IEA INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

PVPS annual report 2013

IMPLEMENTING AGREEMENT
ON PHOTOVOLTAIC POWER SYSTEMS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

ANNUAL REPORT 2013

COVER PHOTO AND ABOVE:

Multicolored transparent photovoltaic façade at the ***SwissTech Convention Center, Swiss Federal Institute of Technology in Lausanne EPFL, Switzerland.***

This 300 m² PV installation is the world's first multicolored Dye Solar Cell Façade, composed of "Grätzel Cells," which encompasses a length of 36 meters and a maximum height of 15 meters. Annual production is estimated at 2,000 kWh.

PV Installation Planned and Produced by: Solaronix SA, Aubonne, Switzerland; with the support of Romande Energie.
Architects: Richter · Dahl Rocha & Associés architectes SA, Lausanne, Switzerland.
General Contractor: HRS Real Estate SA, Crissier, Switzerland.

Photo: © IEA PVPS / DanielForster.com

CHAIRMAN'S MESSAGE

The IEA Photovoltaic Power Systems Programme IEA PVPS is pleased to present its 2013 annual report. 2013 has been a turning point in many aspects for the global development of photovoltaics: On the one hand, the rapid cost reduction of photovoltaic power systems of the last years has continued throughout the year, but at a slower pace. At the same time market support has become more constrained in a number of countries, namely in Europe. On the other hand, markets in Asia and the USA have continued to grow vigorously. Together with the increasing cost-competitiveness of photovoltaics, the worldwide market has reached a new maximum with close to 38 GW installed in 2013, well above the roughly 30 GW of 2012. Asia has seen a larger market than Europe for the first time. Close to 140 GW of photovoltaic systems were installed worldwide at the end of 2013, enough to cover roughly 1 % of the global electricity supply. Together with this upswing of the market, the photovoltaic industry is seen to grow again, following a painful period of consolidation.

As a leading and unique 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 policy advice to our key stakeholders remain our highest priorities. Due to the increasing recognition of photovoltaics as an important future energy technology, the interest in the work performed within IEA PVPS is constantly expanding. Throughout 2013, IEA PVPS has been in close contact with the IEA Secretariat, thereby contributing to the latest IEA publications.

2013 marked the first year of the 5th 5-year term of IEA PVPS, covering the period of 2013 – 2017. In this new 5-year term, the focus and the activities of the IEA PVPS Programme move closer to market related issues, both technical and non-technical, capitalizing on the many experiences meanwhile available and striving for a further sustainable development and implementation of photovoltaic technology. While continuing to foster the key issues for the deployment of photovoltaics mentioned above, the new term of IEA PVPS is further characterized by an increasing focus on business models, sustainable policy frameworks as well as technical and market related integration of photovoltaics in the electricity system.

Interest and outreach for new membership within IEA PVPS continued in 2013. The Copper Alliance has joined IEA PVPS as the 28th member, thereby introducing a new industrial dimension to our membership. I welcome the Copper Alliance as the most recent IEA PVPS member and look forward to a long and fruitful cooperation. The PVPS membership of Thailand will finally materialize in 2014. Contacts have continued with Greece, India, Morocco, New Zealand, Singapore and South Africa as well as with EPRI (Electric Power Research Institute USA) and ECREEE (ECOWAS Regional Centre for Renewable Energy and Energy Efficiency). IEA PVPS continues to cover the majority of countries active in development, production and installation of photovoltaic power systems.

The overall communication efforts were continued through systematic distribution of PVPS products at conferences, workshops and by means of direct mailings. Communication was further supported by the PVPS website www.iea-pvps.org. Moreover, booths and workshops at the industry exhibition of the 28th European Photovoltaic Solar Energy Conference in Paris (France), Solar Power International in Chicago, Illinois (USA), as well as the 23rd International Photovoltaic Science and Engineering Conference PVSEC-23 in Taipei (Taiwan), attracted a large number of visitors and provided an excellent forum for dissemination purposes.

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. Several of the more recent IEA PVPS Tasks have produced important new publications. 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. Following many years of managing successfully our Task 1, Greg Watt from Australia has been succeeded by Gaëtan Masson from Belgium. I would like to thank Greg Watt for his continued efforts and wish Gaëtan Masson success in his new responsibilities. With this, I take the opportunity to thank all Executive Committee members, Operating Agents and Task Experts, for their dedicated efforts and contributions to IEA PVPS.

S. Nowak

Stefan Nowak
Chairman

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PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

IEA

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD), which carries out a comprehensive programme of energy cooperation among its member countries. The European Union also participates in the IEA's work. Collaboration in research, development and demonstration (RD&D) of energy technologies has been an important part of the Agency's Programme.

The IEA RD&D activities are headed by the Committee on Research and Technology (CERT), supported by the IEA secretariat staff, with headquarters in Paris. In addition, four Working Parties on End Use, Renewable Energy, Fossil Fuels and Fusion Power, are charged with monitoring the various collaborative energy agreements, identifying new areas of cooperation 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 Division 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 and organisation, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. By late 2013, fourteen Tasks were established within the PVPS programme, of which six are currently operational.

The twenty-eight PVPS members are: Australia, Austria, Belgium, Canada, the Copper Alliance, China, Denmark, EPIA, European Union, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, the Netherlands, Norway, Portugal, SEIA, SEPA, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States of America. Belgium joined IEA PVPS in 2012 and the Copper Alliance joined PVPS in 2013.

IEA PVPS CURRENT TERM (2013 – 2017)

As one of the few truly global networks in the field of PV, IEA PVPS can take a high level, strategic view of the issues surrounding the continued development of PV technologies and markets, thus paving the way for appropriate government and industry activity. Within the last few years, photovoltaics has evolved from a niche technology to an energy technology with significant contributions to the electricity supply in several countries. IEA PVPS is using its current term to put particular emphasis on:

- Supporting the transition and market transformation towards self-sustained PV markets;
- Working with a broader set of stakeholders, especially from utilities, financiers and industry;
- Assessing and sharing experience on new business approaches and business models;
- Providing targeted and objective information on PV energy services for successful implementation and high penetration;
- Providing a recognised, high-quality reference network for the global development of PV and related matters;
- Attracting new participants from non-IEA countries where PV can play a key role in energy supply.
- Carrying out relevant activities of multinational interest;
- Specifically, IEA PVPS will carry out collaborative activities related to photovoltaics on the topics: Quality and reliability, environmental aspects, grid integration, urban, hybrid and very large-scale systems, off-grid energy services, policy and regulatory frameworks, as well as a broad set of information and communication efforts;
- Finally, where appropriate from an energy system point of view, IEA PVPS will increase the efforts to share its results and cooperate with stakeholders from other energy technologies and sectors.

The overall desired outcomes of the co-operation within IEA PVPS are:

- A global reference on PV for policy and industry decision makers from PVPS member countries and bodies, non-member countries and international organisations;
- A global network of expertise for information exchange and analysis concerning the most relevant technical and non-technical issues towards sustainable large-scale deployment of PV;
- An impartial and reliable source of information for PV experts and non-experts about worldwide trends, markets and costs;
- Meaningful guidelines and recommended practices for state-of-the-art PV applications to meet the needs of planners, installers and system owners. Data collected and the lessons learned are distributed widely via reports, internet, workshops and other means;
- Advancing the understanding and solutions for integration of PV power systems in utility distribution grids; in particular, peak power contribution, competition with retail electricity prices, high penetration of PV systems and smart grids. Monitoring these developments and giving advice from lessons learned will be increasingly useful for many parties involved.
- Establish a fruitful co-operation between expert groups on decentralised power supply in both developed and emerging countries;
- Overview of successful business models in various market segments;
- Definition of regulatory and policy parameters for long term sustainable and cost effective PV markets to operate.

IEA PVPS MISSION

The mission of the IEA PVPS programme is:

To enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems.

The underlying assumption is that the market for PV systems is rapidly expanding to significant penetrations in grid-connected markets in an increasing number of countries, connected to both the distribution network and the central transmission network.

This strong market expansion requires the availability of and access to reliable information on the performance and sustainability of PV systems, technical and design guidelines, planning methods, financing, etc., to be shared with the various actors. In particular, the high penetration of PV into main grids requires the development of new grid and PV inverter management strategies, greater focus on solar forecasting and storage, as well as investigations of the economic and technological impact on the whole energy system. New PV business models need to be developed, as the decentralised character of photovoltaics shifts the responsibility for energy generation more into the hands of private owners, municipalities, cities and regions.

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, contributing to sustainability in the energy system and a growing contribution to CO2 mitigation:

1. PV Technology Development

Mainstream deployment of PV is in its infancy and will continue to need technology development at the PV module and system levels in order to integrate seamlessly with energy systems around the world. Performance improvements, specialised products and further cost reductions are still required. In addition, renewable energy based technologies, such as PV, by definition rely on the natural cycles of the earth's energy systems and their output therefore varies with the hourly, daily and seasonal cycles of sun, wind and water. This contrasts with energy supplies based on fossil fuels and nuclear, where the energy source is stored and thus available when required. As renewables contribute increasingly to mainstream electricity supply, the need to balance varying renewable energy inputs to meet demand also increases. For optimised PV deployment, this means that synergies with other renewables as well as storage, forecasting and demand-side related activities will become more important and suitable technology development will be required.

IEA PVPS shall:

- Evaluate and validate emerging PV technologies that are still at pre-commercial level and to provide guidelines for improvement of the design, construction and operation of photovoltaic power systems and subsystems to increase reliability and performance and to minimise cost;
- Contribute to the development of new standards, accreditation and approval processes, objective operational experience, grid interconnection-standards; investigation of barriers and communication of success stories;
- Assess the impact of PV on distribution networks, in mini- and micro-grids as well as in other applications and provide analysis of the issues and possible solutions;
- Examine the use of demand management and storage as elements in optimisation of renewable energy system deployment;
- Identify technical opportunities and provide best practice for emerging applications (non-domestic systems, community systems, hybrids, mini-grids, weak grids);
- Foster industry – academia interaction focusing on PV technology development.

2. Competitive PV Markets

Until recently, PV mainly relied on support schemes provided by governments or aid organisations. Within the next few years, the transition towards PV as a competitive energy source will need to take place in most of the energy markets. Therefore, this process needs to be accompanied by reliable information and credible recommendations.

IEA PVPS aims:

- To assess economic performance of PV across member countries and undertake collaborative research to overcome current issues;
- To develop material that will assist in the development of standardised contractual agreements between PV system owners and utilities;
- To encourage private and public sector investments that facilitate the sustainable deployment of PV in new markets and within mainstream energy markets;
- To investigate the synergies between PV and other renewables for optimum power supply in different regions;
- To stimulate the awareness and interest of national, multilateral and bilateral agencies and development and investment banks in the new market structures and financing requirements for economic deployment of PV systems;
- To collate information and prepare reports on market structures suitable for long term sustainable PV deployment;
- To identify economic opportunities as well as promising business models and provide best practice examples for emerging applications (non-domestic systems, community systems, hybrids, mini-grids, weak grids);
- To evaluate and promote "bankability" and innovative business models in PV projects namely:
  - Identifying criteria banks / financiers use in order to determine the terms of potential funding of projects (now and in the future, after the end of subsidized tariffs);
  - Identifying and evaluating insurance or innovative bridging products that would allow banks / financiers to fund more projects and apply better conditions;
  - Identifying, characterizing and potentially develop innovative business models in the PV sector aiming at the definition of clear market rules and legislation that potentiates such business models.

IEA PVPS Executive Committee, 42nd IEA PVPS ExCo Meeting, Scheveningen, The Netherlands, November 2013.

3. An Environmentally and Economically Sustainable PV Industry

The PV industry, even though with many years of experience, is still in its juvenile phase. The huge market growth in recent years needs to be followed by a phase of consolidation. IEA PVPS shall contribute to sustainable industry development around the globe. Development of human resources by adequate education and training, caring for quality in the products and services, aspects of environmental health and safety in the production (e.g. collection and recycling, as well as the whole life cycle of PV products) are essential to establish this new sector as a pillar in the new energy economy.

IEA PVPS shall:

- Investigate the environmental impact of PV products in their whole life cycle;
- Assist the development of collection infrastructure by examining and evaluating the collection infrastructure of other recyclables (e.g., electronics, liquid crystal displays);
- Enhance the interaction among industry players so that they share information and resources for collection and recycling;
- Show the technical and cost feasibility of collection and recycling to environmental-policy makers;
- Create a clear understanding of safety and provide recommendations on the use and handling of hazardous substances and materials during the manufacturing process;
- Foster industry – academia interaction focusing on PV's sustainability.

4. Policy Recommendations and Strategies

As PV moves into mainstream energy markets, standards, laws and regulatory arrangements made when fossil fuels dominated energy supply may no longer be suitable. Where PV is connected to distribution networks, market structures will need to be developed which accommodate on-site generation, two-way electricity flows, and associated energy efficiency and demand management opportunities, whilst also providing signals for ancillary services to enhance grid stability. Guidelines are needed for adapted innovation processes to achieve a sustainable PV industry, as well as best practice of the frame conditions in industry-policy for a competitive photovoltaic industry. For central PV-generation, new rules may be required to cater to variable generators, and market signals provided for accurate forecasting, synergies with other renewables and storage. In off-grid applications, cross subsidies currently provided across the world for diesel generation will need to be examined if PV is a more cost effective solution, while tax structures and other arrangements designed around annual fuel use may need to be changed to cater for the up-front capital investment required for PV.

IEA PVPS shall:

- Contribute to long term policy and financing schemes namely to facilitate implementation of innovative business models, national and international programmes and initiatives;
- Share the activities and results of national and regional technology development and deployment programmes;
- Provide objective policy advice to governments, utilities and international organisations;
- Identify successful policy mechanisms leading to self-sustained market growth;
- Examine and report on international examples of PV as a significant player in national and regional energy systems;
- Investigate the impact of the shift towards renewables on other - mainly fossil and nuclear – generation businesses in high PV scenarios.
- Develop strategies for markets where PV power is already economically competitive with end-user power prices.
- Develop long term scenarios and visionary papers and concepts namely developing a Multi – PV Technology Roadmap, by that contributing to new strategies and innovation.

5. Impartial and Reliable Information

PVPS is well established as a highly credible source of information around the PV sector. Even though many PV communities, agencies and other organisations exist, this role remains as one of the key IEA PVPS objectives. This role as a global reference for PV related issues will experience significant development within the upcoming period, including the impact of PV technology on the environment, existing energy systems and the society at large.

