWER (MWP)	CUMULATIVE POWER (MWP)
2000	0,22	0,08	0,30	1,14
2001	0,12	0,05	0,17	1,31
2002	0,29	0,07	0,36	1,67
2003	0,40	0,01	0,40	2,07
2004	0,55	0,08	0,63	2,70
2005	0,22	0,07	0,29	2,99
2006	0,20	0,23	0,43	3,42
2007	0,20	14,25	14,45	17,87
2008	0,10	49,98	50,08	67,95
2009	0,10	34,15	34,25	102,20
2010	0,10	28,55	28,65	130,85
2011	**0,10**	**12,65**	**12,75**	**143,60**

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

Fig. 3 - Reintroduction of Ospreys in Portugal project - 5,6 kW stand-alone PV system. The system is installed on a private farm in Alentejo and supplies a house-laboratory which has been prepared to monitor the birds (photo: EDP).

TRENDS

At a time of financial difficulty for the government, citizens and businesses, a significant slowdown in Renewables' investments is expected in the coming years. While the new 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 2012 with an aggregated cap of 40 MW (10 MW micro and 30 MW mini). Further, fiscal incentives will be withdrawn, namely tax deductions and reduced VAT. Nevertheless, expectations exist that this capacity will be realised, especially if flexibility of the cap among regimes is allowed, reflecting adjustments to the effective demand observed. Moreover, in 2012 it is expected that these regimes will be revised, and eventually merged, to comply with a net-metering philosophy, where self-consumption will be mandatory. In any case, any new decree will most certainly be in force only in 2013.

SEIA

SOLAR ENERGY INDUSTRIES ASSOCIATION®
TOM KIMBIS, SEIA VICE PRESIDENT, STRATEGY & EXTERNAL AFFAIRS / GENERAL COUNSEL
CHRISTINE COVINGTON, SEIA MANAGER OF TRADE & COMPETITIVENESS

SEIA

The Solar Energy Industries Association (SEIA) is the trade association for the U.S. solar industry. As the voice of the industry, SEIA works with its 1,000 member companies at both the federal and state levels to make solar a mainstream and significant energy source by expanding markets, removing market barriers, strengthening the industry, and educating the public on the benefits of solar energy. SEIA represents solar companies across a variety of solar energy technologies, including photovoltaic, solar water heating, and concentrating solar power. SEIA members include manufacturers, distributors, contractors, installers, financiers, and project developers of solar energy.

II. Monitoring Market Development

SEIA continues to collect and publish authoritative data on solar energy deployment in the U.S. each quarter in partnership with GTM Research through the *U.S. Solar Market Insight* reports. This data provides vital market statistics on the status and growth of the solar industry in the U.S.

In 2011, the U.S. installed 1,855 MWdc of photovoltaic capacity, representing 109 percent growth over the rate of in 2010.

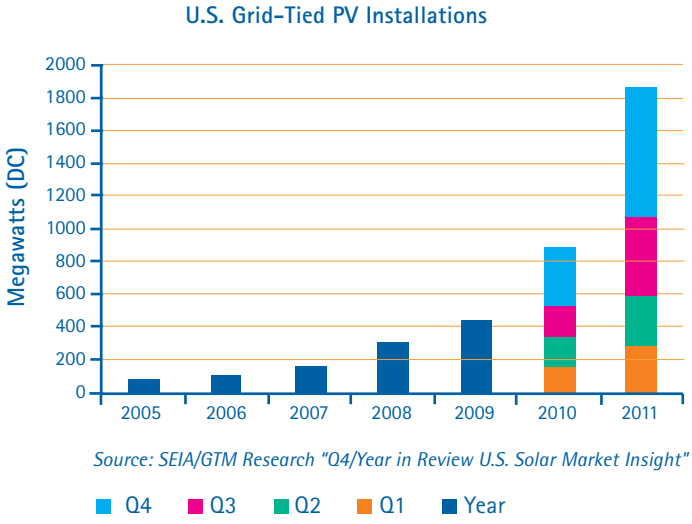

Fig. 1 – U.S. Grid-Tied PV Installations. SEIA/GTM Research "U.S. Solar Market Insight 2011 Year in Review."

Cost reductions are a driving force behind the historic growth in the U.S. solar market. Solar has become more affordable than ever and is cost effective in many areas across America. "As of the end of 2011, the blended average installed price of PV in the U.S. had dropped by 36 percent compared to the beginning of 2010."

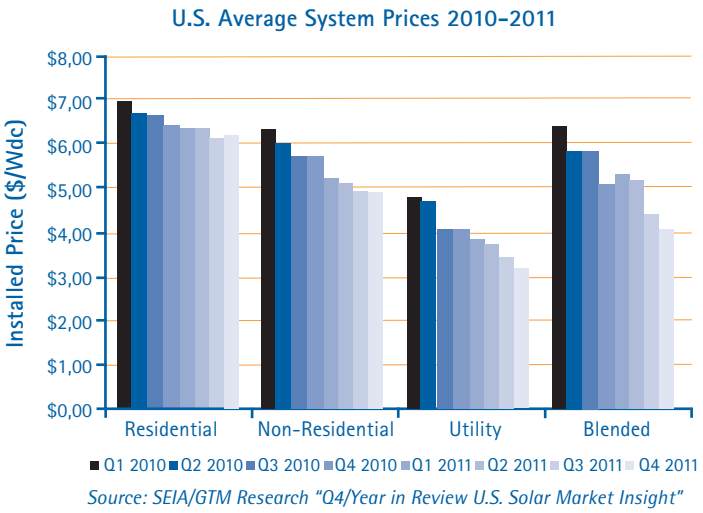

Fig. 2 – U.S. Average System Prices 2010- Q3 2011. SEIA/GTM Research "U.S. Solar Market Insight 2011 Year in Review."

U.S. SOLAR POLICY ISSUES

Solar energy markets are defined by the policy environment in which they operate. While national solar policy benefits from some stability from the 30-percent investment tax credit (ITC) in place through 2016, one important policy expired at the end of 2011. The Section 1603 Treasury program provided grants in lieu of the ITC to address challenges associated with utilizing tax credits. It is unclear whether or not this important provision will be reinstated. SEIA is working actively to extend this program as well as to support new legislative and regulatory policies that advance the U.S. solar market.

While federal policy is in flux, state policy also continues to evolve. The U.S. PV industry operates as more than 50 distinct markets, each of which must integrate a unique blend of local, utility, state and federal policies. As the national trade association for the industry, SEIA has traditionally focused only on federal policies. Yet, as more markets emerge in new states, the importance of integrated federal and state policy planning increases. It is with this in mind that SEIA expanded its role in state affairs by merging with the Solar Alliance at the beginning of 2012.

ENVIRONMENT, HEALTH AND SAFETY INITIATIVES

In 2011, SEIA organized several key environment, health, and safety initiatives. First and foremost, the SEIA EHS Committee developed the Solar Industry Commitment to Environmental & Social Responsibility, which set forth a series of EHS and sustainability priorities. The Commitment includes language on Labor, Ethics, Environment, Health and Safety, and Management Systems. In 2012, SEIA will continue to expand on this work by developing processes for updating the Commitment, governance of the Commitment, and accounting mechanisms.

SEIA's EHS Committee now consists of four distinct Working Groups: Codes & Standards, Environmental & Social Responsibility,

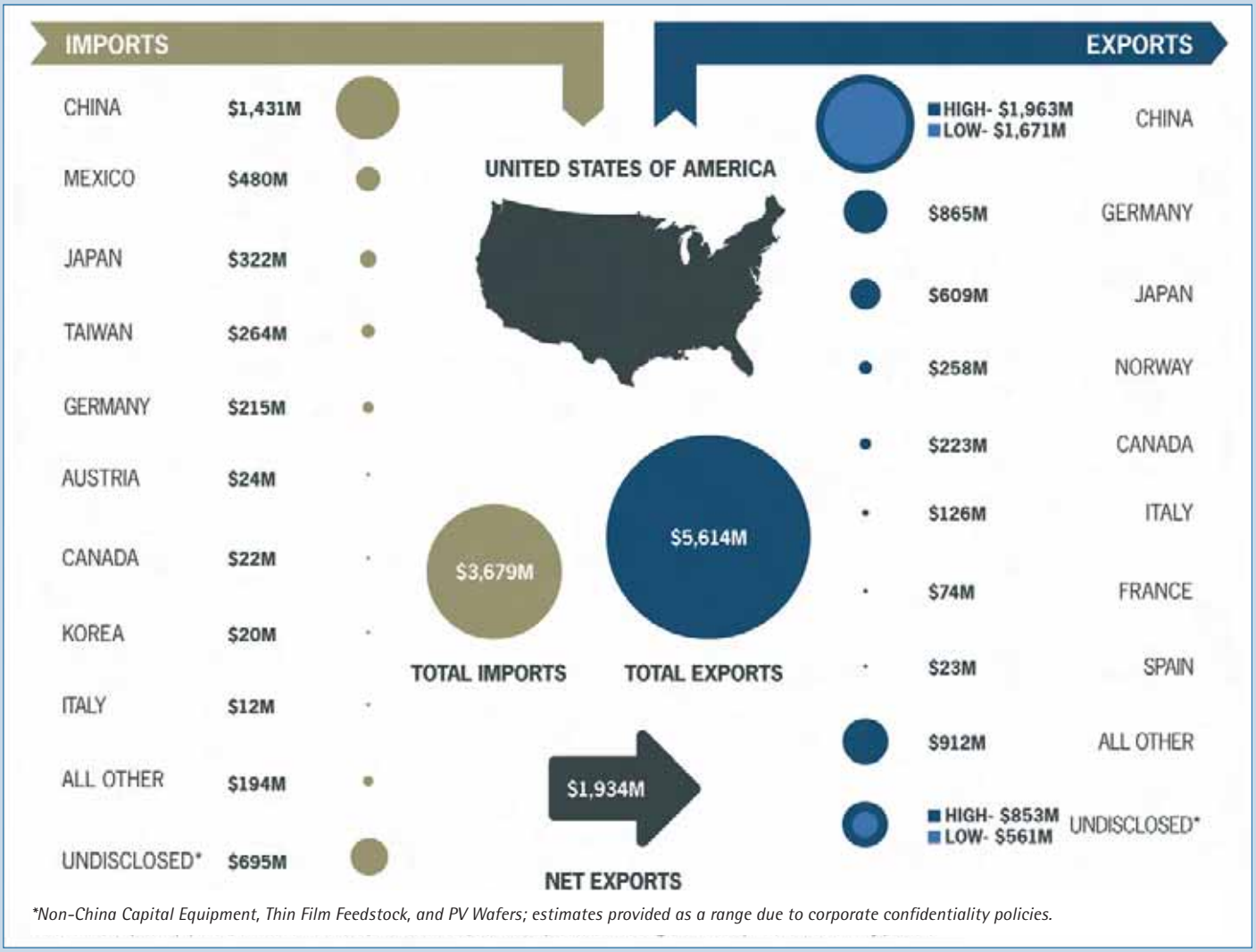

Fig. 3 - PV Imports and Exports by Source/Destination in 2010.

PV Recycling, and Installer Safety & Workforce Development. Each Working Group provides a unique forum for discussion of a targeted topic and development of topic-specific initiatives.

Through the Working Groups, SEIA has provided specific information and guidance to its members, including webinars on topics such as building codes, fire safety, and installer safety. In addition, the Working Groups function to comment on relevant EHS legislation and regulations, including comments submitted on PV Recycling regulations, building codes, and product standards.

GLOBAL TRADE IN PV COMPONENTS

Trade between the U.S. and China became one of the hottest topics in the PV industry when seven U.S. PV manufacturers brought a trade case against Chinese manufacturers of crystalline PV cells and modules alleging that illegal trade practices were harming U.S. producers. Preliminary rulings in the case are expected from the U.S. Department of Commerce in early 2012 but the impacts of this case will likely play out throughout the 2012 and into 2013 as suppliers and buyers adapt their business strategies.

While SEIA has not taken a position on this trade dispute, it continues to monitor the situation closely in order to help ensure positive outcomes for the U.S. solar industry regardless of the rulings. The U.S. benefits from robust two-way trade in the solar industry as detailed in annual trade reports SEIA commissioned with GTM Research. (See Fig. 3 - "PV Imports and Exports by Source/Destination in 2010")

SEIA'S INVOLVEMENT IN IEA PVPS ACTIVITIES

SEIA supports PVPS on the Executive Committee, Task 1, and Task 12. In 2012, SEIA will expand its role in PVPS to be Co-Operating Agent of Task 12. As Co-Operating Agent, SEIA's first objective is to finalize the Task 12 Workplan. Guided by the Workplan, SEIA will work with the Experts to organize meetings, coordinate activities, and organize the publications and website of Task 12.

Through the 2012 priorities, we will work to elevate the LCA and PV Recycling Subtasks to develop resources for the industry and data sets. Also, the Task 12 Experts have chosen to expand Subtask 3 to include safety throughout the life-cycle of PV products. Thus, SEIA will contribute its resources and expertise in this area to the IEA Task 12 projects.

SEPA

THE SOLAR ELECTRIC POWER ASSOCIATION
WWW.SOLARELECTRICPOWER.ORG

The Solar Electric Power Association (SEPA) is an educational non-profit organization based in Washington, D.C, USA, dedicated to helping utilities integrate solar power into their energy portfolios. From facilitating peer-to-peer interaction between utilities and the solar industry to hosting one of the industry's leading educational forums on utility solar, SEPA is the go-to resource for unbiased utility solar information.
SEPA's membership is comprised of electric utilities, solar companies, and other companies with an interest in solar electricity. From research projects and national events, to one-on-one counseling and peer matching services, SEPA is the go-to resource for unbiased and actionable solar intelligence.

SEPA'S UTILITY SOLAR RANKINGS REPORT

Utility Use of Solar Grows Dramatically – and Not Just in the Sunniest Regions

America's electric utilities are ramping up their use of solar power, and not just in the sunny Southwest. That's one of the principal findings of the new SEPA Utility Solar Rankings report released on June 9, 2011, by the Solar Electric Power Association.

The SEPA Utility Solar Rankings Report shows top utilities expanded solar integration by 100 percent in 2010. Its key findings were:

- Marked growth in utility solar power in states outside the Southwest;
- Growth in centralized projects;
- Major increase in utility ownership of solar capacity.

More and more utilities are integrating solar power into their energy portfolios, including many in states such as New Jersey, Idaho and North Carolina. Solar power has largely been associated only with California and the Southwest, but that's no longer the case. In SEPA's 2008 Rankings report, 75 percent of the new solar capacity was located in California. By contrast, in the 2010 survey, 63 percent of new capacity came from other states.

SEPA's report identifies the Top 10 U.S. utilities that added the most new solar power to their systems last year and the Top 10 utilities that added the most solar on a watts-per-customer-served basis.

Altogether, the Top 10 utilities reported that they added 561 megawatts of new solar capacity, an increase of 100 percent over 2009.

Pacific Gas and Electric Company (PG&E), in northern California, led all utilities in the most new solar energy added to its grid with a total of 157 megawatts. But the next two positions are held by East Coast utilities: Florida Power & Light Company (FPL), based in Juno Beach, Florida, and Public Service Electric & Gas Company (PSE&G), based in Newark, New Jersey. The highest ranked cooperative utility on the list – Tri-State Generation and Transmission Cooperative Association (Tri-State) in Colorado – was sixth with 30 megawatts of solar added in 2010.

On a watts-per-customer basis, the utility ranked first was a municipal utility, Silicon Valley Power in Santa Clara, California. It was followed by PSE&G and Hawaiian Electric Company.
The report also identifies two other noteworthy trends: a growing number of solar projects are centralized, and more utilities are choosing to own their own solar capacity, rather than rely largely on purchasing solar from independent power producers. In the past, utilities have largely relied on distributed photovoltaic systems for most new solar capacity. They are now integrating more larger-scale centralized projects.

In 2010, these centralized installations included a 48-megawatt photovoltaic project in Nevada, the Copper Mountain project, with power purchased by PG&E, and a 30-megawatt PV facility in New Mexico, the Cimarron project, with power purchased by Tri-State. In addition, the largest new concentrating solar power project in nearly 20 years – the 75-megawatt Martin Solar Center – owned by FPL, went into operation.

Of the 561 megawatts of solar added last year, 140 megawatts are actually owned by the utilities. The ownership trend is a truly significant finding. It represents a 300 percent increase over the numbers reported in 2009.

SEPA expects the growth in utility solar power to continue and SEPA's findings show that utilities are continuing to find new, viable business models for bringing the benefits of solar power to their customers.

The report contains additional details about the total solar capacity of U.S. utilities, rankings by regions, geographical diversity and other utility solar trends. The full report can be found at www.sepatop10.org.

SEPA'S SOLAR ENERGY INFORMATION

Utility Solar Knowledge Center

The Utility Solar Knowledge Center is a resource portal which allows you to intelligently filter through hundreds of documents, multimedia, news and events by technology, market sector, job function, and other options. Visit the Utility Solar Knowledge Center: http://www.solarelectricpower.org/utility-solar-knowledge-center/utility-solar-knowledge-center.aspx.

Online Solar Tools

This SEPA website includes five online Solar Tools:

- Solar Projects
- Business Models
- Solar Solutions
- Solar Networking
- Utility Case Studies
- Utility Solar Business Models

Publications

Each year SEPA produces a number of research reports on current industry topics which are selected by the SEPA Project Committee. Recent and recommended reports published by SEPA include:

- February 2012 - Community Solar Program Design: Working Within the Utility
- February 2012 - Centralized Solar Projects Update Bulletin (Q4 2011 & Year in Review)
- January 2012 - US Fact Finding Mission Briefing
- January 2012 - Heating Up: The Impact of Third-Party Business Models on the U.S. Market for Solar Water and Space Heating
- December 2011 - Utility Solar Business Model Quarterly Bulletin: «Regulatory Considerations»
- December 2011 - Buy versus Build: A Qualitative Comparison of Financial, Tax and Regulatory Issues Influencing Utility Solar Procurement
- November 2011 - Electric Utilities' Solar Employment Needs Brief

UTILITY AND SOLAR INDUSTRY EXPERTISE – AN UNBIASED RESOURCE FOR SOLAR QUESTIONS

SEPA's team of regional utility solar experts can help the utility decision maker cut the time to develop and implement solar business plans, and help turn new technologies and markets into business opportunities. Expertise is provided on:

- Solar Technologies – PV, CSP and Solar Water Heating
- Grid Integration
- Net Metering
- Interconnection Standards and Codes
- Business Models
- Regulatory and Legislative Trends
- Procurement
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SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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

Fig. 1 - PV installation on the roof of PV module manufacturer ATERSA (Valencia).

GENERAL FRAMEWORK

In 2011, Renewable Energies have covered the 33 % of the electrical demand in Spain. That number is 3 points less than in 2010, and the reason is mainly due to the decrease in hydroelectric production. The leader among Renewables is wind energy, which accounts for the 16 % of the total demand, and represents the third global position after nuclear (21 %), and combined cycles (19 %).

PV production covered the 3 % of total electricity demand for 2011(provisional data out of grid operator REE), with maximum close to 4 % in June and July. The situation at the beginning of 2011 for the PV was not clear due to the new regulation issued at the end of 2010, in November (important reduction of tariffs for new PV installations) and December (limitation of equivalent working hours on installations). Those facts together with the temporal and retroactive reduction of the tariff for kWh on PV plants working before 10/2008, led to the emergence of some negative feelings in the sector, due to the potential uncertainties in the regulatory frame.

As a result of that, some initiatives might have been slowed, and in some cases postponed, but, the reduction on the price of PV modules, down for more than 50 %, have made the PV plants to achieve good enough costs of the kWh produced, as to match reasonable cash flow for the investment. At the end of the year more than 90 % of capacity available for installation under the Royal Decree rules was used.

On November 2011 a new Law regulating grid connection of small PV plants (<100 kW) was issued. That document announced future incentives to facilitate auto consumption activities in order to promote distributed generation.

Recently (January 2012), a new regulation issued eliminating any feed-in-tariff for the electricity out of PV installations will imply the slow down of the prior mega-plants scheme, while letting the road free to innovative ways of using the PV possibilities through BIPV and distributed small PV plants.

NATIONAL PROGRAMME

The National Programme for Renewable Energies and specifically for PV is aligned with the objectives established in the European Parliament directive 2009/28/CE, with respect to achieving 20 % of primary energy supply coming out of Renewable Energies by 2020 and 10 % for transportation.

The "Plan de Energías Renovables (PER) 2011-2020" was issued by the IDAE (Instituto para la Diversificación y el Ahorro de la Energía) following that directive and approved by the Council of Ministers on November 11, 2011. That document describes the strategy for achieving the proposed objectives. The plan has been established, taking into account the Reference Energetic scenario as of 2010 and the additional Energetic Efficiency one. The "Plan de Acción de Ahorro y Eficiencia Energética" estimates a 2 % annual reduction of the final energetic intensity in the period between 2010 and 2020 (for a moderate economic growth). With those considerations, the goal established for the participation of RREE in the energetic mix for 2020 is 20,8 %, with a contribution to transportation of 11,3 %. In these circumstances, the objective for the gross electricity generation out of Renewable Energies by 2020 is 38,1 %; although challenging it is still achievable, due to the expected technological innovations.

The plan, as established, implies a rigorous tracking and control of evolution of the indicators, in order to achieve the proposed goals. In that sense, it must be considered as an active document, which should be modified and adapted if changes in the starting hypothesis occur.

R&D, D

R&D and Demonstration activities are playing a key role in the development of any technology. In the specific case of the PV, during 2011 those activities have been financed at the national level inside the programmes lead by the Ministry of Science and Innovation. There are different types of calls, some of them, directed towards more applied developments, come out of the CDTI (Centre for Technical and Industrial Development) and have as preferential participation industrial partners together with R&D centres. But there are some other calls addressed to basic science investigation mostly directed to academic institutions. Both of them are needed for the success of the initiative. There are also local calls coming out of the autonomous communities, together with the national calls and the 7th Framework Programme of EC.

In Spain there are approximately 30 centres (private, public, universities...) working on R&D in Photovoltaics. Among them the Solar Energy Institute (IES) of the Polytechnic University of Madrid, the CPV Systems Institute (ISFOC) in Puertollano (Ciudad Real), CIEMAT (Energy Research Centre) in Madrid, National renewable Energy Center (CENER) in Sarriguren (Navarra), and various Universities have the highest activity.

During the year 2011, out of 396 projects approved in the national R&D calls, 80 projects were for the "Energy Special Action," with a 27 % of the 560 MEUR total budget. It is important to note the increase from the previous year in support for the Energetic Efficiency, Wind, Solar and Smart grid technologies.