IEA PVPS shall:

- Collect and analyse information on key deployment issues, such as policies, installations, markets, applications and experiences;
- Present/publish the reliable and relevant parts of this information in appropriate forms (presentations, brochures, reports, books, internet, etc.);
- Increase awareness of the opportunities for PV systems amongst targeted groups via workshops, missions and publications;
- Respond to the IEA and other organizations' needs regarding the worldwide development of PV technology and markets;
- Identify the needs for PV specific training and education;
- Develop education and awareness materials which remove informational barriers among key target audiences, including consumers, developers, utilities and government agencies;
- Prepare material and tools for training and education in industry.

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. The following Tasks have been established within IEA PVPS:

- Task 1. Strategic PV Analysis and Outreach;
- 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. Study on Very Large Scale Photovoltaic Power Generation System;
- Task 9. Deploying PV Services for Regional Development;
- 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 of PV Systems. 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. Depending on the topic and the Tasks, the internal organisation and responsibilities of the Operating Agent can vary, with more or less developed subtask structures and leadership. Operating Agents are responsible towards the PVPS ExCo and they generally represent their respective Tasks at meetings and conferences. The Operating Agent compiles a status report, with results achieved in the last six months, as well as a Workplan for the coming period. These are being discussed at the Executive Committee meeting, where all participating countries and organisations have a seat. Based on the Workplan, the Executive Committee decides to continue the activities within the Task, the participating countries and organisations in this Task commit their respective countries/organisations to an active involvement by their experts. In this way, a close cooperation can be achieved, whereas duplication of work is avoided.

TASK STATUS REPORTS
TASK 1 – STRATEGIC PV ANALYSIS & OUTREACH

Fig. 1 – 40th Task 1 Meeting in Jeju, Korea, November 2013.

Fig. 2 – 40th Task 1 Meeting. Experts at Work, Jeju, Korea, November 2013.

Fig. 3 – Task 1's New Business Models Workshop, Paris, France, October 2013.

TASK 1 – STRATEGIC PV ANALYSIS AND OUTREACH

The objective of Task 1 was revised and enhanced in 2013 which is reflected its current role. Task 1 shares a double role of expertise and outreach, which is reflecting in its new name.

Task 1 aims to promote and facilitate the exchange and dissemination of general information on the technical, economic, industrial, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation.

Expertise:

- Task 1 serves as the think tank of the PVPS programme, by investigating and clarifying the evolutions and trends of the PV market, identifying issues and advancing knowledge.
- Task 1 researches market and industry development trends, analyses support and R&D policies.

Outreach:

- Task 1 compiles the agreed PV information in the PVPS countries and a more broadly, disseminates PVPS information and analyses to the target audiences and stakeholders.

Following the 2013 changes, Task 1 has been reorganized into four Subtasks, covering all aspects, both new and previously enacted activities.

SUBTASK 1.1: Market, Policies and Industrial Data and Analysis

Task 1 aims to follow the evolution of the PV development, analyzing and anticipating its drivers and supporting policies. It aims at broadly advising the PVPS stakeholders about the most important developments in the program countries. It focuses on facts, accurate numbers and verifiable information in order to give the best possible overview of the diversity of PV support schemes in regulatory environments around the globe.

National Survey Reports

National Survey Reports (NSRs) are 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 Task 1 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.

TRENDS in Photovoltaic Applications Report

Each year the printed report, Trends in Photovoltaic Applications, is compiled from the NSRs produced annually by all countries participating in the IEA PVPS Programme. 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

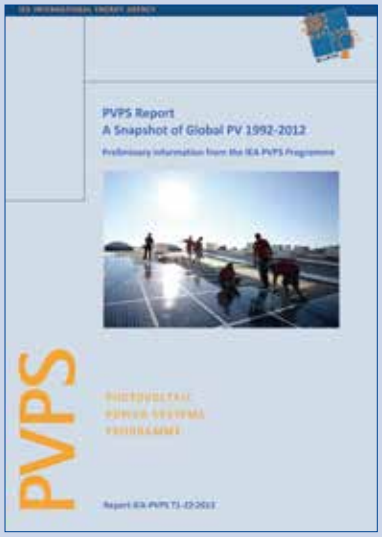

Fig. 4 - PVPS Report: A Snapshot of Global PV 1992-2012; Report IEA-PVPS T1-22:2013.

Fig. 5 – Trends in Photovoltaic Applications – Survey Report of Selected IEA Countries between 1992 and 2013; Report IEA-PVPS T1-23:2013.

is prepared by a small editorial group within Task 1 and is funded by the IEA PVPS Programme. Copies are distributed 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 2013, eighteen issues of Trends have been published.

A Snapshot of Global PV Report

Since 2013, a new report, A Snapshot of Global PV, is compiled from the preliminary market development information provided annually by all countries participating in the IEA PVPS Programme. The Snapshot report aims at presenting a first sound estimate of PV market developments from the previous year and is published in the first quarter of the new year. Task 1 aims to produce this report every year in order to communicate PV market developments earlier. The Trends report continues to present accurate market development results later in the year, with an in-depth analysis of the drivers and factors behind PV market development.

SUBTASK 1.2: Think Tank Activities

Task 1 aims to serve as the Think Tank of the PVPS programme, providing the Executive Committee and dedicated tasks with ideas and suggestions on how to improve the research content of the PVPS programme. In this respect, Task 1 has identified at least four fields of possible improvement for PVPS activities in 2013. In order to build on the strategy meeting in Stockholm, Task 1 led in September 2012 a first session dedicated to the improvement of communication in general. The meeting in Vienna in February 2013 was partially used to conduct a strategy exercise, focusing on Task 1's future actions. Task 1 has decided to go forward with regular updates of what could contribute to the future PVPS strategy. In this respect, Task 1 will provide inputs for possibly enhancing other PVPS Tasks' content.

- New Business Models for PV Development: With the emergence of a PV market driven in some countries solely by the competitiveness of PV, there is increasing interest in the question of new business models. At first, Task 1 will focus on self-consumption based PV development, including transitional support schemes, such as net-metering.
- PV as Building Elements: While most of the PV market development has been based on BAPV installations, the potential of BIPV remains largely untapped and requires additional research to become fully exploitable. Task 1 has identified the need for the PVPS programme to start researching PV as building elements. This was presented at the last PVPS Executive Committee meeting as a subject for a potential new activity within the PVPS programme.
- PV and Utilities: this subject has been identified as crucial for a large-scale development of PV. It will be further investigated during the year 2014.
- Integration of PV in the Electricity Grids and Markets: While research is ongoing on the improvement of the integration of PV into distribution grids and the electricity systems in general, Task 1 has identified a need to further research PV integration into the electricity system at large and especially the integration into electricity markets. This will be further investigated in the coming years, possibly through additional actions in Task 14's revised program.

SUBTASK 1.3: Communication Activities

Task 1 aims at communicating the PVPS programme's main findings through the most appropriate communication channels. In this respect, five main types of communication actions are conducted throughout the year.

- Events: Task 1 organizes or participates in events during PV-related conferences and fairs. Workshops are organized on various subjects; sometimes in cooperation with other PVPS Tasks or external stakeholders. In 2013, the following workshops were organized in several locations around the world:
  - Paris, France - September 2013: EU-PVSEC Conference and Exhibition: A joint Task 1 and EPIA workshop on new business models was organized. This workshop focused on PV development in the "post-FiT" environment, with special attention to electricity market and grid integration issues.
  - Taipei, Taiwan - October 2013: PVSEC-23 Scientific Conference: A Task 1 workshop was organized as part of the PVSEC-23's official programme. This workshop focused on PV development with testimonies from around the world.
  - Jeju, Korea – November 2013: Held as part of the 40th Task 1 meeting in Korea, a Task 1 workshop took place in cooperation with KPVS, KOPIA, KIER, Yeugnam University, KTL, KCL, KTC, KETI, TUV Rheinland Yeugnam, KEMC, Korean Ministry of Trade, Industry & Energy and the Konkuk University. It focused on PV reliability and new business models.

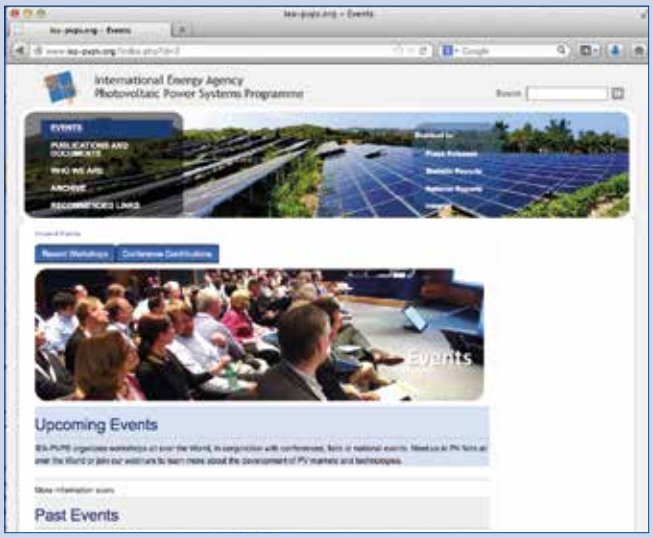

Fig. 6 - The www.iea-pvps.org website has the latest information on IEA PVPS publications, databases, events and news.

- In addition, IEA PVPS was one of the "Joint Forces for Solar" event's partners at Intersolar Europe in Munich, Germany, in June 2013. Task 1 speakers represented the programme in several conferences in 2013; namely in Germany, Poland and France.

- Publications: Task 1 publications, as mentioned above, aim at providing the most accurate level of information regarding PV development.
- Website and Social Networks: Task 1 manages IEA PVPS programme's website: www.iea-pvps.org. During 2013, the website has been slightly modified and reorganized, with additional information. It has been partially revamped in order to become more accessible. It includes these new features:
  - Direct access to Press Releases;
  - Direct access to the Intranet ;
  - Events agenda on the homepage with a link to a more detailed page;
  - Access to information published on social networks;
  - Latest news on the homepage ;
  - Publications by reverse order of publication;
  - New Trends report page ;
  - Link to the new PV Performance Database;
  - Addition of the IEA Energy Technology Network's logo, in order to reinforce the link to IEA.

Next Steps in Website Evolution:

The website will continue to evolve, adding new features and additional information.

- Access to documents through thematic pages (market, grid integration, pico PV, hybrid, sustainability, etc.);
- Integration of completed Tasks' external websites through thematic pages;
- Better integration of the PV Performance Database;
- Improved look & feel (especially navigation menu) in order to find the information faster.
- Introduction page in other languages (especially non-European languages) and direct link to documents and national links in these languages. The French version of the hybrid PV systems is the first of these documents uploaded.

Social Networks

In order to increase the IEA PVPS programme's visibility, news published on the website is also published on some selected social networks: Twitter and LinkedIn, until now.

Press Releases

New publications are now followed by a press release to around 400 contacts. This contact list will be extended to progressively include more media from Asian, African and Latin American countries in a progressive way. Translation of press releases is done by some countries in order to expand the visibility.

Five press releases have been issued in 2013, covering the two Task 1 reports (Snapshot and Trends), the two Task 9 reports issued in 2013 (Pico PV Systems and Hybrid PV Systems), and two workshops (Task 1/ EPIA in Paris and Task 14 /MetaPV in Brussels).
Newsletter: The PVPower newsletter edition has been discontinued and its renewal is under discussion for 2014.

SUBTASK 1.4: Cooperation Activities

In order to gather adequate information and to disseminate the results of research within Task 1, cooperation with external stakeholders remains a cornerstone of the PVPS programme.
This cooperation takes places with:
Other IEA Implement Agreements (SHCP, RETD, etc.)
Stakeholders outside the IEA network: IRENA, REN21, etc.

SUMMARY OF TASK 1 ACTIVITIES AND DELIVERABLES PLANNED FOR 2014

Task 1 activities will continue to focus on development of quality information products and effective communication mechanisms in support of the PVPS strategy. Further, Task 1 will continue to analyze PV support policies and provide adequate and accurate information to policy makers and other stakeholders. In addition, Task 1 will continue to progress ideas for future PVPS work arising from the PVPS strategy development process – in particular, enhancing the understanding of the value of PV in electricity markets, the role of utilities in the PV sector and the new business models.

SUBTASK 1.1: Market, Policies and Industrial Data and Analysis

National Survey Reports will start to be published from April 2014 and uploaded to the PVPS website.
The target date for publication of the 2nd Snapshot of Global PV report is the end of Q1 2014.
The target date for publication of the 19th Trends in Photovoltaic Applications report is the end of Q3 2014.
A report on self-consumption and similar schemes (such as net-metering) is foreseen for 2014. The publication date has not yet been defined.

SUBTASK 1.2: Think Tank Activities

The main subjects developed in 2014 with regard to the PVPS Think Tank Activities can be described as follows:

- Follow-up on "PV as Building Elements" activities within the PVPS programme.
- The subject of new business models will be continued, with an initial focus on self-consumption.
- An initial research on what role utilities could play in the PV sector and how PVPS could contribute could be addressed in 2014.
- The integration of PV into the electricity system at large, including the electricity grids and markets will be addressed through Task 14's renewal, among others.
- A close follow-up on Task 13's renewal concerning PV performance and quality will be ensured, as well.
- Liaison with all PVPS Tasks in order to better exchange content and identify how Task 1 can bring in new ideas.

SUBTASK 1.3: Communication Activities

Task 1 will continue its communication activities in 2014. First by communicating on the publications and events organized within Task 1 and second, by contributing to the entire PVPS programme's dissemination of publication and event information.
The website will be expanded in 2014 and partially revamped in order to become more content-oriented. All Task websites will be incorporated into the unique PVPS website.

SUBTASK 1.4: Cooperation Activities

Task 1 will continue to cooperate with adequate stakeholders in 2014. In particular, the link to the IEA shall be reinforces and Task 1's cooperation with IRENA and REN21 shall be enhanced. Regarding the cooperation between IEA Implementing Agreements, a special focus will be on the cooperation with the future IEA SHCP Task 53 (PV in Heating & Cooling Systems).

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.

MEETING SCHEDULE (2013 AND PLANNED 2014)

The 39th Task 1 meeting was held in Vienna, Austria, 18-20 February 2013.
The 40th Task 1 meeting was held in Jeju, Korea, 3-6 November 2013.
The 41st Task 1 meeting will be held in Tel Aviv, Israel, 23-25 April 2014.
The 42nd Task 1 meeting is being planned for Kyoto, Japan in November 2013, together with the IEA PVPS Executive Committee meeting and the WCPEC-6, the 6th World Conference on Photovoltaic Energy Conversion.