In the PV world, the subjects identified for finance have been oriented towards higher efficiency technologies, components and materials cost reduction, and a special interest on BIPV products development:

- Concentrating Photovoltaics (CPV) technologies and components development;
- Building Integrated Photovoltaics (BIPV);
- PV module cost reduction developments.

However, some of the developments and research on the Smart Grids and Energy Efficiency activities will also play a key role for the impulse of PV in the urban areas. Handling in an efficient way the small injections of electricity in the grid might be the limiting factor for the development of auto consumption, and PV integrated in buildings and urban areas is one of the most important vectors for achieving the Energetic Efficiency.

The initiatives described are aligned with the Strategic Energy Technology Plan (SET Plan) of the EU, presented on October 2010 as a tool to coordinate R&D on the member states. The SET Plan has specific routings for establishing PV as a competitive energy technology, with a goal of 12 % of total electricity consumption in Europe by 2020 being produced by PV.

IMPLEMENTATION

The installed PV capacity at the end of 2011 in Spain was close to 4,099 MW, 7,1 % more than in 2010. The total annual electricity production by PV means was 7,912 GWh, 25,4 % more than previous year. The energy produced has been able to cover 3 % of the total electricity demand for the year 2011 (data out of grid operator REE).

Historically, the PV installation growth in Spain has been based on the mechanism of regulated feed-in-tariff. Figure 2 shows that evolution and, as a consequence, the installed PV capacity.

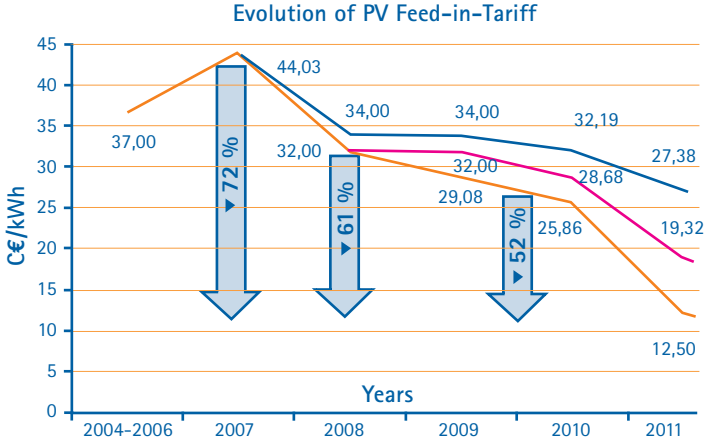

Fig. 2 – PV feed-in-tariff evolution in Spain (Source: UNEF).

Fig. 3 - Urban PV by SOL SURESTE (Murcia).

Fig. 4 - PV on the roof of a private house (Cantabria).

Numbers of final PV installed in 2011 have not been consolidated yet but will exceed 4,099 MW.

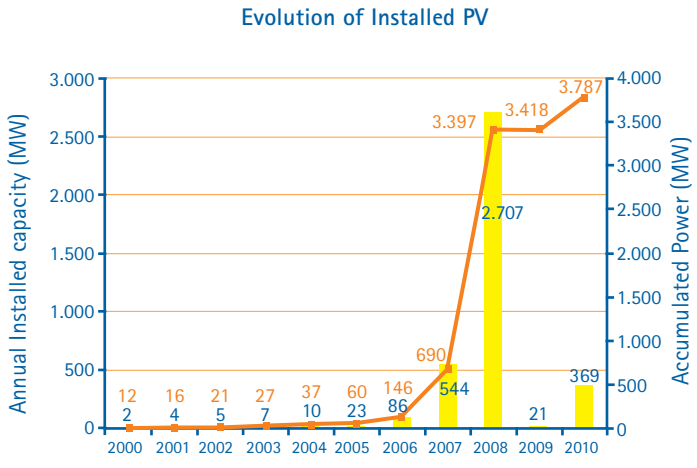

Fig. 5 – Evolution of installed PV in Spain (Source: IDAE).

Although during 2012, there will still remain construction for some of the capacity inscribed in 2011, the new regulation as of RDL 01/2012, with total elimination of feed-in tariff will have a big impact on the future numbers.

Fig. 6 - The hotel: BIPV installation on the Façade of HOTEL TRES REYES in Pamplona.

Fig. 8 - PV installation on top of a desalinization plant from Acciona (Torrevieja).

INDUSTRY STATUS

The slow down of PV installed capacity has led to a net loss of jobs in the sector, mostly on the engineering and PV installations side. With respect to components manufacturing, the activity has also gone down and, as a result, some of the PV components production plants have discontinued operations or at least, reduced production shifts. That circumstance affected the areas of silicon and wafers production and some of the PV cells manufacturers. On the other side, one of the existing thin film manufacturing plants has stopped activity and the announced project for CIGS did not start yet.

Potential orientation of the new market in Spain with emphasis on distributed generation will require the evolution of some of the industries towards products for that specific application in the shape of BIPV or the development of new consumer products with PV integrated on them.

MARKET DEVELOPMENT

Although the tariff conditions have gone down, during 2011 the lowering of the PV components price and the optimum engineering of the installation and choice of components has allowed the new projects to have attained almost 400 MW on new PV plants.

The recent regulation as of November 2011 facilitating access to distributed generation can be the way for future market development. In that direction, there is a clear and urgent need to develop the various legislative aspects to allow a final robust net metering schema.

Figure 7 illustrates the evolution of accumulated PV power proposed by the IDAE in "Plan de Energías Renovables 2011-2020". With the last regulation it does not seem easy to accomplish, at least during first years, the proposed goals.

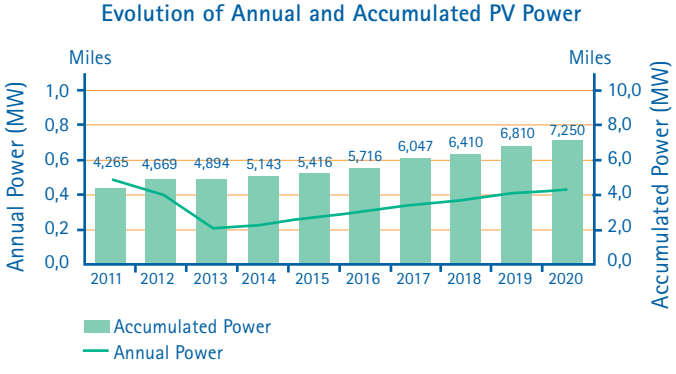

Fig. 7 – Annual and accumulated PV power evolution in Spain (Source: IDAE).

Fig. 9 - PV installation on the roof of "Transportes Antonio Pascual" (Alcoy).

FUTURE OUTLOOK

The recently approved (January 27, 2012) RDL 1/2012 eliminates the economic incentives for energy production out of new PV plants, so the future PV installations will not have the possibility of a feed in tariff. The new law does not affect the already working plants and their existing energy retribution.

Although that circumstance has caused a big impact in the future of big PV plants, new opportunities appear on the horizon as a result of the interest demonstrated by the government in the development of the distributed generation model. The maturity of the PV technologies can allow the approach of the costs of energy produced to the costs for the low scale consumption.

However, for an effective implantation of the distributed generation model, the regulation on the "net-metering activity" along with a simplification of the general administrative procedures, are still pending. There is still work for the regulator, work for the consumers and work for the electrical companies in order to facilitate the net metering.

In that scenario, PV should be part of a new electrical system scheme with differential characteristics:

- PV will play a key role in distributed energy generation, and as being part of the new concept of smart grids;
- Specific application of BIPV is necessary for achieving the goal of Energy Efficiency in buildings;
- PV should give support to initiatives such as electrical vehicles.

Finally, on the short and medium term approach, the expected cost reductions on the components and the grid parity achievable in Spain sooner than 2015 might avoid the need of economic incentives for the electricity produced by PV devices.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
SARA BARGI AND LINUS PALMBLAD, SWEDISH ENERGY AGENCY
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Fig. 1 - The Swedish Energy Agency, the main funding agency for energy research in Sweden, has CIGS thin film solar cells on the roof (Photo: Swedish Energy Agency).

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, CO_2-emissions related to electricity production are relatively low, since hydro, nuclear, bio and wind energy are the main contributors. Strategic priorities are wind power, bioenergy and smart grid solutions, but there is also great interest in PV, which is also often seen as a relevant part of smart grids.

Until recently, PV installations in Sweden were almost exclusively limited to small off-grid systems in remote locations, mainly recreational houses in the countryside. PV remains a competitive option without subsidies for use in such locations.

Since subsidies were first introduced in 2005, the number of grid-connected installations has increased rapidly. For the first few years, the subsidy was aimed exclusively at public institutions, but since 2009 there is no such limitation. The installed grid-connected power has grown from only 250 kW in 2005 to 5 700 kW in 2010. However, PV still accounts for a mere 0,006 % of Swedish electricity production.

There is strong support among many stakeholders for net metering, but so far, net metering has been prevented by tax laws. Awaiting progress on this question, several power utility companies 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 thinks that efforts towards implementation should increase. However, it appears that the recent large declines in cost of PV panels have not yet reached the ears of the majority of the population.

NATIONAL PROGRAMME

The Swedish Energy Agency is responsible for the national energy research programme. Presently PV research is included as a part of the overall budget which amounts to about 100 MEUR per year, and there is no fixed budget for PV alone. In the last few years, 5 MEUR per year have been directed to PV research from the energy research programme budget. Additional resources for PV research come from several research councils, universities and private institutions.

For research more closely connected to increased implementation of PV, there is a programme called SolEl, financed by the Swedish Energy Agency, utilities, the real estate industry and companies with an interest in photovoltaic applications. The main objectives of the SolEl programme are to support technological development, demonstration of applications, analysis of performance and costs of PV systems, as well as dissemination of information. Recent projects that were granted funds focus on building integrated PV (BIPV), grid connection, standardisation issues and projects about collection and dissemination of information.

Swedish objectives for PV research are of a general character. World-class research shall be maintained and further stimulated; there should be a vivid PV industry, and PV should become an established source of electricity and a natural part of the urban environment. For 2012 – 2016, a new strategy and new goals for PV research are being formulated, which might result in, for instance, a goal for installed power.

Fig. 2 - The Museum of Ethnography in Stockholm exhibits Inca gold, samurai swords – and since 2011, an 80 kW roof-top solar cell installation (Photo: Energibanken).

Fig. 3 - Stockholm's largest installation began operating in 2011. 123 kW of solar cells bring extra power to a bus depot in Gubbängen (Photo: Energibanken).

Fig. 4 - The bus depot in Gubbängen has solar cells on the façade as well as on the roof (Photo: Energibanken).

R&D

Research on PV in Sweden is strong 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 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 closely with the spin-off company Solibro Research AB, but is also doing projects together with other Swedish companies.

At Lund University, the division of Energy & Building Design studies energy-efficient buildings and how to integrate PV and solar thermal into those buildings.

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. Focus is on development of new polymers with improved absorption and formation of charge ability, alternative component structures of stable inexpensive and simple devices and alternative component structures for optical switching.

Research on dye-sensitized solar cells is carried out at the Center of Molecular Devices, which is a collaboration between Uppsala University, the Royal Institute of Technology (KTH) in Stockholm and the industrial research institute Swerea IVF in Mölndal. The objectives for the center are to increase understanding of fundamental processes, material properties, device testing and up-scaling. A scientific highlight is the discovery and development of a new effective electrolyte based on cobalt.

INDUSTRY AND MARKET DEVELOPMENT

The installed capacity in Sweden in 2010 was 11 MW, almost equally distributed between grid-connected and off-grid installations. These 11 MW produced about 10 GWh in 2010, 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 40 TWh per year.