TASK 1 PARTICIPANTS IN 2013 AND THEIR ORGANIZATIONS

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

COUNTRY	NAME	ORGANIZATION
Australia	Greg Watt	APVI - Australian PV Institute
Austria	Hubert Fechner	University of Applied Sciences, Technikum Wien
Belgium	Gregory Neubourg	APERe
Canada	Paul Luukkonen	CanSIA - Canada Solar Industries Association
Canada	Yves Poissant	Natural Resource Canada – CanMET Energy, Government of Canada
Canada	Wesley Johnston	CanSIA - Canada Solar Industries Association
China	Lv Fang	Electrical Engineering Institute, Chinese Academy of Sciences
Copper Alliance	Fernando Nuno	Copper Alliance
Denmark	Peter Ahm	PA Energy A/S
European Photovoltaic Industry Association	Marie Latour Gaëtan Masson	EPIA
European Commission	Arnulf Jaeger-Waldau	European Commission, Directorate General for Energy
European Union	Pietro Menna	European Commission, Directorate General for Energy
France	Yvonnick Durand	ADEME
Germany	Lothar Wissing	Forschungszentrum Jülich
Israel	Yona Siderer Shoshana Dann	Ben-Gurion National Solar Energy Centre
Italy	Salvatore Guastella	RSE SpA
Italy	Francesca Tilli	RSE SpA
Japan	Osamu Ikki Izumi Kaizuka	RTS Corporation
Japan	Masanori Ishimura	NEDO
Korea	Chinho Park	Yeungnam University
Malaysia	Wei Nee Chen Gladys Mak S.L.	SEDA
Mexico	Jaime Agredano Diaz	Instituto de Investigaciones Electricas
Norway	Øystein Holm	Multiconsult
Portugal	Pedro Paes	EDP
Solar Electric Power Association	Justin Baca	SEIA
Spain	Vicente Salas	Universidad Carlos III de Madrid
Sweden	Johan Lindahl	Uppsala University
Switzerland	Pius Hüsser	Nova Energie GmbH
Thailand	Kulwaree Buranasajjawaraporn	Thailand Ministry of Energy
Turkey	Mete Cubukçu	Turkish PV Technology Platform (UFTP)
Turkey	Metin Colak	Solar Energy Institute, Ege University
United Kingdom	Steve Martin	Department of Energy & Climate Change (DECC)
United States of America	Robert Margolis David Feldman	NREL

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

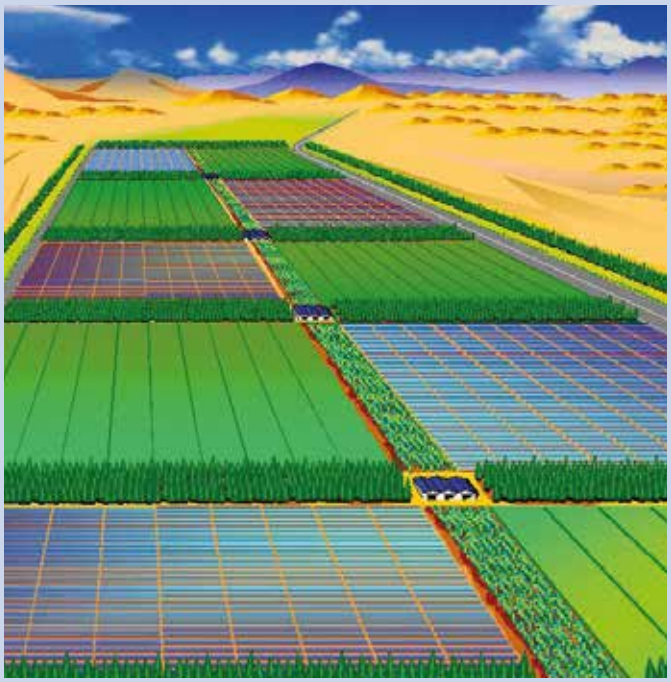

Fig.1 - Image of a VLS-PV System in a Desert Area.

Fig. 2 - Agua Caliente PV power plant- technical visit at the 29th Task 8 meeting in Arizona, USA, in June 2013.

Fig. 3 - Curbans PV power plant- technical visit at the 30th Task 8 meeting in France, in October 2013.

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 to develop practical project proposals toward implementing VLS-PV projects in the future.

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

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

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

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

SUMMARY OF TASK 8 ACCOMPLISHMENTS FOR 2013

Through Task 8 meetings and e-mail communications, Task 8 has been discussing work items described below.

Also, Task 8 has published a series of reports entitled, "Energy from the Desert," and has been performing their dissemination actively.

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

Employing the concepts of VLS-PV, the criteria and other results produced under other Subtasks, Subtask participants have been undertaking case studies on VLS-PV systems for the selected regions and evaluating the resulting effects, benefits and environmental impacts. The feasibility and potential of VLS-PV on deserts will be evaluated from local, regional and global viewpoints.

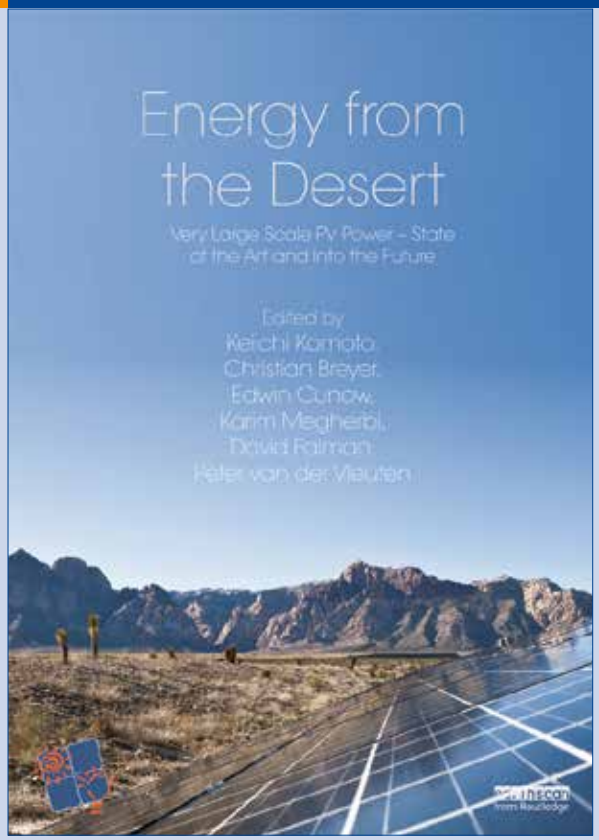

Fig. 4 - Energy from the Desert: Very Large Scale PV Power -State-of-the-Art and into the Future.

The following case studies are being carried out:

- Environmental aspects, including biodiversity, of VLS-PV;
- Environmental impacts of large-scale PV power station;
- Business model based on local assembly of PV modules;
- China as a world role model;
- VLS-PV Case Study on the Gobi Desert: North-East Asian Super Grid;
- Studies on VLS-PV project in Africa;
- International tendering of large scale PV.

As for the environmental aspects of VLS-PV systems, Task 8 has been carrying out an nformation exchange and collaborative work with PVPS Task 12.

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

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

The following items are discussed:

- Technical options for the entire energy system: Combination with other renewable energy technologies; Solar hydrogen, methane, etc., as storage technologies; VLS-PV as part of super-grids;
- Surveying VLS-PV trends: Lessons learnt from existing large scale PV plants.

There would be potential items for communication with Task 13 (operation and reliability of large scale PV systems) and Task14 (grid-connection of large scale PV systems).

SUBTASK 7: VLS-PV Vision, Strategy and Communication

Based on the previous results and changing market environment, Subtask participants would perform active dissemination and communication with stakeholders to develop VLS-PV vision and strategy. Additionally, a possible approach and enabler to achieve the vision and implement the strategy would be developed and identified. Suggestions/recommendations/drafts of how to overcome hurdles/barriers, from technical and non-technical viewpoints would be proposed, in order to accomplish this Task 8 activity.

The following items are discussed:

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

DISSEMINATION ACTIVITIES

Task 8 organised the INES-Task 8 workshop on "Large Scale PV System Design and Development," with the INES, France, in conjunction with the 30th Task 8 meeting in October 2013.

Furthermore, Task 8 made presentations at the following international events:

- International Joint Workshop on Super Grid in North-East Asia, in Busan, Korea, (March 2013);
- 39th IEEE-PVSC in Tampa, FL, USA (June 2013);
- 28th EU-PVSEC in Paris, France (September/October 2013);
- ADB-Japan New and Renewable Energy Seminar for South and South East Asian Countries, Tokyo, Japan (October 2013);
- PVPS Workshop @ 23rd PVSEC in Taipei, Taiwan (October 2013).

SUMMARY OF TASK 8 ACTIVITIES PLANNED FOR 2014

Task 8 will continue to discuss work items towards the accomplishment of VLS-PV activity, as well as active dissemination at international conferences and communication with stakeholders.

Based on the results, Task 8 will start discussions and drafting works for a technical report.

KEY DELIVERABLES

Internal Publications

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

External Publications

Book: "Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems", James and James, 2003 (ISBN 1 902916 417)
Report: "Summary – Energy from the Desert: Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems", 2003
Report: "Summary – Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems", 2006
Book: "Energy from the Desert: Practical Proposals for Very Large Scale Photovoltaic Systems", Earthscan, 2007 (ISBN 978-1-84407-363-4)
Book: "Energy from the Desert: Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects", Earthscan, 2009 (ISBN 978-1-84407-794-6)
Report: "Summary - Energy from the desert: Very Large Scale Photovoltaic power - state-of-the-art and into the future", 2012
Book: "Energy from the desert: Very Large Scale Photovoltaic power - state-of-the-art and into the future", Earthscan from Routledge, 2012 (ISBN 978-0-415-63982-8(hbk) /978-0-203-08140-2(cbk)))

MEETING SCHEDULE [2013 AND PLANNED 2014]

29th Task 8 meeting was held in Arizona, USA, 24-26 June 2013.
30th Task 8 meeting: was held in Chambery, France, 7-8 October 2013.
31th Task 8 meeting: will be held in Morocco, 23-25 April 2014.
32nd Task 8 meeting: will be held in Kyoto, Japan, 23-24 November 2014.

LIST OF TASK 8 PARTICIPANTS

COUNTRY	PARTICIPANT	ORGANISATION
Canada	John S MacDonald	Day4 Energy Group Inc.
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France	Karim Megherbi	Renewable Energy/Carbone Abatement
Germany	Edwin Cunow	LSPV Consulting
Germany	Christian Breyer	Reiner Lemoine Institut gGmbH
Germany	Christof Koerner	Siemens AG
Israel	David Faiman	Ben-Gurion University of the Negev
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Italy	Francesco De Lia	ENEA
Italy	Gianluca Gigliucci	ENEL
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Japan	Kosuke Kurokawa	Tokyo Institute of Technology (Tokyo Tech)
Japan	Tomoki Ehara	E-konzal
Japan	Masanori Ishimura	New Energy and Industrial Technology Development Organization (NEDO)
Korea	Jinsoo Song	Korea Institute of Energy Research (KIER)
The Netherlands	Peter van der Vleuten	Free Energy Consulting
Mongolia (observer)	Namjil Enebish	National Renewable Energy Center

TASK 9 – DEPLOYING PV SERVICES FOR REGIONAL DEVELOPMENT

RATIONALE AND OBJECTIVES

Deploying PV services for Regional Development

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 such as PV penetration in the urban environment, PV hybrids, very large scale PV plants and high penetration in grids.
- Produce substantive work on applications, meeting the needs of rural communities such as water pumping, health (refrigeration, lighting, etc.), "pico PV services" (highly efficient integrated appliances for lighting and ICT needs), and on relevant business models for deployment. The results of this work will be integrated in the dissemination process.

MILLENIUM DEVELOPMENT GOALS RELATED	INTEGRATION OF PV IN ENERGY SYSTEMS
1 – PV for Drinking Water Pumping 2 – PV and Health, Community Services 3 – Pico PV Services	4A – PV and Hybrid Mini-grids for Rural Loads 4B – Modelling for Rural Loads 5 – PV in Medium-scale Fast Growing Urban Cities; What are the business models?
6 – Deployment and outreach in Asia • Asian Development Bank, ASEAN Center for Energy 7 – Deployment and outreach in Africa • Club ER, IRENA, AfDB	

Task 9 - Deployment of PV Services for regional development

Fig. 1 – IEA PVPS Task 9's Activities.

SUMMARY OF TASK 9 ACTIVITIES

SUBTASK 1: PV for Water Pumping

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

With the publication of the position paper on **"Policy Recommendations to Improve the Sustainability of Rural Water Supply Systems,"** in June 2012, the Subtask work has been completed and the material is still being used for dissemination activities.

SUBTASK 2: PV and Health Centers

PV technology has been used in the past in a number of health applications both by national and international organizations (WHO, UNICEF, etc.) for vaccine refrigeration, health clinic equipment, etc. The aim of this Subtask is thus to facilitate PV application as a least cost option for electrification of rural health infrastructures in developing countries, by providing project operators with case studies and practical lessons learned for successful project implementation. This Subtask is led by Fraunhofer ISE which is currently working on the following activities:

- Conducting an overview and capitalizing on lessons learnt from the past
- Relevance of further deployment – What is the service – to investment value? What is/are the institutional model(s)?
- Analysis and potential of medical activities covered by PV Systems
- Classification of PV technology options for health centers
- Compilation of field cases in a common structure
- Evaluation, simulation and perhaps testing of PV systems and their components (if necessary)
- Publication and dissemination of the results in a report

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 purely commercial bases.

The document entitled, **"Pico Solar PV Systems for Remote Homes - A New Generation of Small PV Systems for Lighting and Communication,"** was published in February 2013. This Subtask is thus completed and dissemination activities are on-going. This

Fig. 2 - 28th Experts' Meeting, 7 April 2013, Bangkok, Thailand.

Fig. 3 - 29th Experts' Meeting, 27 September 2013, Paris, France.

document has been presented during the "Regional Workshop on Rural Electrification," organised by the Asean Center for Energy (ACE) and GIZ in Myanmar, as well as at the Task 9 Open Event in Bangkok, organised by the Swiss Government and the Thai Ministry of Energy (DEDE) in April 2013.