There is a handful of module producers in Sweden that mount imported crystalline silicon solar cells. Almost all of the produced modules are exported since the internal market volume is very small compared to the combined module production capacity of the companies. Several of the Swedish PV module manufactures have experienced difficulties.

There are two companies exploring newer types of solar cells. Midsummer AB inaugurated their factory in 2011, where they produce thin-film CIGS cells and sell manufacturing equipment. NLAB Solar AB is developing transparent dye sensitised solar cells for integration in glass windows, and are presently building a pilot plant.

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 new subsidy programme from 2009 has resulted in more activity among these companies and since there has been a lot of interest from private households there are several companies that market products specified for this market segment.

Low-concentrating combined photovoltaic/thermal systems are a Swedish niche, in which research and development has been conducted for more than ten years. Absolicon and Solarus are companies specializing in such systems.

SWITZERLAND

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

Fig. 1 – 5 kWp PV Façade System. Schötz, Lucerne (photo: Solventure GmbH).

GENERAL FRAMEWORK AND IMPLEMENTATION

Recent national energy scenarios and studies have confirmed an important contribution expected from photovoltaics in a future sustainable electricity supply. In 2011, the relevance of photovoltaics has increased following the government's decision to step out of nuclear power as a consequence of the Fukushima nuclear accident. According to the recent scenarios, in absolute terms, some 10 – 12 TWh could come from photovoltaics by 2050, representing some 20 % of the present national electricity consumption. The solar industry claims such contributions to be achievable much sooner.

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, with 2011 as the fourth year of the present period 2008 – 2011. The master plan developed by the Federal Commission for Energy Research (CORE) in cooperation with the Swiss Federal Office of Energy (SFOE) is based on strategic policy goals (energy & environment, science & education, industry & society) (www.energieforschung.ch).

Market deployment continues to grow at moderate levels, thanks to the feed-in-tariff scheme now available for a few years. However, 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. No short term changes are however expected for the support framework, except for regular reductions of the feed-in tariffs applied.

The photovoltaic sector in Switzerland further developed in the year 2011, the most important increase taking place in the market implementation, whereas R&D and industrial activities remained roughly constant at a high level. On the technology front, the key

Fig. 2 – 81,18 kWp Integrated PV Trapezoidal Roof System. Mörschwil, St. Gallen (photo: ALUSTAND®).

Fig. 3 – 64 kWp PV Installation on the Muottas Muragl Cable Railway. Samedan, Graubünden (photo: gvz-rossat ag/sa).

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. Amplified by the strong Swiss currency, global competition for industry has fiercely increased. 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 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 the fourth year of the present RTD master plan, around 70 projects, supported by various national and regional government agencies and the private sector, were conducted in the different areas of the photovoltaic energy system. Innovative solutions, market orientation, cost reduction, industrial viability and transfer as well as increased efficiency and reliability are the main objectives of the technical R&D.

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (amorphous and microcrystalline silicon, compound semiconductors, dye-sensitised and organic solar cells). Work on thin film silicon at the Swiss Federal Institute of Technology (EPFL) in Neuchâtel concentrated on micromorphous solar cells with a particular emphasis on silicon oxide intermediate reflector layers. Significant progress was also achieved in the area of high-efficiency heterojunction silicon solar cells. Industry co-operation was extended with various companies. Based on these co-operations, the oerlikon solar Company announced a new record efficiency of 12,5 % for micromorphous solar cells.

With regard to CIGS solar cells, the Swiss Federal Laboratories for Materials Testing and Research EMPA focused the work on high efficiency flexible CIGS cells on plastic and metal foils. As a highlight, a new record efficiency of 18,7 % was announced for CIGS solar cells on plastic substrate. For dye-sensitised solar cells,

Fig. 4 – 60,3 kWp Single Axis PV Tracker System with Solar Wings on Ski Lift. Tenna, Graubünden (photo: hassler energia alternativa ag).

work continued at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. Exploratory work was undertaken on new solar cell concepts (organic and extremely thin absorber (ETA) cells) at EMPA. An increasing interest for photovoltaic technology can be observed 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. A dedicated website deals with the topic of BIPV (www.bipv.ch) and includes information about available products.

As a new topic, grid integration has received increased interest and new projects have started in this area. With the ongoing market development, quality assurance and reliability of products and systems, as well as standardisation, continue to be of high priority. The Swiss centres of competence at the Technical Universities of Burgdorf and Lugano carefully evaluate products such as PV modules, inverters and new systems. The test infrastructure is continuously expanding and recently includes the largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf, www.pvtest.ch) as well as a new test centre for IEC module certification (Lugano, www.isaac.supsi.ch/pv/labo). Long term experience with the operation of photovoltaic power systems is carefully tracked for a number of grid-connected systems, ranging between 10 and 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 for the first prototype of the solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard. Meanwhile, the solar powered boat PlanetSolar (www.planetsolar.org) has continued its journey around the globe throughout the whole year. The completion of the first maritime journey around the world solely by solar energy is expected in May 2012.
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 2011. The co-operation within the IEA PVPS programme has remained a further strategic activity.

On the programme level, international co-operation is also taking place through the European PV-ERA-NET project (www.pv-era.net) and the European Photovoltaic Technology Platform (www.eupvplatform.org).

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 wiresawing machines from Meyer Burger as well as from Applied Materials Switzerland; and measuring equipment for PV module manufacturers from Pasan (now a part of Meyer Burger Group). Solar plugging systems are offered by Multicontact as well as Huber & Suhner.

Industrial activities evolve in the field of process equipment (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.

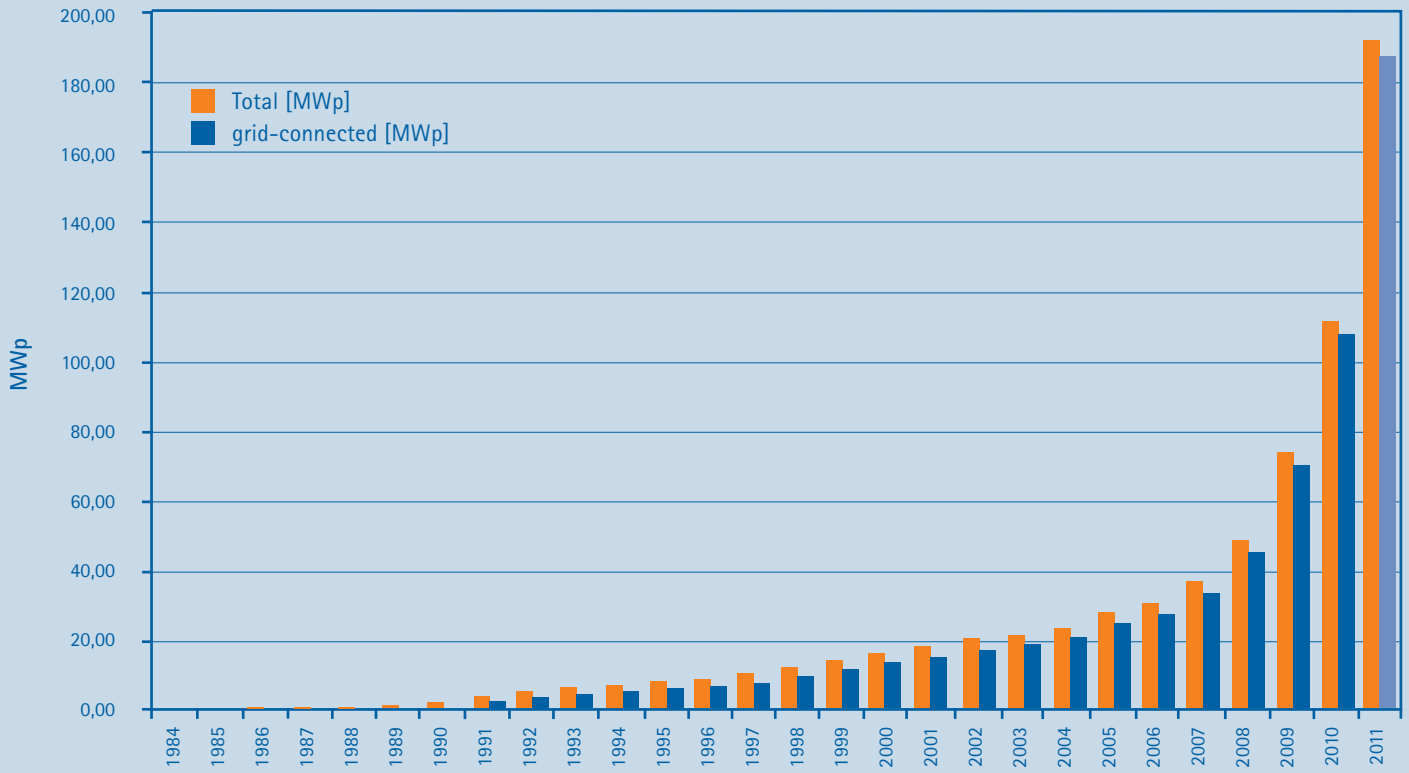

Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2011 (total and grid-connected, estimated values for 2011).

Inverters have proved to be an export success. Sputnik Engineering produces grid-connected inverters with a capacity of 600 MW per year and presently ranks as number 3 in the European market. 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. The export volume of Swiss photovoltaic products continues to be high, with more than 90 % 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.

Fig. 6 - 5,1 kWp ARTline PV Façade System, Alp Dado/Laax, Graubünden (photo: SolarMarkt GbmH Aarau).

The annual market volume for grid-connected systems is estimated to a value around 100 MWp, of which about 80 MWp were installed in 2011. The total installed capacity has thus risen to more than 190 MW (Figure 5), corresponding to close to 25 W/capita.

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS - PIECES FALLING INTO PLACE

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Fig. 1 - Module manufactured by ODTÜ-GÜNAM & Nurol Technology collaboration.

Fig. 2 - 300 kW grid-connected PV system by TEKNOLOGIS in Ankara.

GENERAL FRAMEWORK

With a population reaching 75 million, Turkey's electricity production and consumption based on primary energy resources are continuing to increase. Gross electric energy consumption of Turkey was 229,3 TWh in 2011 and increased by 9,0 % in reference to 2010. Total installed capacity of electricity was 51 116 MW as of August 2011 and can be broken down by resources as 36,5 % hydro and renewables, 63,5 % thermic (natural gas, coals, liquid fuels etc.). Total electric production in 2010 was reported as 209,3 TWh and can be broken down by resources as 46 % natural gas, 25 % coal, 24 % hydro, 3 % other thermic resources (liquid fuels etc.), 1 % wind and 1 % other renewables (PV, wastes etc.). Cumulative installed PV power in Turkey by the end of 2011 was estimated to be about 6,5-7 MW.

NATIONAL PROGRAM

Amendments including incentives have been made into Law 6094: "Utilization of Renewable Energy Resources for Electrical Energy Production," effective on January 8, 2011. A purchase guarantee of 13,3 USDcents/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 cents/kWh);
- PV modules, (+1,3 USDcents/kWh);
- PV cells, (+3,5 USDcents/kWh);
- Inverter, (+0,6 USDcents/kWh);
- Material focusing solar energy on PV modules, (+0,5 USD cents/kWh).