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

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

A. PV and Mini-grids / Hybrids

The publication entitled, **"Rural Electrification with PV Hybrid Systems - Overview and Recommendations for Further Deployment,"** was published in May 2013. Since this document is a joint publication of Task 9 and the CLUB-ER the publication was translated into French and is available on the PVPS website, along with the original English version.

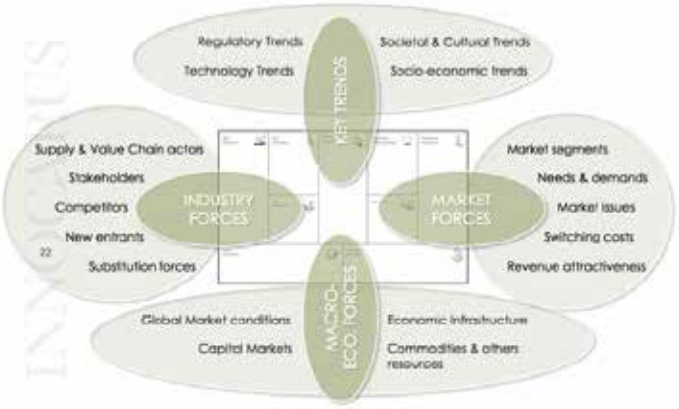
Task 9 experts have decided to further work on this subject and in particular, on size optimisation (PV/Battery/Fuel), design and modelling issues in the perspective of a wider development in emerging regions. In fact, there are neither published guidelines nor widely-shared clear recommendations available about the design of PV hybrid systems. Therefore, the goal is to elaborate a document providing recommendations on suitable designs for isolated loads, bringing a substantial advantage versus single-source solutions, as well as being efficient and cost-competitive.
The new publication entitled, "Design of PV Hybrid Systems in Mini-grids and Optimization Issues," shall be finalized within the first semester of 2014. Some former Task 11 (Hybrid Systems within Mini-grids) Experts participated in the Subtask meeting that took place in Lyon, France, in February 2013.

B. PV in Urban Environment

France and Denmark have expressed interest in working on a document on PV in urban settings in developing regions. Denmark has presented a concept paper on PV in urban settings in developing regions. The targets are the cities that are expected to grow very fast in the future. The goal is to prepare a practical catalogue containing a compendium of possibilities that can be envisaged and the indication of simple issues to be taken into consideration by the urban planners/ decision makers.

SUBTASK 5: Innovative Business Models

Switzerland is currently working on innovative business models for PV in the built up environment of medium scale cities, through a general analysis framework:



The work shall lead to a publication. Following the outcome, it is envisaged to replicate this exercise for business models for other Subtasks.

SUBTASK 6: Deployment and Outreach

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

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

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

Collaboration with Asia:

- Task 9 Experts were invited to contribute and participate to the "Regional Workshop on Rural Electrification," organized by the Asean Center of Energy (ACE) and the GIZ in April 2013, in Rangoon, Myanmar. Task 9 Experts made three presentations, namely on: Pico PV services, PV Hybrid Systems and Mini-grids.
- A Task 9 Open Event was also organized in Bangkok by the Swiss Government and the Ministry of Energy of Thailand, targeting Thai actors involved in the PV sector. Task 9 Experts presented their past and current work, as well as recent Task 9 publications at this event.

KEY DELIVERABLES PUBLISHED IN 2013:

- Rural Electrification with PV Hybrid Systems - Overview and Recommendations for Further Deployment; Report IEA-PVPS T9-13:2013.
- Pico Solar PV Systems for Remote Homes - A new generation of small PV systems for lighting and communication; Report IEA-PVPS T9-12:2012.

Both Reports are available on the IEA PVPS website: www.iea-pvps.org .

KEY DELIVERABLES TO BE PUBLISHED IN 2014:

- Hybrids Design and Optimization Issues Report, (Mid-2014)
- Business Models for PV in the Urban Environment Report
- PV and Health Centers Report

TASK 9 MEETING SCHEDULE (2013 AND PLANNED 2014)

2013

28th Experts' Meeting, 7 April 2013, Bangkok, Thailand.
29th Experts' Meeting, September 2013, Paris, France.

Task 9 Subtask 4 Meeting

Subtask 4 Hybrid System, 7 February 2013, Lyon, France.

2014

30th Experts' Meeting, March, Lyon, France (TBC).
31st Experts' Meeting, Kyoto, Japan (TBC).

TASK 9 PARTICIPANTS

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

- *Germany, GIZ confirmed its interest in collaborating with Task 9, especially on the PV Hybrid publication.*
- *Voluntary contribution from former Task 11 experts: NSE LTD (Greece), Tss4U (The Netherlands), TTA (Spain), Steka Elektronik (Germany), Sunpower (France).*
- *Observers: Thailand, Ministry of Energy and EGAT, Malaysia, as well as IRENA.*

TASK 12 - PV ENVIRONMENTAL HEALTH & SAFETY ACTIVITIES

Fig. 1 – IEA PVPS Task 12 Experts at the Task 12 Experts Meeting, NREL, Golden, CO, USA, June 2013.

INTRODUCTION

Renewable energy, with photovoltaics in a prominent role, will need to provide an increasing share of the world's energy demand in order to slow the ever mounting streams of greenhouse gases emitted by our global society. In operation, photovoltaics generate electricity without emissions of any kind, and the life-cycle emissions of a kWh of PV electricity are only a small fraction of those of fossil-fuel generated electricity. In the manufacturing and at end-of-life, however, the material flows for producing PV cells and modules must be managed sustainably and responsibly, in terms of environmental health and safety impacts. The photovoltaics industry, to date, has understood that the advantages of renewable energy should be emphasized by responsible management of environmental, health and safety aspects.

As the industry grows and the technology advances, material designs and industrial processes are continually evolving. Safety practices also evolve with the growth of a sector or industry. Continual diligence and communication on the sustainable management of material flows, industrial processes and safety practices is necessary to safeguard health and the environment, and takes on even greater importance as we progress towards larger scales of photovoltaic deployment. Research such as life cycle assessment can help to predict future environmental emissions and lead to research and development improvements that avoid those future impacts.

OVERALL OBJECTIVES

Task 12 engages in fostering international collaboration in assessing and communicating environmental, health and safety (EH&S) aspects of photovoltaic technologies considered over the life-cycle of the PV systems. Task 12 creates and disseminates reliable and accurate information on the EH&S impacts of PV technology to policy makers, industry participants and the public with the goal to improve consumer understanding and confidence, to encourage industry best practices and to aid policy makers to make informed decisions.

Furthermore, Task 12 brings the expertise of its participants in assessing methods and standards for the evaluation of EH&S aspects of PV systems.

The overall objectives of Task 12 are to:

1. Quantify the environmental profile of PV electricity, serving to improve the sustainability of the supply chain and to compare it with the environmental profile of electricity produced with other energy technologies.
2. Help improve waste management of PV by collective action on collection and recycling, including legislative developments as well as development of technical standards.
3. Distinguish and address actual and perceived issues associated with the EH&S aspects of PV technology that are important for market growth.
4. Disseminate the results of the EH&S analyses to stakeholders, policy-makers, and the general public.

The first objective is served with Life Cycle Assessment (LCA) that describes energy, material and emission flows in all stages of the life cycle of PV. The 2nd objective is accomplished by proactive research and support of industry-wide activities (e.g., input to Industry Associations, such as EPIA in Europe or the China Photovoltaic Society to develop and help implementing voluntary or binding policies – such as WEEE in Europe.). The 3rd objective is addressed by advocating best EH&S practices throughout the solar value chain, and assisting the collective action of PV companies in this area. The 4th objective (dissemination) is accomplished by presentations to broad audiences, peer review articles, reports and fact sheets, and assisting industry associations and the media in the dissemination of the information.

APPROACH

Task 12 is subdivided into three topical Subtasks reflecting the first three objectives stated above. The fourth objective, dissemination of information, is contained as an activity within each of the three Subtasks: Recycling, life cycle assessment and safety in the PV industry.

Fig. 2 – IEA PVPS Task 12 Experts at the Task 12 Experts Meeting, MINES Paris Tech, Paris, France, September 2013.

ACCOMPLISHMENTS OF IEA PVPS TASK 12

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

The Task 12 group has been instrumental in bringing the issue of PV module recycling to the fore by supporting the 1st and 2nd International Conference on PV Module Recycling, in 2012 and 2013, hosted by EPIA and PV CYCLE, and by disseminating best-practices on PV end-of-life module recycling. Task 12 members have been visible in organizing workshops on PV recycling, such as the one organized by Brookhaven National Laboratory, NY, USA (BNL)) during the 34th IEEE Photovoltaic Specialists Conference (PVSC) in Philadelphia, PA, USA, in June 2009. Publications by Task 12 members include articles on the technical and cost feasibility, on a cost optimisation model for the collection and recycling of PV modules, as well as on the development of a method for recycling Cd and Te from CdTe photovoltaics. Another prominent Task 12 presence is that of NEDO (Japan) who is now engaged in PV recycling research supported by the Kitakyushi Foundation for the Advancement of Industry, Science and Technology (FAIS).

SUBTASK 2: Life Cycle Assessment

Task 12 brings together an authoritative group of experts in the area of the life-cycle assessment (LCA) of photovoltaic systems, who have published a large number of articles in high-impact journals and presented at international conferences. In November, 2011, Task 12 published the expanded 2nd edition of the "Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity," and the associated report on life-cycle inventories (LCI) with data on the photovoltaic life-cycle materials and processes, necessary for conducting LCA studies.

Task 12 members have contributed to the factsheets on photovoltaics produced by EPIA's Sustainability Working Group, and have contributed to the update of the LCI data on photovoltaics in the ecoinvent database. In addition, Task 12 members are contributing to synergistic activities such as the UNEP International Resources Panel report on Environmental Sustainability of Low Carbon Technologies which uses hybrid LCA to consider benefits, impacts and tradeoffs of PV and other low carbon technologies along many environmental impact categories.

SUBTASK 3: Safety in Facilities

Task 12 members have also brought attention to safety issues associated with various stages in the life-cycle of photovoltaics in various seminars (e.g. on Silane Safety, at the IEEE PVSC in San Diego, April 2008) and workshops (e.g. "PV Fire Safety," September 2010).

PLANS FOR 2014

The main activities in 2013 have revolved around a change in leadership beginning in June, a renewing of governance and a re-focusing on the Subtasks of Task 12, with the resulting new Workplan for the period beginning in 2014.

SUBTASK 1: Recycling of Manufacturing Waste and Spent Modules

Task 12 will continue to discuss end-of-life solutions for PV modules at the global level, and has been expanded this year to cover manufacturing waste.

This activity will seek to provide updates and clarity on the legislative framework in Europe (WEEE) and other nations, as well as to promote best practices. It will seek to expand the platform for the international cooperation on PV end-of-life module recycling, and support International Conferences and Workshops advising recycling options and capabilities, and promote the creation of industry recycling programs in the U.S. and Asia.

With the adoption and implementation of the recast WEEE Directive[1] - making collection and recycling of end-of-life PV modules a legal requirement in all European Union Member states - a multitude of existing producer compliance schemes will also look at the waste stream from PV modules. Going forward, industry coordination on technical standardization as well as best practices in implementation will become important. This Task will support activities in CENELEC TC111X WG6 and the eStewards program on the development of recycling standards for PV technologies (e.g., through EPIA participation in the respective forums).
The new Workplan sets out as a deliverable a review of regulations, technologies/systems and experiences (including cost, if information available), with recommendations based on lessons learned.

1 DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast)

SUBTASK 2: Life Cycle Assessment

The life cycle assessment (LCA) expertise on photovoltaic systems is one of the prominent strengths of the Task 12 group. The update of the Task 12 LCA guidelines, published in 2011, is envisioned to contain additional topics (e.g., water use, recycling and a discussion of externalities).

Guidelines for net energy comparisons (i.e. using the energy return on investment (EROI) metric) will be produced in this activity. It is envisioned that it will be a separate document from, but referenced to, the LCA guidelines. The recent use of the EROI metric to show that PV is an uneconomic technology has re-awakened a dialogue in the energy community about the merits and shortcomings of EROI as a metric[2].

In a new activity, for the next 3 years, Task 12 will be coordinating the development of the pilot phase product environmental footprint category rules for PV electricity. The DG Environment (Directorate A1. Eco-Innovation & Circular Economy) of the European Commission put out a tender for proposals to develop 'product category rules' to set the standards for the life cycle assessment of the environmental impact of 1 kWh of photovoltaic (PV) electricity. The rationale for this project is based upon the observation that there is a growing demand for LCA based product declarations. At the same time, the many methodologies are 'similar but different', leading to difficulty in comparing products. This initiative for the development of Product Environmental Footprint Category Rules (PEFCR) will simplify and make consistent the environmental assessment of European products. The application was submitted in July, 2013. The partner organizations that submitted this application, also referred to as the 'Technical Secretariat' of the project are: This Task 12 group, EPIA, the Int'l Thin-Film Solar Industry Assoc. (PVthin), Yingli Solar, First Solar, Total, Calyxo, ECN and Treeze. The supporting organizations are: IEA PVPS, WWF International - Energy Policy Unit, REC and the Bulgarian Photovoltaic Association. This three-year project was granted in early October 2013. As one of the winning 14 proposals selected from a set of 90 submissions, it is international recognition of Task 12's expertise in LCA methodology for PV.

Task 12 also develops and publishes data for Life Cycle Inventories (LCI). This activity concerns the updating and expanding of LCI data which Task 12 makes publicly available in IEA reports. Focal areas include developing data inventories to model the following:

- The Global Supply-Chain. The aim is to find ways to gather LCI data for PV manufacturing, and other stages of the life-cycle, in the various regions of the globe.
- The Balance of System. The aim is to highlight the data which actually represents the average of the most prevalently installed systems, so that the average really reflects the installed systems.
- Water use in PV life cycle (manufacturing, panel washing). The issue of water footprint of electricity generating technologies is emerging as a significant issue with significant data gaps.

2 (http://www.springer.com/energy/renewable+and+green+energy/book/978-1-4419-9436-3)

TABLE 1 - TASK 12 PARTICIPANTS

COUNTRY/ ASSOCIATION	PARTICIPANT	ORGANISATION
Austria	Susanne Schidler	University of Applied Science, Fachhochschule Technikum Wien, Department of Renewable Energy
China	Lu Fang	Institute of Electrical Engineering, Chinese Academy of Sciences
China	Zhang Jia	Institute of Electrical Engineering, Chinese Academy of Sciences
EPIA	Andreas Wade	European Photovoltaic Industry Association
France	Isabelle Blanc	MINES ParisTech
Japan	Mitsutoshi Hino	Kyocera Corporation
Japan	Keiichi Komoto	Mizuho Japan
Japan	Atsuyuki Yamamoto	NEDO (Technology Development Organisation)
Norway	Ronny Glöckner	ELKEM solar
Spain	Marco Raugei	ESCi (Escola Superior de Comerc Internacional) and Oxford Brookes University (UK)
Switzerland	Rolf Frischknecht	treeze Ltd., fair life cycle thinking
The Netherlands	Mariska de Wild-Scholten	SmartGreenScans
The Netherlands	Carol Olson	Energy Research Center of the Netherlands (ECN)
USA	Garvin Heath	National Renewable Energy Laboratory (NREL)
USA	Parikit Sinha	First Solar

Task 12 members will also contribute analyses of the life-cycle impacts associated with various technical or policy roadmaps. In particular, such a forecast to 2050 of life cycle impacts of scenarios of PV deployment and supply chains is being pursued in work in conjunction with a Task 12 member's contract with the Swiss government. These efforts contribute to an analysis leading to an energy strategy for Switzerland.

Task 12 will also take on developing the LCI for module recycling, as well as developing methodological recommendations to fill the void on recycling data for PV systems and how LCA practitioners can employ it.

SUBTASK 3: Safety in PV Industry

This Task includes not only safety in facilities through the manufacturing process, but also safety throughout the life-cycle of a PV product, including the safety of solar installers and decommissioning agents.

Fire safety - The activity on PV Fire Safety includes surveying cases of fire where PV was present, reviewing current practices, codes and standards for dealing with these situations, and identifying recommendations for firefighters, the PV industry, and PV users in operation and maintenance to prevent fires. Workshops (in China, Europe and maybe the USA) to communicate with stakeholders will be an important activity and are expected to occur in 2015.

PUBLICATIONS

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

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

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

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

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

MEETING SCHEDULE (2013 AND PLANNED 2014)

In 2013, the Task 12 Experts Meetings were held in Golden, Colorado, USA, in June, and in Paris, France, in September.

In 2014, the Task 12 Experts meeting will be held in Beijing, China, on 17-18 March, and in Kyoto, Japan, on 23-24 November.

TASK 13 – PERFORMANCE AND RELIABILITY OF PV SYSTEMS

Fig. 1 - Task 13 Expert Meeting in Rotterdam, the Netherlands, 18-20 March 2013 (Photo: Thomas Nordmann).

INTRODUCTION

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

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

The Task 13 is considered an extension of the work formerly carried out under PVPS Task 2 "Performance, Reliability and Analysis of Photovoltaic Systems". When Task 2 was concluded in 2008, the PVPS ExCo members as well as the participants felt a strong need for further working on the subject. Presently, there are seventeen countries and 30 institutions collaborating in this project, which had started its activities in May 2010.

OVERALL OBJECTIVE

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

Task 13 aims at:

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

APPROACH

The PV industry is very interested in information on performance and reliability. Companies which have the required data at their disposal tend, however, to be reluctant to share this information. The project partners aim at meeting this challenge by involving these companies at an early stage of the project development. This gives the industry's representatives the opportunity to introduce cooperative and tailor-made activities into the current work. In order to guarantee anonymous processing of the data provided by the industry, standardised reporting forms are being developed and agreements will be established with the project partner in charge of the respective Subtasks.

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

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

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

Task 13 activities are organized into the following Subtasks:

SUBTASK 1: Statistical PV System Performance Analysis

Subtask 1 has addressed the statistical analysis of PV system performance. One key objective was to enable the access to a large set of PV system performance data to the general public, which has been achieved by the so-called PV Performance Database. Participants of Task 13 have collected the operational data of PV systems in their countries in a standardized format on a monthly basis. So far, the data in this database consists of 79 newly received datasets representing 328 operational years from Task 13 activities and the already existing data from 500 grid-connected PV systems from the Task 2 database.

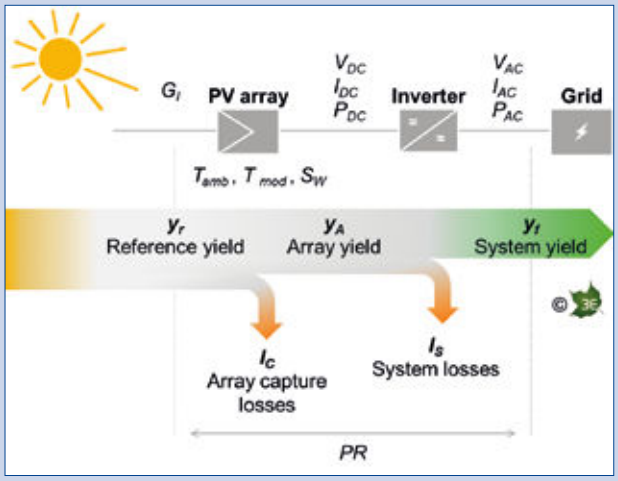


Fig. 2 - Illustrates the energy flow in a grid-connected photovoltaic system with a limited but selected collection of variables describing the main energy conversion steps taking place within the PV system (Diagram: Achim Woyte, 3E).

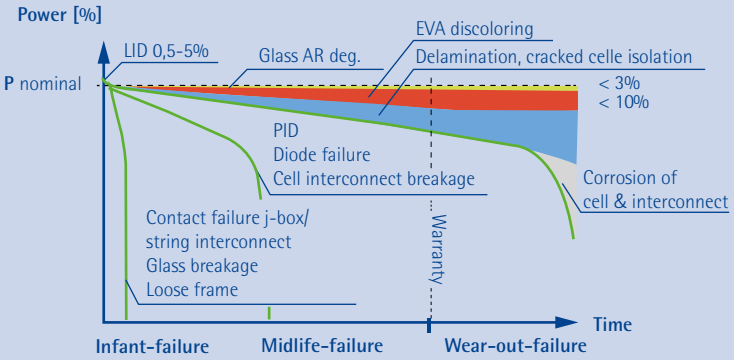


Fig. 3 - Three typical failure scenarios for wafer based crystalline photovoltaic modules are shown. Definition of the used abbreviations: LID – Light Induced Degradation, PID – Potential Induced Degradation, EVA – Ethylene Vinyl Acetate, j-box – junction box (Diagram: Marc Köntges, ISFH).

In the online-database entries can be selected individually or as a group and the operational data can be displayed or exported in graphic or table form. This allows users to create reports on selected grid-connected PV systems. During the year 2013 the new IEA PVPS Online Performance Database has been made publicly accessible at www.iea-pvps.org.

A team has been set-up to collaborate on Subtask 1.2 Statistics on the Operation of PV Systems. The motivation for this is to answer the question, "How well is PV serving the world?" The aim is to provide only three numbers for ease of communication to PV customers: annual AC yield, performance ratio, and degradation. A guideline will be drawn up that would allow all Task 13 members to gather national data in the same format. The team will collect all national data and will show the global distribution of annual AC yield in kilowatt hours per year per installed kW. A global distribution of performance ratio values can be determined using either measured irradiance or satellite data. Degradation rates can be inferred from a series of annual data. As the focus will be on annual data, the aim is to provide the customer/owner of PV system with a benchmark value of performance.

In cooperation with the industry and national programmes, future use of the database may be in analysis of 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. 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. However, the database will also be useful as a benchmark for new PV installations.

SUBTASK 2: Analytical PV System Assessment

Subtask 2 aims at the analytical assessment of PV system operation. To this end, various methods and models for the analysis of PV system performance have been gathered, tested and further developed, leading to detailed guidelines on how-to perform state-of-the-art PV performance assessments and system failure analysis. A comprehensive report on obtained results of this work is currently in the process of being published, with summarized results of this work given hereunder.

The documentation of best practices in PV system monitoring, based on common practices in the field, is focused first. Typical configurations of PV monitoring setups are described along with standard sets of PV performance indicators and their calculation routines. As monitoring hardware has a decisive influence on obtained data quality, an overview of different irradiation sensor equipment and their distinct applications are given. In addition, examples for straightforward visual representations of PV monitoring data by means of stamp-like plot collections are presented.

The actual analysis of PV monitoring data is focused using a number of detailed and practical examples on how-to use the mathematical approach of periodic linear regression to perform actual data analysis. The approach of linear regression allows for analyzing the energy flow in a grid-connected photovoltaic system with a limited but selected collection of variables. This allows the main energy conversion steps taking place within the system (see Figure 2) to be analyzed such that at least performance variations but also a number of distinct system failures can be detected numerically in an automatized fashion.

Although the focus is on conventional PV power plant applications, also a number of detailed effects related to special PV module technologies have been considered. Effects related to special PV technologies, namely CIGS and amorphous silicon PV have been studied in particular. Based on data from different experimental installations in the field, their specific behaviour has been modeled and compared to classical crystalline silicon PV. In conclusion, for CIS technologies no major modifications to the existing models for crystalline silicon are required when modeling the output over a month or longer. For modules involving amorphous silicon, the existing models for crystalline silicon require major modifications in order to take into account the sensitivity to the spectral composition of the incoming light.

Finally, measures that can help to improve the performance of PV systems have been described, based on lessons learned from PV system design as well as operational monitoring using real time data acquisition. Regarding system design decisions, the main factors of influence are mounting angle and row distance, related

TASK 13 PARTICIPANTS IN 2013 AND THEIR ORGANISATIONS

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

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

to irradiance gains and shading losses, inverter to module power ratio and cabling optimizations. Several examples on both shading losses and inverter to module power ratio are highlighted. Regarding operational monitoring in real time, the basic approach of real-time data processing is described. Detailed recommendations are given, especially for inverter manufacturer, with inverter functions being central to achieving progress in the area of system optimization.

In conclusion, the set of practical guidelines, methods and models that can be considered as best practices in the area of analytical monitoring of PV systems today may contribute to further increase the performance of PV power plants also in the future. The report is foreseen to be published during spring 2014.

SUBTASK 3: PV Module Characterisation and Reliability Assessment

Subtask 3 addresses testing and characterisation methods for performance and reliability assessment of PV modules. Task 13 experts prepared a technical report entitled "Characterization of Performance of Thin-film PV Technologies" on how to measure the power of thin-film modules and evaluate these from an international perspective. Although thin-film PV modules have been in production for decades, the characterization of their performance, both outdoors and under artificial light, remains a topic of active research. This is because the field contains a diverse set of PV technologies, each of which has physical differences from conventional crystalline silicon PV. These differences range from different temperature coefficients to complex short-term or seasonal transients in performance. This report summarizes the nature of these special behaviours and demonstrates best practices for handling them in the context of several case studies.

The first portion of the report deals with the performance of thin-film PV modules in solar simulators. Achieving repeatable performance measurements is challenging, even under artificial light. Stable, spectrally matched reference modules are generally unavailable, which can lead to errors in the effective illumination level. Some technologies have high capacitance, leading to problematic dependence of results on the duration of illumination and of the I-V curve sweep.

The report then covers the issues surrounding the measurement and analysis of outdoor performance of thin-film PV modules. The widely varying spectral responses, temperature coefficients and metastable behaviours of different thin-film technologies lead to special challenges in outdoor performance analysis. This is illustrated by the presentation of a new method of collecting and analyzing performance data from many international partners. Specific issues of spectral performance analysis are then discussed, including measured-spectrum and modeled-spectrum methods.

The target audience of the report is scientists and engineers who participate in the collection, analysis and prediction of indoor and outdoor performance data. This includes planners, operators and manufacturers of PV power plants, participants in the standardization of methods for performance measurement and workers in academe or at national laboratories.

Fig. 4 - The Task 13 Workshop on PV system performance assessment was held as a parallel event at the European PVSEC's programme in Paris, France, in October 2013. The Workshop entitled "Analysis of Photovoltaic System Performance," attracted more than 120 interested participants from industry and research.

During 2013, Task experts finalized a third external report on "Review on Failures of Photovoltaic Modules." In the first part, this document reports on the measurement methods which allow the identification and analysis of PV module failures. In the second part, the most common failures of PV modules are described in detail. Figure 3 gives an overview of the principle time dependence and the impact of the most important degradation mechanisms in PV modules. In the third part, new test methods are proposed for detection of PV module failures in the field. In April 2014, the finalized Technical report on PV module failures will available for download and in print.

The target audience of this report is PV module designers, PV industry, engineering lines, test equipment developers, testing companies, technological research laboratories, standardization committees, as well as national and regional planning authorities.

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

SUBTASK 4: Dissemination

This Subtask is focussed on the information dissemination of all deliverables produced in Task 13. The range of activities in this task includes workshops, presentations, databases and technical reports.

The following technical papers were published in 2013:
Kendall Esmeijer, Wilfried G.J.H.M. van Sark: Statistical Analysis of PV Performance using Publically Available Data in the Netherlands, 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September – 4 October 2013

Achim Woyte, Mauricio Richter, Nils Reich, Christian Reise, David Moser, Stefan Mau, Ulrike Jahn: Monitoring of Photovoltaic Systems: User Stories and Interpretation Guidelines, 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September - 4 October 2013

H.G. Beyer: Using Broad-Band Irradiance Data to Model the Short Circuit Response of a-Si-Modules, 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September - 4 October 2013

Ulrike Jahn, Gabi Friesen, Markus Schweiger, Matteo Marzoli, Werner Herrmann: Comparison of Different PV Module Technologies – New Method to Analyse Performance Characteristics Obtained from Field Tests at Different Locations, 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September – 4 October 2013

S. Hoffmann, M. Koehl, Modelling the Leakage Current for Potential Induced Degradation, 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September – 4 October 2013.

T. Lorenz, E. Klimm, K.-A. Weiss, Can Anti-soiling Coating on Solar Glass Influence the Degree of Performance Loss over Time of PV Modules Drastically? 28th European Photovoltaic Solar Energy Conference, Paris, France, 30 September – 4 October 2013.

Task 13 organized two workshops on PV System Performance Analysis in conjunction with the following scientific conferences: IEEE in Tampa, FL, USA, in June 2013 and 28 EU PVSEC, in Paris, France, in October 2013.

The Workshop "Analysis of PV System Performance" was held as a parallel event as part of the EUPVSEC's programme in Paris on 1st October 2013 (Figure 4). Leading specialists from Europe and America focused on lessons learned from measuring real-world performances of PV power plants in the field. To this end, presenters also described state-of-the-art methods and tools for PV monitoring data analysis as to better identify system problems and technology differences in diverse environments.

The workshop in Paris attracted more than 120 participants from over seventy countries who are interested in scientific and technical developments in PV system performance analysis. Task 13 and the speakers of this workshop received many positive responses to their presentations.