Other regulative steps taken by the related public bodies are listed below:

- Inventory of "Available connection capacities for regional transformer substations based on solar electricity power plants" (August 12, 2011);
- Amendment on "Electricity market license regulation" (August 11, 2011);
- Regulation "Certification and support of renewable energy resources" (July 21, 2011);
- Regulation "Electricity market unlicensed electricity generation" (July 21, 2011);
- Regulation "Electricity generation plants based on solar energy" (June 19, 2011);
- Regulation "Domestic manufacturing of the components used in electric energy generation installations using renewable resources" (June 19th, 2011).

These regulations prescribe the technical and financial procedures and principles for supplying energy to the grid. Another regulation defining the guideline for connection to the distribution grid is currently about to be published by the Electricity Market Regulatory Authority (EPDK).

R&D

Some PV technology projects continued or started in 2012 with state subsidies by the universities and/or public enterprises are listed below:

- Photovoltaic Test and Research Center, TÜBITAK-UME, 2,6 MEUR, 2012-2013.
- New generation/ dye synthesized/ organic PV cell production studies, Ege University Solar Energy Institute (EÜ-GEE), 2011-2013, 1 MEUR, 2011-2013.
- GAP Renewable Energy and Energy Efficiency R&D Center, Harran University, 4 MEUR, 2011-2013.
- Environmental Tests Center, TÜBITAK-UME, 12 MEUR, 2009-2012.
- Energy feasibility studies for 100 public buildings, Ministry of Environment and Urban Planning, 1,7 MEUR, 2012-2013.
- Energy Information and Technology Management Center (EBITEM), Ministry of Energy and Natural Resources, 8,7 MEUR, 2010-2014.
- Studies on renewable energy resources, Ministry of Energy and Natural Resources, 0,6 MEUR, 2012.
- Photonics Research Center, Gazi University, 5,25 MEUR, 2011-2013.
- Utilization of renewable energy resources and increasing energy efficiency, Regional Development Administration of Southeastern Anatolia Region (GAP), 4,9 MEUR, 2009-2013.

Fig. 3 - Solar House used as "Antalya Metropolitan Municipality – Clean Energy Branch Office," Antalya.

Fig. 4 - 10 kW grid-connected/dual axis tracker PV system by Enisolar Ltd. in the Bosch Factory, Bursa.

In addition to these highlights, the following R&D activities were maintained in 2011:

- EÜ-GEE's PV activities are mainly maintained on 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 Turkish PV Technology Platform (UFTP).
- The research activities of Middle East Technical University - Solar Energy Research Center (ODTÜ-GÜNAM) 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.

ODTÜ-GÜNAM collaborates with Nurol Technologies Inc. on its crystalline silicon based cell production studies (Fig. 1) (www.gunam.metu.edu.tr).

- Gazi University's R&D activities are focused mainly on the "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. The Center has epitaxial and bulk-single crystal growth systems, such as MBE and Czochralski, together with a wide range of characterization and fabrication infrastructure (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) interests are:
  - R&D on thin film and novel PV cell technologies;
  - Testing and characterization of PV modules (www.ume.tubitak.gov.tr).
- 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).
- Muğla 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. The Muğla University Campus is the largest photovoltaic park in Turkey, with 110 kW installed PV systems of both grid connected and standalone applications (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. 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).
- Istanbul 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).
- Established in 2011, RA Alternative Energy and Software Technologies Co. Ltd. has been granted support from the Small and Medium Enterprises Development Organization – KOSGEB, in the scope of R&D Innovation program for their optimization and simulation software for hybrid renewable systems.
- Mavisis Co. and Interaktif Ltd. continue their R&D activities to develop new concepts for the power electronic interfaces to be used in/for renewable energy systems.
- TEKNOLOGIS has developed a geographical information system for photovoltaic investments in Turkey ("PVmap Turkey") with the research support of ODTÜ and the financial support of the Ministry of Science, Technology and Industry.

Fig. 5 - 6 kW grid-connected PV system by Motif Proje Ltd. in Samsun.

Fig. 6 - 15 kW grid-connected PV system by Girasolar Ltd. in Izmir.

IMPLEMENTATION

Many companies are still waiting for grid-parity to invest MW-scaled projects in Turkey. Currently, there are a few kW PV pilot projects. Some attractive PV applications which are installed in 2011 are explained below:

- TEKNOLOGIS built a 300 kW solar research facility in Ankara using various types of modules, inverters, and mounting systems ("Solar Lab Turkey"). The "Solar Lab Turkey," opened in October 2011, is the base for optimization software for solar power plant investments and was financially supported by the Ministry of Science, Technology and Industry. The laboratory operates in collaboration with zmir Economy University and Gazi University (Fig. 2). TEKNOLOGIS started to build a 420 kW Project for Hacettepe Teknokent, Ankara (www.teknologis.com.tr).
- Antalya Metropolitan Municipality established the first Clean Energy Branch Office as a department of a Municipality in Turkey. The office continues its studies in a Solar House Building which has been concluded in April 2011 (Fig. 3) (http://www.antalya.bel.tr).
- Enisolar Ltd. installed 10 kW grid-connected/double axis tracking PV system in the Bosch Bursa Factory (Fig. 4). (www.enisolar com).
- Motif Proje Ltd. installed 6 kW grid-connected PV systems in Samsun (Fig. 5). Motif Proje Ltd. also installed 3,5 kW PV system in ODTÜ-GÜNAM and 2,2 kW solar irrigation system in Ankara (www.motifproje.com).
- Girasolar Ltd. installed 15 kW grid-connected PV system for AK AN YAPI (Fig. 6) and some small scaled off-grid applications (555 W – "BERKAY ERIŞ EVI " and 1,1 kW – "KADRI ESEN EVI ").

INDUSTRY STATUS

Currently there is not any manufacturer on feedstock, ingots, wafers and cells in Turkey. There are a few PV module and PV module constituents (glass, frame etc.) manufacturers. Some leading companies and their main activities are briefly introduced below:

- ANEL Group is the first full-automated PV module manufacturer in Turkey since 2009. The ANEL Group, having IEC 61215 certification for their PV modules, produces various goods for known European brands with TÜV, IEC, CE, ISO 9001 and ISO 4001 certifications. The ANEL Group concluded a 1,26 MW PV power plant in Northern Cyprus by providing an EU project support (www.anelenerji.com.tr).
- Trakya Cam Co., a leading flat glass supplier in the region, one of the largest glass producers in Europe is increasing sales for Solar Glass. The parent 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 is producing two types of tempered, patterned solar glass in both 3,2 mm and 4 mm thickness named DURASOLAR P+. Durasolar P+, which are tested and certified by the SPF Institute and are certified as U1 class (www.trakyacam.com.tr).
- Nurol Technologies Inc. started crystalline silicon solar cell and module studies in R&D department of ODTU-GÜNAM facilities. The main purpose of the project is developing the cell production processes, making prototypes and producing the high quality production. This production and know-how will guide to a Nurol Holding investment decision on PV sector (www.nurolteknoloji.com).
- Inci Akü Co. manufactures the VRLA AGM and VRLA Gel battery for renewable energy and UPS applications. The Inci 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).
- Ardıç Glass Co. is another company which is willing to enter tempered glass manufacturing in Ankara (www.ardiccam.com.tr).
- Another module manufacturer, Tera Solar Ltd., produces 5 W to 250 W mono- and poly-crystal modules and has a 5 MW/year production capacity in Bursa (www.tera-solar.com).
- Clean World Energy Co. (www.cwenergy.com.tr) and ANTAK Ltd. (www.an-tak.com/) initiated their PV module manufacturing activities in Antalya in 2011.
- Alfa Machinery Industry Co. is scheduled to begin PV Module Manufacturing in the period 2012-2013 (www.alfakazan.com.tr).
- SOLARTURK Co. will start a 60 MW capacity PV module production by mid 2012 in Gaziantep (www.solarturk.com.tr).
- Interaktif Enerji Ltd., carrying on its activities at KOSGEB TEKMER building at Ege University Campus, designs power electronic interfaces used in renewable energy systems.
- Mavisis Co. produces on-grid and off-grid solar and wind inverters, load banks, grid connected power shifting devices, multifunctional inverters and laboratory equipment like Photovoltaic Simulators (www.mavisis.com).
- RA Alternative Energy Technology supported by KOSGEB and established in zmir is an innovative R&D company working on Renewable Energy and focusing on software development (www.raenerji.com).
- Selektif Technology supported by KOSGEB and established in the stanbul Technical University is an innovative company working on Renewable Energy Technologies and Materials (www.selektif.com.tr).

Fig. 7 - UFTP Seminar, October, 26th, Antalya.

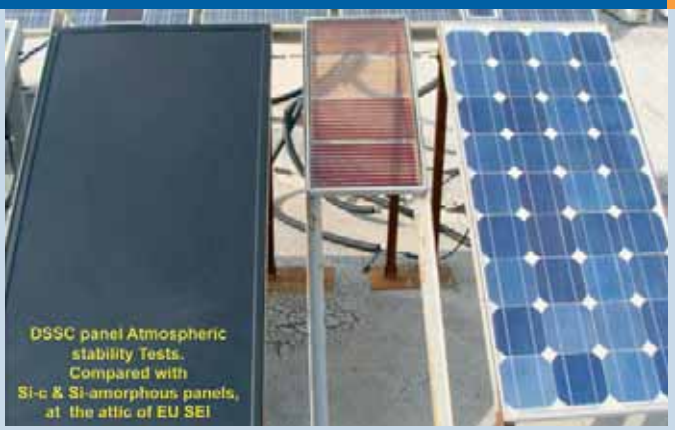

Fig. 8 - DSSC Panel Atmospheric Stability Tests. Si-c & Si-amorphous panels on EU-SEI's attic.

MARKET DEVELOPMENT

Due to the declared incentives not meeting market expectations, the PV sector is still in its infancy in Turkey.

The Turkish PV Technology Platform (UFTP) lead by Ege University Solar Energy Institute (EÜ-GEE), continues its endeavors to bring related bodies together on a common platform and facilitate information flow for healthy market development.

The UFTP hosted the following IEA PVPS events in 2011:

- 35th IEA PVPS Task 1 Experts Meeting, February 17-18, 2011, Istanbul.
- 38th IEA PVPS Executive Committee Meeting, October 27-28, 2011, Antalya.

The UFTP pursues its creation of an effective national PV road map for Turkey. Besides several national seminars and workshops, the UFTP also hosted the following exceptional workshops with international participation, in order to increase the awareness and know-how in the PV sector (More details: www.uftp.org.tr).

- "Advantages of and Possible Issues Surrounding Grid-Connected PV Power Systems," February 16, 2011, Istanbul.
- "Photovoltaics for Solar Cities," October 26, 2011, Antalya (Fig. 7).
- "Crystalline Silicon PV Manufacturing," November 28, 2011, Istanbul.
- "Quality of PV Systems," November 29, 2011, Istanbul.

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

- An official PV Mirror Committee – MTC116 has been established under the Turkish Standards Institute. The committee has been formed of academicians and industry representatives and is studying PV technology standards –translating, harmonizing and annexing these according to national requirements.
- EÜ-GEE prepared the vocational qualification standards of basic renewable energy (wind, PV, solar thermal, biomass) jobs and delivered these to National Qualifications Authority (MYK).

One of the most well-known fairs in Turkey, the Solar Energy and Technologies Fair, will be held on April 12-14, 2012. (www.solarexistanbul.com).

Another highly anticipated event in Turkey, the "SolarTR-2: Solar Electricity Conference and Exhibition," will be held in Antalya, on November 7-9, 2012; with special emphasize on research, investments and requirements in Middle East (www.solartr.org). This event will be held tri-lingually – Turkish, English, and Arabic.

FUTURE OUTLOOK

Although the PV market in Turkey is still fairly small, a highly competitive market is expected to be emerging soon with the grid-parity being reached.

The Turkish Electricity Transmission Company (TEIAŞ) warned that "unless the necessary steps are taken, electricity supply will not meet the demand in 2016." With this warning, along with the environmental responsibility issues, public awareness gradually increased over the last five years and alternative energy resources have become a new area of interest.

Another significant key point is the increasing interests of local governments on PV activities. As an example, Bornova and Seferihisar Municipalities which are districts of zmir attracted attention with their endeavors on developing local sustainable and renewable energy activities. Bornova Municipality is a signatory of EU Covenant of Mayors and became a member of EU Energycities in 2011. Seferihisar Municipality has become the first ever Cittaslow in Turkey and been declared as the Cittaslow capital of Turkey. By focusing on sustainability, these municipalities are willing to increase their PV activities.

Grant donators like SME Support Administration (KOSGEB) and development agencies are prioritizing the renewable themed projects. In the near future it is expected that they shall open calls directly under the title of renewable energy resources.
In the light of these striking activities, a rapidly growing market in the near future in Turkey will not be surprising.

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UNITED KINGDOM

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DONNA MUNRO, SOLAR CONSULTANCY

Fig. 1 - PV systems in South Cumbria, UK. The main photo shows PV in the Crake Valley on Lowick Community Hall, next to the church. The Hall, close up on left, has a 3,5 kWp solar PV array integrated into the traditional slate roof. The PV array was installed as part of major refurbishment works to the hall, including a number of other sustainable features. The right hand photo shows a nearby house with a 2,8 kWp PV system and a solar water heating system. (Photos: Donna Munro).

GENERAL FRAMEWORK AND IMPLEMENTATION

In June 2011, the UK Government enshrined in law a new commitment to halve greenhouse gas emissions, on 1990 levels, by the mid-2020s. A Carbon Plan[1] has been developed that sets out the Government's plans for achieving the emissions reductions committed to for the mid-2020s and looks at pathways to the 2050 target.

The Carbon Plan explains how, over the next decade, the UK will prepare for the future by demonstrating and deploying the key technologies needed to decarbonise power, buildings and road transport in the 2020s and beyond. This plan sets out how the UK will develop a portfolio of technologies for each sector. In electricity, the three parts to the portfolio are renewable power, nuclear power, and coal- and gas-fired power stations fitted with carbon capture and storage. In transport, ultra-low emission vehicles including fully electric, plug-in hybrid, and fuel cell powered cars are being developed. In buildings, the technologies will include air- or ground-source heat pumps, and using heat from power stations.

The power sector currently accounts for 27 % of UK emissions. As heating, transport and industry become increasingly electrified, the amount of electricity the UK needs to generate is very likely to increase from today, and it will need to be almost entirely carbon-free. By 2050, the three sources of UK electricity are likely to be renewables (in particular onshore and offshore wind farms); coal, biomass or gas-fired power stations fitted with CCS technology; and nuclear power. The grid will need to be larger, stronger and smarter to reflect the quantity, geography and intermittency of power generation.

The UK's target is to generate 15 % of its energy from renewables by 2020. A financial framework is being established that provides long-term, comprehensive and targeted support for renewable technologies. The main financial incentives are the:

- Renewables Obligation[2]. This is the main support scheme for renewable electricity projects over 5 MW in the UK (smaller installations are supported through the Feed in Tariff). It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources.
- the Feed in Tariff[3], avaialble to businesses, communities and consumers wanting to install solar PV, micro-wind, micro-CHP and micro-hydro.
- the Renewable Transport Fuel Obligation.
- A Renewable Heat Incentive[4] (RHI). This is a new scheme with RHI tariff payments available to commercial and industrial generators and communities generating renewable heat from later this year. Tariff payments to households will begin in 2012.

NATIONAL PROGRAMME

The Feed-in Tariff scheme, operational in the UK since 1 April 2010, supports the installation of anaerobic digestion, solar PV, wind, micro-CHP and hydro power systems. Solar PV has proved to be the easiest technology to deploy with rapidly falling costs.

The uptake of the PV feed-in Tariff (FiT) has ramped up steadily and during 2011 led to a surge in installations which began in earnest in September and peaked in early December. By the end of January 2012, a total of 737 MW of PV had been installed, well in excess of the initial predictions when the scheme was introduced. The government estimated that if the trend in installations continued, PV deployment could reach 1,3 GW by the end of March 2012, and the cumulative cost to consumers over 25 years would be in the region of 7 billion GBP (in real, discounted terms).

Measures are therefore being taken to slow down the rate of installations. The tariffs offered are being cut from March 3rd 2012, as shown in Table 1, after remaining at their initial level for nearly 2 years. Requirements are also being introduced that new applications for the PV FiT demonstrate that the building to which the PV is attached, or wired to provide electricity, has an Energy Performance Certificate rating of Level D or above. In addition, a 20 % reduction in the tariffs offered will apply to any solar PV installation where the FiT generator owns or receives FiTs payments from 25 or more other PV installations.

TABLE 1 – PV FEED-IN-TARIFFS IN THE UNITED KINGDOM

BAND (kWp)	CURRENT TARIFF (p/kWh)	TARIFF FROM 1 APRIL 2012 (p/kWh)
• 4kW (new build)	37,8	21
• 4kW (retrofit)	43,3	21
> 4-10kW	37,8	16,8
> 10-50kW	32,9	15,2
> 50-100kW	19	12,9
> 100-150kW	19	12,9
> 150-250kW	15	12,9
> 250kW-5MW	8,5	8,9
stand alone	8,5	8,9

In addition, the government is consulting on ways of controlling the cost of the FiT scheme in the future. Options proposed include:

- A further tariff reduction on 1 July 2012 and 6 monthly reductions thereafter.
- A degression mechanism where the speed of tariff reductions is contingent on levels of deployment of new PV systems.
- Cutting the tariff lifetime for new PV systems from 25 to 20 years.

Further information is available on the Department of Energy and Climate Change website: www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/fits/fits.aspx

In addition to the FiT, microgeneration benefits from reduced value added tax (VAT): small-scale onsite low carbon and renewable energy technologies pay 5 percent VAT.

Barriers to microgeneration due to requirements for planning permission have also been removed. In England and Scotland, changes to permitted development rights were introduced in 2008 and 2009. These grant rights to carry out certain limited forms of development on the home, without the need to apply for planning permission. Most solar PV became eligible for permitted planning as a result.

RESEARCH, DEVELOPMENT & DEMONSTRATION

The UK is recognised as being a world leader in 3rd Generation photovoltaics and in organic solar technology. Crystalline Silicon is becoming less important as a research area. Excitonic/dye sensitised solar technology is a growing research area.

The Engineering and Physical Sciences Research Council (EPSRC), is the main UK government agency funding research and training in engineering and the physical sciences. Recent EPSRC funded solar projects[5] include:

- Two SUPERGEN projects in solar energy, thin films (PV21, 6,2 MGBP) and dye sensitized and excitonic solar PV (3,3 MBGP).
- UK India collaboration in PV research with two 2,5 MGBP research programmes.
- Solar for hydrogen generation at Imperial College (4,4 MGBP).
- Programme grant to Cambridge University (6,7 MGBP).
- Science bridging award working with the USA (1,5 MGBP)
- Materials for energy grants (3,6 MGBP)

In addition UK researchers participate in the Solar Europe Industry Initiatives (SEII). There is also on-going R&D in solar system performance, solar devices and solar concentrators as well as R&D work on smart grids and infrastructure.

INDUSTRY AND MARKET DEVELOPMENT

Data from the UK Renewable Energy Association (REA) shows there are now 4 000 solar companies registered with Renewable Energy Assurance Ltd (REAL) in the UK. The REA estimates that the UK solar sector now employs around 25 000 people. This represents more than an 8-fold growth in employment in the UK solar industry since the UK Feed-In Tariff (FiT) scheme began in 2010. 80 % of these jobs are in the installation sector.

Solar installers and products must be registered under the Micro-generation Certification Scheme (for systems under < 50 kW) to be eligible for FiT payments. Installer companies must belong to a consumer code of practice.

In addition to installation companies, the UK has over 60 companies working in the solar manufacturing supply chain and 6 solar manufacturing/assembly plants. Sharp, Sony, Romag/Gentoo, GB Solar, Corus, G24i currently manufacture/assemble solar in the UK. The construction company Kingspan has developed an integrated energy efficiency and solar commercial roofing system for UK manufacture with the potential to employ over 1000 people, however plans have been affected by the sharp cuts to solar FiTs.

IMPLEMENTATION

Monthly updates are available on the web[6] of the capacity registered under the FiT. At the end of January 2012, 805,7 MW of installed capacity was confirmed on the Feed in Tariff scheme, covering 186 283 installations.

Solar Photovoltaics represented 91 per cent (737 MW) of the total installed capacity, and 99 per cent (183 500) of all installations.

504 MW of capacity (173 475 installations) was sub-4 kW retrofitted Solar Photovoltaics.

Domestic schemes represented 69 per cent (559,4 MW) of total installed capacity and 97 per cent (181 387) of installations.

There is a time lag between installing a PV system and registration on the FiT register. It is estimated that an additional 215 MW of PV installations, up to 50 kW, had been installed by the end of January but was not yet on the register.

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:

- DECC Renewables Statistics

Planning Pipeline Database

Updated monthly, Renewable Energy Planning Database (REPD), tracks the progress of thousands of renewable electricity projects through planning, construction and operational phases.

- Planning Pipeline Database

Feed-in Tariff Statistics

Quarterly and Monthly data on capacity and installations

- Feed-in Tariff Statistics

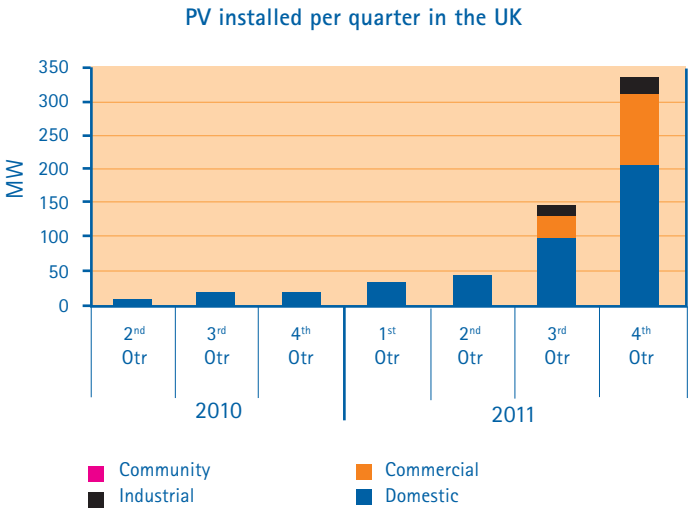

Fig. 2 – PV installed in the United Kingdom, 2010-2011.