MEETING SCHEDULE (2013 AND PLANNED 2014)

The 7th Task 13 Meeting was held in Rotterdam, Netherlands, 18-20 March 2013.
The 8th Task 13 Meeting was held in Malaysia, 21-24 October 2013.
The 9th Task 13 Meeting will be held at Fraunhofer ISE in Freiburg, Germany, 01-03 April 2014.

TASK 14 – HIGH PENETRATION PV IN ELECTRICITY GRIDS

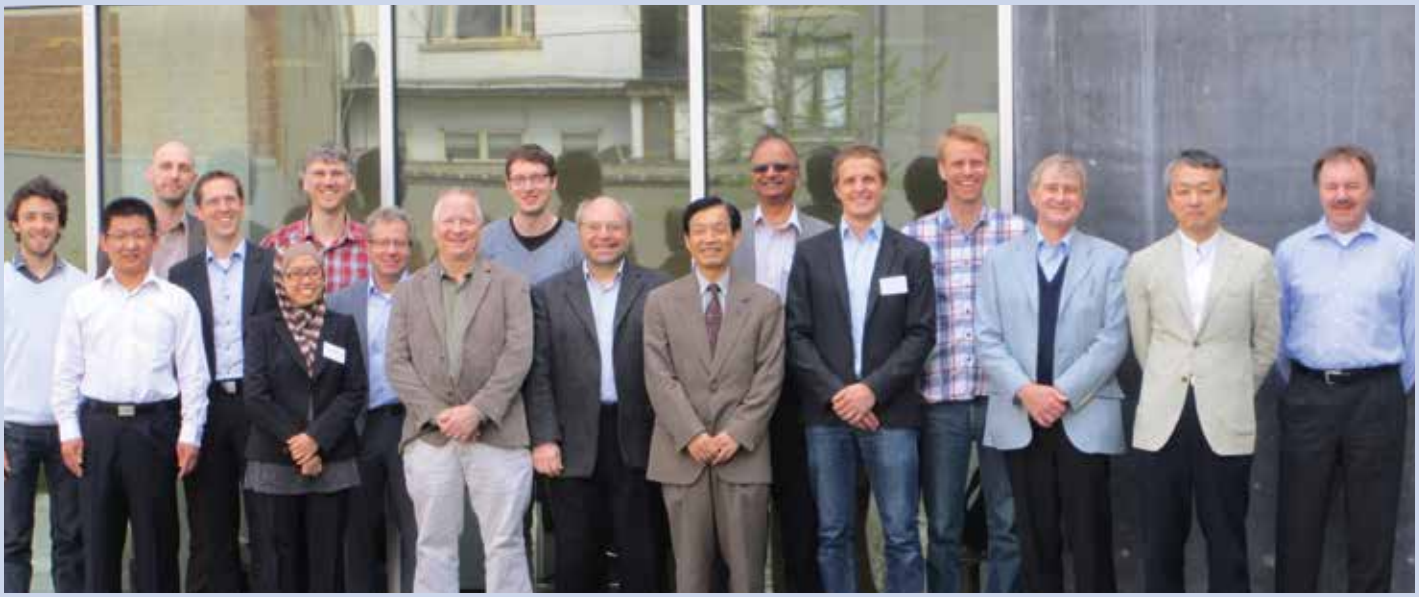


Fig. 1 - Task 14 Experts at Meeting in Brussels, Belgium (Photo: IEA PVPS Task 14).

INTRODUCTION

With PV becoming an increasingly visible part of the electricity mix in a number of countries, proper understanding of the key technical challenges facing high penetrations of PV is crucial to ensure further smooth deployment of PV. Key issues include the variable and somewhat unpredictable nature of PV generation, the power electronics interconnection to the grid and its location within distribution grids typically designed only for supplying loads. Power system protection, quality of supply, reliability and security may all be impacted.

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

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

Recognizing that a limited number of high-penetration PV installations currently exist, it is important to discuss these cases in a collaborative manner. With further growth of distributed as well as centralized PV generation, the need for international R&D collaboration to address this evolving field and to collect and disseminate international knowledge of PV systems at high penetration levels is becoming critical for the further large-scale deployment of PV.

OVERALL OBJECTIVES

Task 14 addresses the role of PV in electricity grid configurations with a high penetration of Renewable Energy Sources (RES), where PV constitutes the main RES.

The main goal of Task 14 is to facilitate the use of grid connected PV as an important source in electric power systems on a high penetration level where additional effort is necessary to integrate the dispersed generators in an optimum manner. The aim of these efforts is to reduce the technical barriers to 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 predominantly technical issues of high penetration of PV in electricity networks, including energy management aspects, grid interaction and penetration aspects related to local distribution grids as well as central PV generation scenarios.

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

The work programme is organized into four main subtasks, addressing the specific aspects related to high penetration PV integration.

SUBTASK 1: PV Generation in Correlation to Energy Demand

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

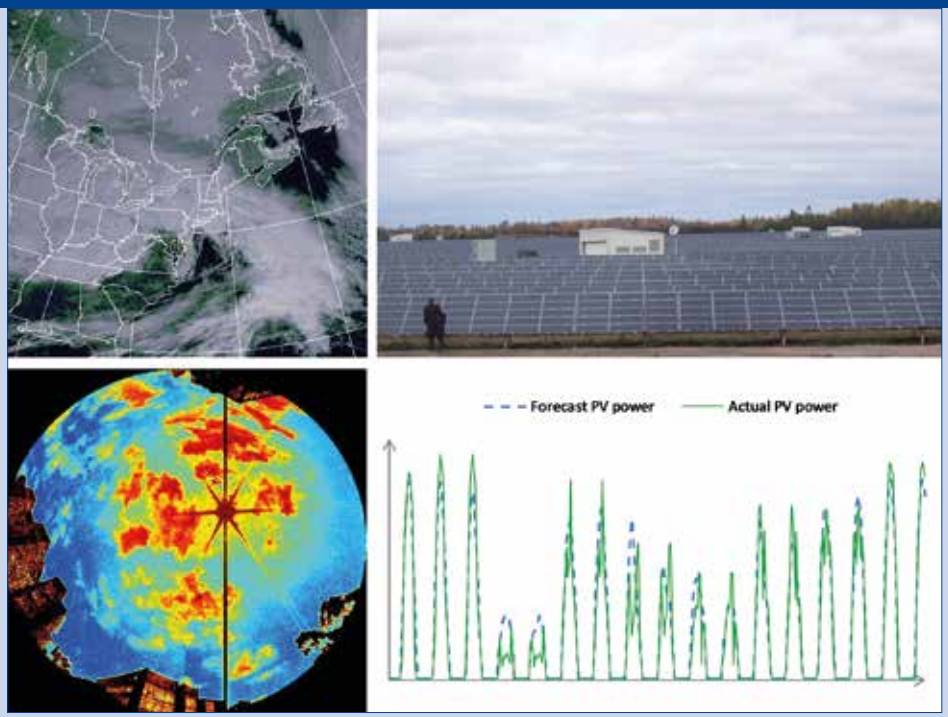


Fig. 2 - Photovoltaic and Solar Forecasting: State of the Art, (Source: IEA PVPS Task 14). Upper left image: Environment Canada. Data courtesy of NOAA (February 27, 2013). Upper right image: Dave Turcotte, CanmetENERGY, Natural Resources Canada).

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

SUBTASK 2: High PV Penetration in Local Distribution Grids

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

Information provided by distribution system operators are used to review the current state of distribution grids with high PV penetration in a number of case studies. By comparing the selected cases from different countries, best practice examples that may be a reference for challenges and solutions will be identified.

Possible optimization approaches for active and reactive power control, such as central coordinated control and local unit parameterization, are reviewed to assess the technical effectiveness and economic efficiency of the analyzed approaches of active and reactive power balancing for country specific distribution grids in an international benchmark.

SUBTASK 3: High Penetration Solutions for Central PV Generation Scenarios

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

SUBTASK 4: Smart Inverter Technology for High Penetration of PV

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

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

PROGRESS AND ACHIEVEMENTS

During 2013, Task 14 continued the successful series of high penetration workshops with two well received events held in Europe and Australia. In May 2013, the Joint MetaPV - Task 14 High Penetration PV Workshop was hosted by 3E in Brussels, Belgium. With guest speakers from Task 14, EPIA, NREL, Laborelec, Infrax, Enel, and more, the workshop addressed more than 50 experts from Belgian utilities, manufacturers and research. The workshop program included presentations from the European MetaPV High Penetration Demonstration project (http://www.metapv.eu) and experiences from Belgium and the EU.

In November 2013, Task 14, the University of New South Wales Australia, and the Australian PV Institute hosted an international workshop on "PV and the Electricity Grid: Overcoming the Technical Growing Pains," which covered two particular themes: Issues and opportunities around PV integration in Australia, and the relevant work occurring overseas in this area; particularly as part of the IEA PVPS Task 14 on High Penetration PV. The workshop's sessions explored Australian experiences with PV integration and the results from international projects as the IEA PVPS Task 14, including presentations from Japan,

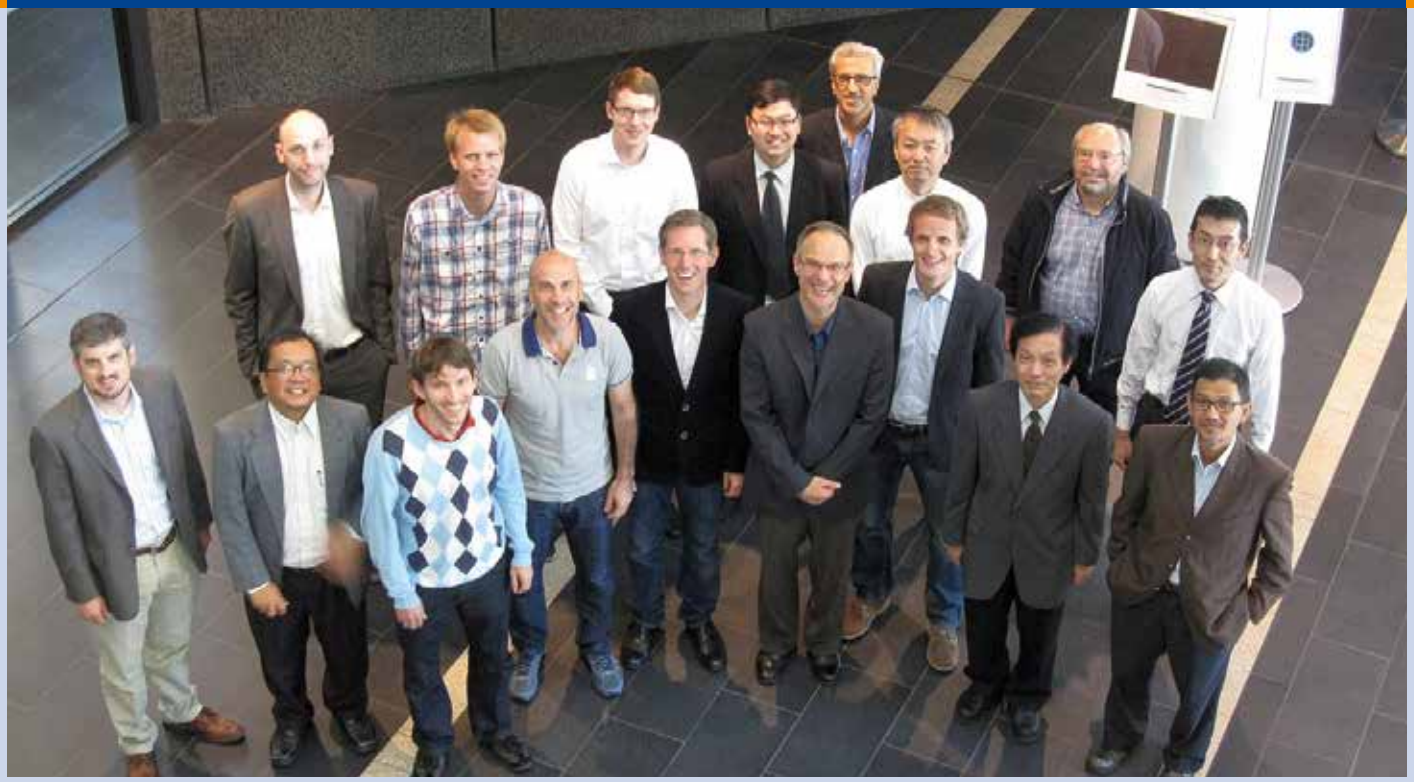


Fig. 3 - Task 14 Experts at the University of New South Wales, Australia (Photo: IEA PVPS Task 14).

Germany, Austria and Belgium, and provided a general overview of Task 14 activities in the participating countries. The workshop audience consisted of more than 60 experts, representing Australian utilities, consulting companies, funding agencies, regulators, research agencies, and international members of the IEA PVPS Task 14 team.

In addition to the well-received series of high-penetration workshops, IEA PVPS Task 14 and IEA SHCP Task 46 jointly organized a technical workshop held at the European Photovoltaic Conference in Paris, France, in October 2013. In the "Solar Resource and Forecast Data for High PV Penetration Electricity Workshop," recent results of on-going work from the two Tasks,l with a focus on solar (short term) forecast, was presented by experts from both of the Tasks. With more than 80 participants, this event brought together experts from solar resource as well as PV research.

Task 14 Workshop presentations from both workshops held in 2013, as well as documents from previous events are publicly available for download at the Workshops section on the IEA PVPS website: http://www.iea-pvps.org/index.php?id=212

Regarding technical work, a collection of case studies of high penetration PV scenarios in Task 14's participating countries was performed, which is currently being compiled into a report. The cases include PV penetration scenarios in local distribution grids as well as from the overall power system wide perspective.

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

SUMMARY OF TASK 14 ACTIVITIES PLANNED FOR 2014

Task 14 activities in 2014 will focus on the compilation of lessons learned and formulate recommendations for managing the grid with high penetration of PV.

In addition, further technical research will be done on the following issues:

- Investigation of the suitability of Forecast Tools with respect to high penetration PV, linking together weather forecasts, prediction and monitoring tools. This work item will be linking the activities of IEA SHCP Task 46 on solar resource characterisation with IEA PVPS Task 14.
- Investigation of inverter related requirements for high penetration PV, including interface related issues and communication/control issues.

INDUSTRY INVOLVEMENT

As from the beginning, industry has been directly involved in the development of the Task 14 concept and Workplan. In addition, a number of PV industry and utility representatives also directly participate in the Task 14 group.