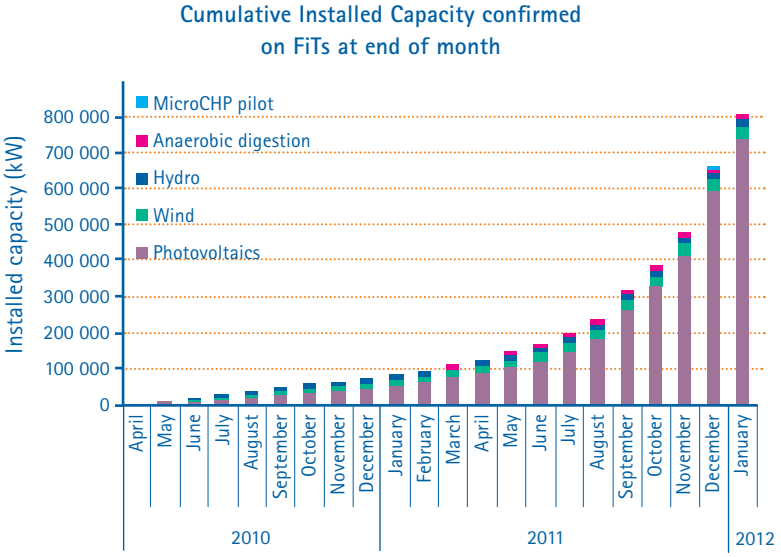

Fig. 3 – Cumulative installed capacity confirmed on FiTs, 2010 – January 2012.

[1] www.decc.gov.uk/assets/decc/11/tackling-climate-change/carbon-plan/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf
[2] www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renew_obs/renew_obs.aspx
[3] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/feedin_tariff/feedin_tariff.aspx
[4] www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/renewable_heat/incentive/incentive.aspx
[5] www.epsrc.ac.uk/ourportfolio/researchareas/Pages/solartech.aspx
[6] www.decc.gov.uk/en/content/cms/statistics/energy_stats/source/fits/fits.aspx

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DAVID FELDMAN AND KRISTEN ARDANI, NATIONAL RENEWABLE ENERGY LABORATORY

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 prevalent than federal policies. Over the course of 2011, 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 yet to be implemented. Despite the lack of a national renewable energy policy framework, PV continues to grow rapidly in the U.S. as a result of local and state initiatives, with the U.S. adding between 1,5 and 2 GW of PV capacity in 2011. At the end of 2010, cumulative installed PV capacity in the U.S. totaled approximately 2,3 GW, bringing the U.S. cumulative installed total to approximately 4 GW [1].

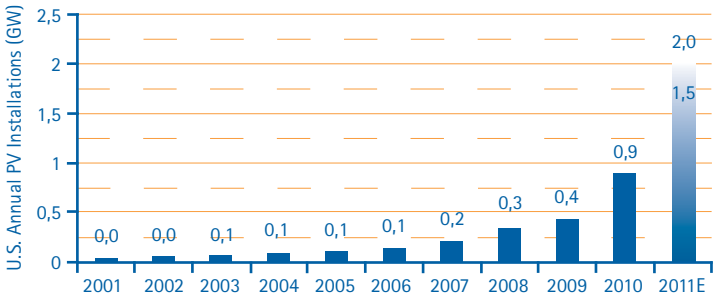

Fig. 1 - U.S. Annual PV Installations. Source: Shayle Kann, GTM Research Q3 2011: Quarterly Market Update. December 2011.

Fig. 1 - 130,6 kW PV system located at Art Institute of Chicago, IL, USA (Photo: Spire Solar Chicago).

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 over the fact that PACE assessments establish senior liens with priority over existing mortgages.

NATIONAL PROGRAM

The United States 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. A short-term program established through Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA) allows owners of non-residential solar energy property who would otherwise receive the 30 % federal ITC to receive an up-front 30 % cash grant instead. This choice is intended to reduce the solar industry's reliance on third-party tax-equity investors, many of whom dropped out of the solar finance market in late 2008 as their tax base was contracted due to the global financial crisis. As of October 31, 2011, the program had awarded 22 060 awards to 870 MW of solar projects. While projects must have begun construction by December 31, 2011, they do not need to be placed in service until the end of 2016.

The ARRA also established a 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. Under a loan guarantee,

Shayle Kann, GTM Research Q3 2011: Quarterly Market Update. December 2011.

Fig. 2 - Steven Bohn, an engineer at SunEdison oversees SunEdison's testing facility at SolarTAC in Aurora, CO, USA. SolarTAC is an integrated, world-class test facility where the solar industry tests, validates, and demonstrates near-market solar technologies (Photo: Dennis Schroeder, NREL).

a government entity promises to assume a private entity's debt if the private entity defaults on its repayment obligations. The DOE, which was required to finalize all awards by September 31, 2011, guaranteed loans for seven PV generating assets, totaling 6,1 BUSD, and four PV manufacturing facilities, totaling 1,3 BUSD.

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 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 2012, 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 supports 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 unsubsidized 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 0,06 USD cents 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 SETP 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 1 USD per watt direct current installed system cost targets by the end of the decade.
- Provide up to 12,5 MUSD for the Rooftop Solar Challenge, an initiative in which cities, states, and regions are awarded funding to develop innovative ways to drive measurable improvements in market conditions for rooftop photovoltaics across the United States, with an emphasis on streamlined and standardized permitting and interconnection processes.

RESEARCH	USD	88,686,697
DEVELOPMENT	USD	134,246,799
DEMONSTRATION	USD	9,577,303
DEPLOYMENT	USD	26,953,662
TOTAL	USD	259,464,461

Fig. 2 - Breakdown of Solar Energy Technologies Program FY 11 R&D Activities.

INDUSTRY AND MARKET DEVELOPMENT

After a doubling of annual PV installations in the U.S. from 2009-10, analysts estimate that the U.S. market did so again in 2011- totaling between 1,5 – 2,0 GW of added capacity. Much of the growth, especially in the second half of 2011, came from non-residential and utility-scale installations. PV capacity continues to be concentrated in a small number of states, such as California and New Jersey. With 2,4 GW of PV projects under construction at the end of 2011, that have individual capacities above 5 MW in size, total installations in 2012 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 facilities, which doubled its PV cell/module shipments from 2009-10, faced some difficulty in 2011. Due to overcapacity in global PV, which caused a rapid decline in price, three U.S. manufacturing companies filed for bankruptcy in August and September of 2011. In addition, others closed facilities or delayed capacity expansion. However, some companies did announce plans for large increases in manufacturing capacity. First Solar will double its domestic production of Cadmium Telluride modules by the end of 2012, and GE announced plans to build a 400 MW PV manufacturing facility, coming on-line by 2013. The DOE also awarded two loan guarantees to PV manufacturing facilities in 2011, with a combined capacity of 1,1 GW.

COMPLETED TASKS
TASK 2 - PERFORMANCE, RELIABILITY AND ANALYSIS OF PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 2 was to provide technical information on PV operational performance, long-term reliability and costs of PV systems, which is very important for an emerging technology. This service was given to a diverse target audience including PV industry, research laboratories, utilities and manufacturers, system designers, installers, standardisation organisations and the educational sector. Task 2 aimed to provide performance data for both general assessments of PV system technologies and improvements of system design and operation.

MEANS

Task 2 work was structured into seven subtasks in order to achieve the objectives.
These were achieved through the development and continuous update of the PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV power systems and subsystems. Task 2 also analysed performance and reliability data for PV systems and components in their respective countries. Activities included the work on the availability of irradiation data, performance prediction for PV systems, shading effects and temperature effects as well as long-term performance and reliability analysis, monitoring techniques, normalised evaluation of PV systems, user's awareness and quality aspects of PV system performance.

Subtasks 1, 5, 6 and 7 were terminated at the end of 2007, while Subtask 3 was concluded in 1999 and Subtasks 2 and 4 were terminated in 2004. Task 2 was officially concluded in 2007.

SUBTASK 1: PV PERFORMANCE DATABASE

Participants worked on the development and update of a PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV systems and subsystems located worldwide. The information was gathered and presented by means of standard data collection formats and definitions. The database allows the comparison of components' quality, long-term operational results, analysis of performance and yields, long-term operational results, analytical calculations, yield prediction and checking of design programmes. A collection of such a variety of high quality operational data presents a unique tool for PV system performance analysis. The performance data are available at the IEA PVPS website: www.iea-pvps.org. In addition, the complete database programme can be downloaded from the same website.

SUBTASK 2: ANALYSIS OF PV POWER SYSTEMS (FROM 1999 TO 2004)

Participants analysed performance and maintenance data for PV power systems and components in their respective countries, both in order to ensure the quality and comparability of data entered in the database under Subtask 1 and to develop analytical reports on key issues such as operational performance, reliability and sizing of PV systems. Participants also compared existing data on operational reliability and developed recommendations on maintenance aspects.

SUBTASK 3: MEASURING AND MONITORING APPROACHES (FROM 1995 TO 1999)

Participants worked on a handbook covering PV system monitoring techniques, normalised analysis of PV systems and national monitoring procedures in the IEA member countries. This document covered measuring and monitoring in the context of PV systems and expanded in breadth and details the issue of monitoring. It helped orientating and relating technical explanations and details of existing experiences and guidelines. Available documentation on measuring and monitoring approaches was brought together and assessed for their scope and contents.

SUBTASK 4: IMPROVING PV SYSTEMS PERFORMANCE (FROM 1999 TO 2004)

Participants worked on recommendations on sizing of PV power systems and suggested improvements for better PV system performance. Participants identified tools to process and analyse data for performance prediction and sizing purposes. Applied energy management schemes were analyzed from the energy and operating cost points of view. Participants took account of the work performed in other Subtasks and worked in collaboration with Task 3.

SUBTASK 5: TECHNICAL ASSESSMENTS AND TECHNOLOGY TRENDS OF PV SYSTEMS

Participants analysed and validated expertise and performance results from grid-connected (GCS), stand-alone (SAS) and PV-based hybrid systems. The aims of this subtask were to demonstrate up-to-date performance validation criteria for a qualitative ranking of PV grid-connected, stand-alone and PV-based hybrid systems. It also identified high performance products, technologies and design methodology in order to foster the development of maximum conversion efficiency and optimum integration of PV. Activities included evaluating PV performance over time and failure statistics, analysing the end-user's consciousness on PV system performance and the use of satellite images for PV performance prediction.

SUBTASK 6: PV SYSTEM COST OVER TIME

Task 2 identified and evaluated the important elements, which are responsible for the life cycle economic performance of PV systems by investigating economic data for all key components of PV systems and by gathering information about real life costs of maintenance of PV systems. Participants worked on national case studies on performance and costs in their countries to provide a good insight of performance and cost trends of PV systems for a 10-year-period.

SUBTASK 7: DISSEMINATION ACTIVITIES

Task 2 put enhanced efforts to disseminate Task 2 results & deliverables to target audiences on the national and international level using websites, workshops & symposia as well as presentations at conferences and seminars. Task 2 deliverables range from the PV Performance Database to technical reports and conference papers. The public PVPS and Task websites enabled downloads and technical information to be provided quickly and cost-effectively to the users. The Task 2 website is available in eight different languages spoken by the Task delegates. For gaining information on the user profile

and customers of Task 2 deliverables, monthly download statistics were prepared on a regular, biannual basis.

Activities included seminar presentations, training courses for system designers and installers (Italy), European master course and university seminars to advanced students (France, Germany), conference contributions for national and international audiences as well as presentations and distributions of the Performance Database programme and other Task 2 deliverables.

Task 2 developed a web based educational tool in close cooperation with Task 10 that is available at www.bipvtool.com. This tool represents a detailed, practical source of information on building integrated PV from the idea to the long-term operation of PV systems.

TASK 2 REPORTS AND DATABASE

Task 2 produced the following technical reports, workshop proceedings and database programme from 1997 to 2007:

Database

IEA PVPS Database Task 2, T2-02:2001
http://www.iea-pvps-task2.org

Task 2 Technical Reports

1. Analysis of Photovoltaic Systems, T2-01:2000, April 2000
2. Operational Performance, Reliability and Promotion of Photovoltaic Systems, T2-03:2002, May 2002
3. The Availability of Irradiation Data, T2-04:2004, April 2004
4. Country Reports on PV System Performance, T2-05:2008, December 2004
5. Cost and Performance Trends in Grid-Connected Photovoltaic Systems and Case Studies, T2-06:2007, December 2007
6. Performance Prediction of Grid-Connected Photovoltaic Systems Using Remote Sensing, T2-07:2008, March 2008

Task 2 Internal Reports

1. Handbook on Monitoring and Monitoring Approaches, ECN, Netherlands, November 1998
2. Proceedings of Workshop "PV System Performance, Technology, Reliability and Economical Factors of the PV Industry", ISFH, Germany, October 2005
3. Report on Users' Awareness of PV System Performance, AIST, Japan, September 2007.

DELIVERABLES – WHERE TO GET THEM?

All technical reports are available for download at the IEA PVPS website:
http://www.iea-pvps.org and the Task 2 website:
http://www.iea-pvps-task2.org/

PARTICIPANTS

Thirteen countries supported Task 2 activities:
Austria, Canada, European Union, EPIA, France, Germany, Italy, Japan, Poland, Sweden, Switzerland, United Kingdom, United States.

Participants represented the following sectors: research & development, system engineering, PV industry and utility.

CONTACT INFORMATION

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

OVERALL OBJECTIVE

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

Task 3's **second programme (1999-2004)** was initiated against this background with the following overall objectives:

Considering all types of stand-alone photovoltaic systems, ranging from small PV kits to power stations supplying micro-grids, the main objective of Task 3 is to improve the technical quality and cost-effectiveness of PV systems in stand-alone and island applications.

Task 3 Aimed:

- To collect, analyse and disseminate information on the technical performance and cost structure of PV systems in these applications
- To share the knowledge and experience gained in monitoring selected national and international projects
- To provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems
- To contribute to the development of improved photovoltaic systems and subsystems"

The main target audience of Task 3 activities were technical groups such as project developers, system designers, industrial manufacturers, installers, utilities, Quality organisations, training providers, end users.

The 1999-2004 work programme included the following subtasks and activities:

SUBTASK 1: QUALITY ASSURANCE

Activity 11: Critical Review of Implementation of Quality Assurance Schemes

To develop quality assurance schemes that will lead to a warranty for all system installations at reasonable cost.

Activity 12: Technical Aspects of Performance Assessment on Field - Quality Management

To identify and establish practical performance assessment guidelines.

SUBTASK 2: TECHNICAL ISSUES

Activity 21: Hybrid Systems

To contribute to cost reduction through standardisation and modularity in order to facilitate large scale dissemination of PV hybrid systems.

Activity 22: Storage Function

To provide recommendations to decrease the cost of storage in PV and PV hybrid systems.

Activity 23: Load/Appliances : Load Management and New Applications

To provide a technical contribution to cost reduction by showing the cost efficiencies associated with effective load management and efficient appliance selection.

Collaborative activities had to develop knowledge based on project implementations, technological improvements from the equipment manufacturers, R&D programmes results, and feed-back coming from the field.

PUBLICATIONS

Task 3 publications can be downloaded from the IEA PVPS website www.iea-pvps.org and are listed below:

TECHNICAL REPORTS PUBLISHED BY TASK 3 DURING THE PERIOD 1999-2004

TITLE	REFERENCE NUMBER
Survey of National and International Standards, Guidelines and Quality Assurance Procedures for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-07:2000
Recommended Practices for Charge Controllers	IEA-PVPS T3-08:2000
Use of Appliances in Stand-Alone Photovoltaic Systems: Problems and Solutions	IEA-PVPS T3-09:2002
Management of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems	IEA-PVPS T3-10:2002
Testing of Lead-Acid Batteries used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-11:2002
Selecting Stand-Alone Photovoltaic Systems - Guidelines	IEA-PVPS T3-12:2002
Monitoring Stand-Alone Photovoltaic Systems: Methodology and Equipment - Recommended Practices	IEA-PVPS T3-13:2003
Protection Against the Effects of Lightning on Stand-Alone Photovoltaic Systems - Common Practices	IEA-PVPS T3-14:2003
Managing the Quality of Stand-Alone Photovoltaic Systems - Recommended Practices	IEA-PVPS T3-15:2003
Demand Side Management for Stand-Alone Photovoltaic Systems	IEA-PVPS T3-16:2003
Selecting Lead-Acid Batteries Used in Stand-Alone Photovoltaic Power Systems - Guidelines	IEA-PVPS T3-17:2004
Alternative to Lead-Acid Batteries in Stand-Alone Photovoltaic Systems	IEA-PVPS T3-18:2004

SCOPE FOR FUTURE ACTIVITIES

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, "PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website:
www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities:
Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

CONTACT INFORMATION

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COMPLETED TASKS
TASK 5 - GRID INTERCONNECTION OF BUILDING INTEGRATED AND OTHER DISPERSED PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 5 was to develop and verify technical requirements, which served as the technical guidelines for grid interconnection with building-integrated and other dispersed PV systems. The development of these technical requirements included safety and reliable linkage to the electric grid at the lowest possible cost. The systems to be considered were those connected with a low-voltage grid, which was typically of a size between one and fifty 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

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COMPLETED TASKS
TASK 6 - DESIGN AND OPERATION OF MODULAR PHOTOVOLTAIC PLANTS FOR LARGE SCALE POWER GENERATION

OVERALL OBJECTIVE

Task 6 officially completed its activities in May 1998. The main objective of this Task was to further develop large-scale modular photovoltaic plants for peaking and long-term baseload power generation in connection with the medium-voltage grid.

MEANS

The Task 6 work was performed by structural engineers and PV industry experts. The work was structured into four 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

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COMPLETED TASKS
TASK 7 - PHOTOVOLTAIC POWER SYSTEMS IN THE BUILT ENVIRONMENT

OVERALL OBJECTIVE

The objective of Task 7 was to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment. The objective was also to assess and remove non-technical barriers for their introduction as an energy-significant option.

It is expected that successful integration of PV systems into the built environment (BIPV) will contribute significantly to the future spread of PV.

For this, active involvement of urban planners, architects and building engineers is required. Task 7 motivated the collaboration between these groups and PV system specialists, utility specialists, PV and building industry and other professionals involved in photovoltaics.

Task 7 considered all grid connected systems other than classified as «ground based arrays». Primary focus of this Task was on the integration of PV into the architectural design of roofs and facades of residential, commercial and industrial buildings and other structures in the built environment (such as noise barriers, parking areas and railway canopies), and on other market factors, both technical and non-technical, that need to be addressed and resolved before wide spread adoption of PV in the built environment will occur. Task 7 officially started on January 1, 1997 and finished end 2001. In 2002, the last reports and deliverables were published. At the end of 2003 there remained only one outstanding issue: the publication of the book «Designing with Solar Power». This book is expected in Spring 2005.

SUBTASK 1: Architectural Design of Photovoltaic Power Systems in the Built Environment

Participants worked on the improvement of the architectural design of PV systems as an integral element in buildings and other structures in the built environment. For this purpose, existing PV projects were documented. In addition, case studies were followed and evaluated by the Task Participants. Many of these case studies were realised as demonstration projects.

SUBTASK 2: Systems Technologies for Photovoltaic Power Systems in the Built Environment

Participants worked on the development of new concepts for photovoltaic power systems in the built environment that can enhance the electrical performance or the performance of the PV system as a building component. New concepts, developed by the Participants shall enhance market opportunities for the industry. This Subtask aims for a number of standardised and certified PV elements for integration in buildings and other structures in the built environment. The Subtask will also provide a number of options to effectively utilise PV electricity and to connect PV systems safely and reliably to the electricity grid, as far as this topic is not addressed by Task 5 of the PVPS Implementing Agreement.

SUBTASK 3: Non-Technical Barriers in the Introduction of Photovoltaic Power Systems in the Built Environment

Participants assessed the non-technical barriers to be removed to make PV in the built environment an energy-significant power supply option. The purpose of this Subtask was to identify the barriers on one side and the (technical, economic, market) potential of PV in the built environment on the other. The main result of this Subtask will be an executive IEA report on strategies for barrier removal and utilisation of the PV potential.

SUBTASK 4: Demonstration and Dissemination of Photovoltaic Power Systems in the Built Environment

The results of the other Subtasks were brought to the market by dissemination of collected information and the demonstration of new concepts. Demonstration of mounting and system concepts takes place through the EPFL Demosite. Results are disseminated by the use of different media (ranging from papers, books, and brochures to new media such as a CD-ROM or a WWW-site). Dissemination will also occur through the second and third International Solar Electric Buildings Conferences and national workshops in conjunction with the semi-annual meetings of the Task. Furthermore, the possibility of a training and education program was assessed and resulted in a CD-ROM.

TASK 7 REPORTS

Task 7 produced the following reports from 1999 to 2002:

1. Literature Survey and Analysis of Non-technical Problems for the Introduction of BIPV Systems, B. van Mierlo & B. Oudshoff, IVAM Environmental Research, 1999. To be ordered at IVAM Environmental Research, NL, Fax + 31 20 525 58 50
2. PV in Non Building Structures - A Design Guide, M.A. Romero, EcoCode-Miljö och Architectur, 1999. To be ordered at Energiebanken, SE, Fax: +46 652 13 427
3. Potential for Building Integrated Photovoltaics, M. Gutschner, NET Nowak Energie & Technologie AG, 2001. To be ordered at NET, CH, Fax: +41 26 49 40 034
4. Guidelines for the Economic Evaluation of Building Integrated Photovoltaics, P. Eiffert, National Renewable Energy Laboratories, 2002. To be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance.
5. Market Deployement Strategies for Photovoltaics in the Built Environment, R. Haas, Technische Universität Wien, 2002. To be ordered at Technische Universität Wien, AT, Fax: +43 1 588 013 7397
6. Innovative electric concepts, H. Wilk, Energie AG, 2002. To be ordered at Energie AG, AT, Fax: +43732 9000 3309
7. Reliability of Photovoltaic Systems, H. Laukamp, Fraunhofer Institute für Solar Energiesysteme, 2002. To be ordered at Fraunhofer Institute für Solar Energiesysteme, GE, Fax: +49 761 4588 217
8. PV/Thermal Solar Energy Systems, Status of the Technology and Roadmap for future Development, H. Sorensen, Esbensen Consulting, 2002, To be ordered at Esbensen Consulting Engineers, DK, Fax: +45 33 26 73 01

11. Executive Summary Report - Non-technical Barriers to the commercialisation of Photovoltaic Power in the Built Environment, P. Eiffert, National Renewable Energy Laboratories, to be ordered at NREL, USA, website: www.nrel.gov/buildings/highperformance

DELIVERABLES - Where to get them?

All reports are available for download at IEA PVPS website: www.iea-pvps.org.
In addition, all reports and many other deliverables are summarized on CD-ROM, which can be ordered at Novem, The Netherlands.

Task 7, Project Results and Documents.
To be ordered at:
Novem, Publication Centre
PO Box 8242
3503 RE Utrecht
The Netherlands
Tel.: +31 30 2393493
Email: publicatiecentrum@novem.nl.

Task 7 book: Designing With Solar Power"
To be ordered at:
The Images Publishing Group Pty Ltd
6 Bastow Place
Mulgrave, Victoria 3170, Australia

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In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

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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

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