Besides the country participation, experts from the European Photovoltaic Industry Association (EPIA) are official members of Task 14 and actively contribute to its activities.
During its whole period, Task 14 has actively integrated industry by organizing special workshops for knowledge exchange between experts from utilities and the Task 14 group.

PUBLICATIONS AND DELIVERABLES

The products of work performed in Task 14 are designed for use by experts from the electricity sector, specialists for photovoltaic systems and inverters, equipment manufacturers and other specialists concerned with interconnection of distributed energy resources.

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

COUNTRY	PARTICIPANT	ORGANISATION
Australia	Ian McGill	University of NSW
Australia	Anna Bruce	University of NSW
Australia	Glenn Platt	CSIRO
Austria	Christoph Mayr	AIT Austrian Institute of Technology
Austria	Roland Bründlinger	AIT Austrian Institute of Technology
Belgium	Karel de Brabandere	3E
Canada	Andrew Swingler	Schneider Electric Canada
China	Wang Yibo	Chinese Academy of Sciences
Denmark	Kenn H. B. Frederiksen	Energimidt
EC	Arnulf Jäger-Waldau	European Commission
EPIA	Manoël Rekinger	European Photovoltaic Industry Association
EPIA	Ioannis-Thomas Theologitis	European Photovoltaic Industry Association
Germany	Martin Braun	Fraunhofer IWES
Germany	Daniel Premm	SMA Technology AG
Germany	Gunter Arnold	Fraunhofer IWES
Germany	Thomas Stetz	Fraunhofer IWES
Israel	Moshe Ohayon	Israel Electrical Company
Italy	Giorgio Graditi	ENEA-Portici Research Centre
Italy	Adriano Iaria	RSE
Italy	Daniele Bacchiocchi	GSE – Gestore Servizi Energia
Japan	Koji Washihara	NEDO
Japan	Kazuhiko Ogimoto	University of Tokyo
Japan	Takashi Oozeki	AIST
Malaysia	Ali Askar Sher Mohamad	SEDA
Malaysia	Azah Ahmad	SEDA
Portugal	Catarina Calhau	EDP - Energias de Portugal
Spain	Vicente Salas	Universidad Carlos III Madrid
Sweden	Antonis Marinopoulos	ABB AB, Corporate Research
Switzerland	Lionel Perret	Planair
Switzerland	Pierre Renaud	Planair
Switzerland	Christof Bucher	Basler Hofmann
Switzerland	Jan Remund	Meteotest
United States	Benjamin Kroposki	National Renewable Energy Laboratory
United States	Barry Mather	National Renewable Energy Laboratory

Fig. 4 - IEA PVPS Task 14 organization.

In October 2013, Task 14 published its first report, "Photovoltaic and Solar Forecasting: State of the Art." The report describes forecast tools with links between weather forecasts and developed prediction and monitoring tools.

Besides PVPS related dissemination activities, Task 14 experts contributed to a number of external events and brought in the experience from the Task 14 work. The main contributions to be noted during 2012 - 2013 included the following events:

- "High Penetration of PV in Grids: First results from IEA PVPS Task 14;" a presentation at the IEEE PES Workshop "Securing the Future of Energy Systems Generation vs. Network Investments," in Bern Switzerland, October 2012.
- Co-organization (together with EPRI) of the panel session "Distribution Feeder Hosting with High Penetration of Distributed PV" at the IEEE General Meeting 2013 in Vancouver, July 2013. Contribution of 3 presentations by Task 14 experts:
  - GM2486, Case Studies of High PV Penetration in Distribution Grids (B. KROPOSKI, National Renewable Energy Laboratory)
  - GM2487, High-Penetration of Photovoltaic in the German Distribution System (T. STETZ, Fraunhofer IWES)
  - GM2495, Distribution Grid Codes and the Integration of Smart PV Inverters in Europe (R. BRUENDLINGER, Austrian Institute of Technology GmbH)

Until the end of its first term in May 2014, the publication plans include:

- A 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, which 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 Systemwide 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, as well as the remote control and communication for Smart Inverters.

In addition, the successful series of utility workshops related to high PV penetration scenarios in electricity grids will continue in 2014, in order to involve industry, network utilities and other experts in the field of PV integration to the Task 14 work.

At the moment, two workshops are tentatively planned for 2014:

- Geneva, Switzerland, April 2014: High Penetration Integration Workshop; organized by Task 14 and representatives from Swiss stakeholders.
- Kyoto, Japan, November 2014: Joint Workshop with other IEA PVPS Tasks.

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

MEETING SCHEDULE (2013 AND PLANNED 2014)

2013 Meetings

- **The 7th Experts' meeting** was held in Brussels, Belgium 6-8 May 2013, hosted by 3E, supported by EPIA and the European MetaPV Project.
- **The 8th Experts' meeting** was held in Sydney, Australia, 26-29 November 2013, hosted by the Australian PV Association (APVA) and UNSW.

2014 Meetings (tentative)

- **The 9th Experts' meeting** is tentatively planned to be held in Geneva, Switzerland, April 2014.
- **The 10th Experts' meeting** is tentatively planned to be held in Kyoto, Japan, November 2014.

AUSTRALIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DR MURIEL WATT, IT POWER AUSTRALIA

Fig. 1 - 120 kW PV array on the 6 Star Tyree Energy Technologies Building, UNSW Australia (Photo: UNSW).

GENERAL FRAMEWORK AND IMPLEMENTATION

The Australian PV market contracted in 2013, with installation levels reducing from the 1 GW installed in 2012 to around 850 MWp. Installed capacity is now well over 3 GWp, accounting for 5 % of electricity capacity and 2 % of electricity generation. Incentives for PV have been removed by State Governments and reduced by the Federal Government. Module prices continued to drop from 1,3 AUD/Wp in 2012 to around 0,75 AUD/Wp and installed prices for small residential systems dropped from an average of around 3 AUD/Wp to around 2,50 AUD/Wp. With continued increases in grid electricity prices, PV is a cost effective option for homeowners across Australia and is of increasing interest to the commercial sector.

Over 1 million Australian homes now have a PV system. Residential penetration levels average 15 % and are over 30 % in some areas. Installation restrictions are being imposed by electricity network operators in some areas to cope with potential issues arising from high penetration levels. The major issue arising, however, is economic, not technical. With revenue for electricity networks and retailers dependent largely on kWh sales, PV uptake has contributed to revenue reductions. Large central generators have also been impacted by the overall reductions in energy sales, with several plant closures. This has made PV a target for the established electricity sector, as well as State Governments which depend on electricity sector dividends. Various proposals have been put forward to reduce the attractiveness of PV, including imposition of levies, prohibition of net metering and restrictions on system sizes.

Electricity prices are expected to continue to rise over the next few years in most jurisdictions, despite the newly elected Australian Government committed to removing the carbon price. Hence the market for distributed PV will remain strong. Several hundred larger, commercial-scale PV systems were installed in 2013 and construction is now underway on a 20 MW ground-mounted system in the Australian Capital Territory, under its renewables program, and a 50 MW system in NSW, in the first stage of the Australian Government's Solar Flagship program.

NATIONAL PROGRAMME

The main support for PV at a national level remains the Renewable Energy Target (RET). Support for large systems is via the Large-scale RET which increases each year to 41 000 GWh of renewable electricity by 2020, maintained to 2030. It operates via a market for Large-scale Generation Certificates (LGCs), with 1 LGC created for each MWh of electricity generated. Support for small-scale systems is via an uncapped Small-scale Renewable Energy Scheme, for which 1 MWh creates 1 Small-scale Technology Certificate (STC). All PV systems up to 100kWp 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. A review of the RET will be undertaken in 2014, with proposals to reduce the target and remove the Small-scale scheme.

Fig. 2 - Shade shelter at bus and taxi rank, Townsville RSL Stadium. The 20 kW array (153 x Kyocera KD135W modules) is part of the Townsville Queensland Solar City Project (Photo: Ergon Energy).

Fig. 3 – 2,1 kW residential array in Perth, using Hanwha Q.Cell's Q.Pro-G2 modules (Photo: Hanwha Q.Cells Australia).

RESEARCH, DEVELOPMENT & DEMONSTRATION

PV research, development and demonstration are supported at the national, as well as the State and Territory level. In 2013, research grants were available through the Australian Research Council and the Australian Renewable Energy Agency (ARENA). The latter invested 168 MAUD in 2013 on 3 new PV R D&D projects.

The Clean Energy Finance Corporation has invested 60 MAUD to finance a 56 MW, single axis tracking solar farm at Moree, NSW; 500 000 AUD to finance 15 grid connected PV systems across Queensland for large beef cattle producer Australian Agricultural Company Ltd; and 1,18 MAUD to the Tumut Shire Council towards energy efficient air-conditioning and lights, plus a PV system.

INDUSTRY AND MARKET DEVELOPMENT

After three years of rapid growth, the industry contracted in 2013, as support programs wound back. However, the market is now more sustainable, with less reliance on subsidies. The Australian PV Institute, with support from ARENA, has released a solar map of Australia, which tracks installation locations, sizes and PV generation: http://pv-map.apvi.org.au/ .

The estimated 850 MWp installed in 2013 comprised mainly small-scale residential systems. Despite increased restrictions on PV power exports to the grid, and low or zero rates now paid for exported power, PV system sizes have continued to increase. The average size of residential systems increased from 1 kW in 2009 to 4 kW in 2013. The overall PV market in 2014 is likely to remain stable, albeit with an increase in commercial system installations at the expense of residential ones. However, development of the commercial market is currently hampered by the lack of standardised procedures or rights to connect, while the residential market may be impacted by restrictions, fees and other dis-incentives. If imposed, these could result in further market contraction in 2014.

There is increasing customer interest in on-site storage. Although not yet cost effective for most customers, a market for storage is already developing. This trend could exacerbate issues faced by incumbent electricity sector businesses, even if it offers a means to manage supply intermittency and peak demand, since it would facilitate the installation of larger PV systems and may also see a trend to self-sufficiency and disconnection of customers from main grids.

Average system size and installed PV capacity in Australia - residential and small commercial systems

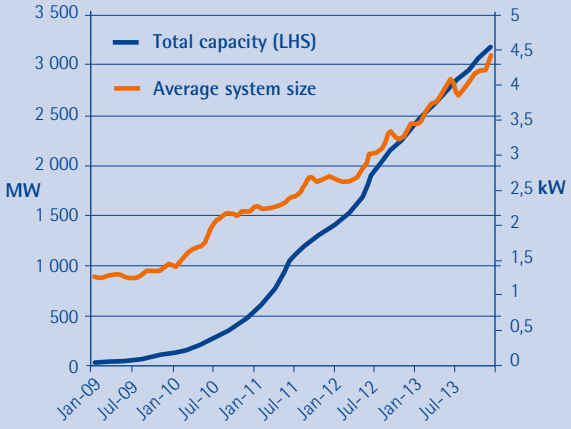


Fig. 4 – Average system size and installed PV capacity for small systems in Australia.

The Australian Capital Territory ran a second solar auction process in 2013 and awarded feed-in tariffs to Zhenfa for a 13 MW Solar Park in Mugga Lane and to OneSun for a 7 MW Solar Farm in Coree. Large-scale central generation PV installations will be more prominent in 2014, with commencement of the Solar Flagships, the ACT systems, and the CEFC financed Moree Solar Farm, as well as other possible installations where planning approval has been given.

AUSTRIA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

HUBERT FECHNER, UNIVERSITY OF APPLIED SCIENCES, TECHNIKUM VIENNA

Fig. 1 - Welser Profile Office Building, Ybbsitz, Lower Austria. BIPV (Mcsi) Facade, RP-Technik ISO 60 hermetic, stainless steel (Photo: Welser Profile).

Fig. 2 - Activities of Austrian R&D centres provide consolidated, methodical and practical know-how with the aim to bring technologies into applications (Photo: CTR Carinthian Tech Research AG, www.ctr.at).

GENERAL FRAMEWORK AND NATIONAL PROGRAMME

The Austrian photovoltaic market is continuously rising. At the end of 2013, about 1 % of the Austrian electricity supply was being provided by photovoltaics.

Austria's support schemes are still complex, the support in general was reduced significantly in 2013: The feed-in-tariff system is designed only for systems larger than 5 kWp and is only responsible for one part of the supported PV systems in Austria; investment support systems for small, private systems are well established on federal and regional level, as well.

Two targets for the national PV market have been laid down in the national green-electricity act (GEA), firstly issued in 2002, and meanwhile revised several times. The official market target is set with 500 MW at the end of 2015 and with a 2020 target of having 1,2 GW installed in Austria. The official 2015 goal was already reached in 2013.

- Feed-in Tariff is provided via the national green-electricity act; The "new RES" are supported by this act mainly via up to 13 years guaranteed feed-in tariffs; a cap with an additional 8 MEUR annually limits the installation. The application had to be submitted via internet on January 16, 2013. The available financial allocation was reached within a few minutes. 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. For 2013, the feed in tariff was set with 18,12 EURcents/kWh for PV on buildings (27,6 EURcents/kWh in 2012) and 16,59 EURcents/kWh for PV on open landscapes (19 EURcents/kWh in 2012). For the first time, an additional 200 EUR subsidy per kWp was offered.
- Systems up to 5 kW are supported by the also limited sources of the governmental Austrian Climate and Energy Fund. This public initiative, launched in spring, will support only small systems up to 5kWp only for private people and was opened for the first time in August 2008. In 2013, the support given per kWp was 300 EUR for standard systems and an additional financial benefit to building integrated systems (BIPV) in the range of 400 EUR per kWp. This was a significant reduction as 800 EUR (1 000 EUR for BIPV) were offered the year before. For the first time, the total available amount of 36 MEUR could not be spent. 9 600 private PV systems were supported, 60 % more than in 2012.
- Besides that, some provinces provide PV support budgets as well, amongst them very specific support, e.g., only for municipal buildings.

RESEARCH AND DEVELOPMENT

The National PV Technology Platform, founded in September 2008 and exclusively financed by the participating industry, research organisations and universities, experienced a very good development in 2013. Primarily supported by the Ministry of Transport, Innovation and Technology, this loose platform was transferred into a legal body in 2012. The PV Technology Platform brings together about 25 partners, active in the production of PV relevant components and the relevant research community in order to create more innovation in the Austrian PV sector. The transfer of the latest scientific results to the industry by innovation workshops, trainee programmes and conferences, joint national and international research projects, and other similar activities are part of the work programme. At the end of 2013, about 5 000 employees were working in the PV industry in Austria. This initiative 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 the different IEA PVPS Implementing

Fig. 3 - The new SmartEST Laboratory for integration testing of large scale renewable energies such as photovoltaics, wind and biomass.

Agreement's Tasks and, concerning grid interconnection of renewables, in the IEA ISGAN Implementing Agreement. The RTD development and approach is widespread located and decentralised orientated. AIT Energy is well established in photovoltaics as a technology provider for research and development projects. AIT Energy activities include the development of methods of mechanical, thermic, electrical and optical characterization and simulation in photovoltaics. Amongst its services, there are the Characterization in Compliance with IEC 61215, IEC 61646 and IEC 61730, and specialized R&D methods. Core areas of research are: Performance and Reliability, Building Integrated Photovoltaics and Emerging Technologies.

Two national programmes, "e!MISSION," by the Austrian Climate and Energy Fund as well as "City of Tomorrow," again by the Ministry of Transport, Innovation and Technology cover quite broad research items on energy technologies, including PV. The research budget for PV related projects within e!MISSION and other programmes by the Austrian Climate and Energy Fund is rising substantially: Whereas in 2007 only 0,15 MEUR were dedicated to photovoltaic research, in 2012, more than 6,6 MEUR were spent for photovoltaic research. This covers about 20 % of the total annual energy research budget of the Austrian Climate and Energy Fund. Further public research funding in the field of PV is given within the COMET initiatives or on an individual project basis.

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

PV and the high penetration in some parts of the low voltage network becomes more and more a driver of the comprehensive and internationally orientated "Smart Grid" activities in Austria. Two demo-sites in Koestendorf and Eberstalzell are aiming at effective integration of high shares of PV into the distribution networks. Research institutes and some distribution network operators are working together with the industry and supported by national and EU research funds.

IMPLEMENTATION AND MARKET DEVELOPMENT

Approximately 363 MW of PV power had been installed in Austria by the end of 2012. There are no final figures available yet for 2013, but it is expected that nearly 600 MW were totally installed in Austria by the end of 2013.

The annual growth rate in 2012 was about two times the rate of 2011, with a total of 175 MW, and by far the largest rate ever, but this will be certainly again surpassed by the 2013 numbers.

The main applications for PV in Austria are grid connected distributed systems, representing much more than 95 % of the total capacity. Grid-connected centralised systems in the form of PV power plants play a minor role. Building integration is an important issue and a cornerstone of the public implementation strategy.

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

MARKET DEVELOPMENT

The Federal Association Photovoltaic Austria is a non-party and corporate association to improve the general conditions for photovoltaics in Austria. The association is very active in public relations, in creating a national network to distribute information on PV and in initiating various workshops and press conferences. By fostering the political contacts, intensive political lobbying work and a broad series

of articles in newspapers on PV, the association is aiming at changing the legislative frame conditions for PV by introducing stable and supportive PV market incentives. By the end of 2013, more than 130 companies and persons involved in the PV business were Association members.

The 11th Annual National Photovoltaic Conference (In 2013, it was a two-day event, organised by the University of Applied Sciences Technikum Vienna and supported by the Ministry of Transport, Innovation and Technology) is now THE established annual come together of the Austrian PV community, bringing together about 250 PV stakeholders in industry, research and administration. Many specific conferences and workshops were also organised by the "PV-Austria" association in 2013. Austrian renewable energy fairs and congresses are focussing more and more on PV.

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 230 participants in 2013. A further 15 courses are planned for 2014.

FUTURE OUTLOOK

The producing Austrian PV industry is strengthening their efforts to compete on the global market, mainly by a close collaboration with the research sector, in order to boost the innovation in specific niches of the PV market.

In general, the situation of the local PV market is improving but would benefit from more stability of the support system as well as clear and realistic national targets.

Strategic initiatives to strengthen the potential of the local PV Industry will be further increased.

Grid integration is a major issue; the fruitful collaboration between research institutes and some national distribution networks operators will create significant results from their first demo-sites. PV research and development will be further concentrated on international projects and networks, following the dynamic know-how and learning process of the worldwide PV development progress. Meanwhile, an Austrian focal point of the international research activities in this field is mainly within the IEA PVPS Task 14 on "High Penetration Photovoltaics in Electricity Grids," which commenced in 2010 and is lead by Austria.

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

The European building directive moving the building sector towards "active buildings" with PV as its central element of generation is already causing a new momentum in the Austrian building sector.

The level of the public know-how and interest about the potential and perspectives of PV is quite high. Several renewable energy education courses are already implemented, some new courses are currently under development. All of them include PV as essential part of the future energy strategy. The importance of proper education for installers and planners of PV systems will increase depending on the market situation; the training is already available and can be extended easily. Meanwhile, at the University of Applied Science Vienna (Technikum-Wien), about 250 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.

BELGIUM

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

GREGORY NEUBOURG, APERE ASBL, BRUSSELS

Fig. 1a & Fig. 1b - Bruxelles Environnement. The new Brussels Environment and Energy Administration Headquarters will be the largest passive office building in Europe and will include 700 m² of BIPV ISSOL modules (Photos: Copyright CEPEZED, ISSOL for Fig. 1a and ISSOL for Fig. 1b).

GENERAL FRAMEWORK

With an installation level just over 200 MWp, 2013 was a dark year for the photovoltaic sector. Even the most conservative projections (250 MWp/year) had not anticipated this outcome. Many reasons can explain this crisis.

The pace of development in recent years was so high that the impact of financial support mechanisms on the final electricity bill became significant. The impact of PV on the grid is also no longer anecdotal, whether in terms of peak power or in terms of total annual energy. Network operators have therefore been increasing their management costs (overvoltage, line enhancement, etc.).

In a context of economic crisis, these costs have pushed DSOs and regional governments to adapt their policies. These adaptations were challenged by different actors in 2013, causing an instability that was not likely to reassure investors. This instability was reinforced by many political debates that unfortunately tended to oppose clean energy and cheap energy without considering the indirect benefits of PV development in terms of economy, environment and employment. In Flanders, two important changes were introduced in early 2013 for domestic installations. The main one was the introduction of a new specific network fee (around 60 EUR/kWp a year for 20 years). The second was a significant reduction of support in terms of green certificates (from 90 to 21 EUR/MWh during 10 years) to get to a reasonable IRR of 5 % over 15 years. Although profitability was maintained, the impact on the sector was dramatic. The number of annual installations was divided by 20 compared to the record year of 2011.

At the end of 2013, the specific network fee was cancelled by the Court of Appeal following legal action brought by the PV Federation (PV Vlaanderen). Following this decision, the Flemish Region decided in January 2014 to remove the mechanism of green certificates for small installations as profitability could be achieved with the net-metering only. The news was warmly welcomed by the sector; especially that it went well with the new requirement to incorporate a minimum share of renewable energy in all new buildings since January 2013.

In Wallonia, as in 2012, the beginning of 2013 was marked by the crisis of green certificates mechanism. To address it, the region developed a new plan to support the sector: The Qualiwatt plan. However, before its implementation in March 2014, a transitional system was adopted from April 2013 that strongly reduced the support in terms of green certificates (from 325 to 97 EUR/MWh during 10 years) for domestic installations.

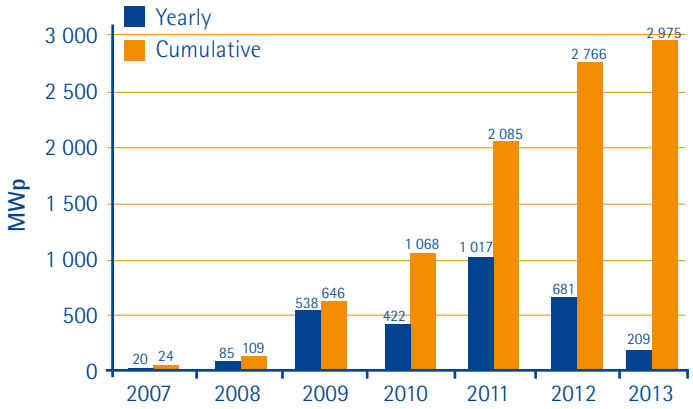
As they did in Flanders, the new Qualiwatt plan removes the green certificates' mechanism. It is replaced by a premium spread over five years and calculated to obtain a simple payback time of 8 years (5 % IRR for a 3 kWp installation). Besides the financial aspects, this new plan will also introduce quality criteria on the equipment, the installer and the installation. The Qualiwatt plan will come into force on March 1, 2014.

In Brussels, the year was exceptional for photovoltaics. The stable support mechanism led to the emergence of many large scale installations on industrial buildings' rooftops. To ensure a simple payback time of 7 years as required by law, a decrease of the financial support in terms of green certificates was applied in August 2013. (From 340 to 204 EUR/MWh during 10 years).

Fig. 2a & Fig. 2b – Aquiris. One of the biggest urban PV installations in Belgium was built in Brussels: 3,2 MWp (Photo: Copyright Aquiris).

MARKET DEVELOPMENT

Photovoltaic: Installed capacity in Belgium



YEAR	YEARLY (MWp)	CUMULATIVE (MWp)
2007	19 668	23 711
2008	84 647	108 358
2009	537 569	645 928
2010	421 548	1 067 476
2011	1 017 077	2 084 553
2012	681 381	2 765 934
2013*	209 415	2 975 349

**Estimation*

In terms of market development, 2013 was the worst year since 2009, with only 209 MWp installed. It brings Belgium to an approximate 3 GW installed capacity (±270 Wp/inhabitant).

Small-scale projects (< 10 KW) represent 61 % of the installed capacity with more than 346 600 installations, which represent approximately 1 household out of 15. The other 39 % include 6 235 large-scale projects. No big changes in the subsidies are planned in 2014 so there is hope that this stability will lead to reach the goal of the moderate scenario (250 MWp/year).

Interestingly enough, the net-metering system (on an annual basis) for small installations has not been questioned in any of the 3 regions of Belgium.

NATIONAL PROGRAM

In 2010, the 2009/28/EC European Directive to reach 20 % of renewable energy was translated in Belgium into a national renewable energy action plan with an objective of 20,9 % of renewable electricity. For PV, it foresaw an installed capacity of 542,1 MW for the end of 2013 and 1 340 MW for 2020. At the end of 2008, the total power of all photovoltaic systems installed in Belgium was about 100 MW. By the end of 2013, it reached almost 3 GW (non-consolidated), which is already more than double of the objective for 2020.

RESEARCH AND DEVELOPMENT

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

INDUSTRY

Issol is the last producer of classical modules, but it is not their main activity. With Soltech, they are the two main companies focusing on BIPV applications. Derbigum is specialized in amorphous silicon. Next to these three big companies, a lot of companies work in all parts of the value chain of PV, making the Belgian PV market a very dynamic sector. (www.pvmapping.be)

CANADA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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

GENERAL FRAMEWORK

Canada's Department of Natural Resources (NRCan) supports priorities to promote the sustainable and economic development of the country's natural resources, while improving the quality of life of Canadians. CanmetENERGY [1], reporting to the Innovation and Energy Technology Sector of NRCan, is the largest federal energy science and technology organization working on clean energy research, development, demonstration and deployment. Its goal is to ensure that Canada is at the leading edge of clean energy technologies to reduce air and greenhouse gas emissions and improve the health of Canadians.

The Canadian Solar Industry Association (CanSIA) is Canada's member of the International Energy Agency PVPS Implementing Agreement and works with industry stakeholders and government decision makers to help develop effective solar policy and identify key market opportunities for the solar energy sector.

Provincial and Territorial government policies are now all supporting "net-metering" or "net-billing" of PV power in Canada. With the significant decline in the PV system costs and a recognition of opportunities to reduce "soft costs" (non-equipment, regulatory and administrative costs), PV generation is gradually approaching grid parity. These policies are aimed at simplifying the regulatory framework for customer s that want to invest in their own renewable energy generation as part of their overall energy conservation measures and to reduce their electricity bills.

The Province of Ontario, Canada's most populous and second largest province, leads the country in photovoltaic (PV) investment. As of December 2013, the cumulative PV installed capacity stood at 470 MW_{AC} under the Renewable Energy Standard Offer Program (RESOP), 390 MW_{AC} under the Feed-in Tariff Program (FIT) and 160 MW_{AC} under the microFIT program for a total of 1020 MWAC. The total amount of installed and under development PV capacity in Ontario is approximately 2 000 MW_{AC}.

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.

The PV Innovation Research Network, funded by the Natural Sciences and Engineering Research Council (NSERC), brings together a core group of 32 academic researchers in Canada, as well as CanmetENERGY, the National Research Council, the Ontario Center of Excellence and 15 industrial partners. The network held its fourth national scientific conference at McMaster University in May 2013. The 4th Overview of PV Solar Cell R&D Capability in Canada was updated and made available on the CanmetENERGY website [2]. It reports on research efforts in Canada, including advances in innovative PV devices that have the potential to leapfrog existing and established technologies.

The NSERC Smart Net-Zero Energy Buildings Strategic Network (SNEBRN) performs research that will facilitate widespread adoption in key regions of Canada of optimized net zero energy buildings design and operation concepts by 2030. CanmetENERGY is contributing to this research effort and has been leveraging its activities through its leadership of the recently completed Task 40/Annex 52, entitled "Towards Net Zero Energy Solar Buildings" - a large international collaboration jointly managed by the IEA SHCP and EBC programs. To achieve this objective, some 75 T40A52 experts from 19 countries, including Canada, have documented research results and promoted practical case studies that can be replicated worldwide [3].

IMPLEMENTATION

Ontario's Energy Plan and Procurement

Ontario's Feed-In-Tariff (FIT) and microFIT programs, managed by the Ontario Power Authority (OPA), are North America's first comprehensive guaranteed pricing structure for electricity production from renewable fuel sources including solar-PV, bio-energy, waterpower and wind. In 2013 in its Long Term Energy Plan (LTEP), the government reinforced its commitment to 900 MW of additional capacity including 4 years of annual procurement targets; 50 MW under microFIT (< 10 kW) and 150 MW of FIT (projects up to 500 kW). There was a further 15 MW FIT procurement in the Unconstructed Rooftop Solar Pilot (URSP) Program for projects on unconstructed buildings. Under the FIT program, the removal of the domestic content requirement for locally manufactured modules and equipment is expected to continue to reduce overall system costs by opening up access to the global supply. The government also moved projects greater than 500 kW out of the FIT standard offer program and into a competitive Large Renewable Procurement (LRP) framework allocating 140 MW for both 2014 and 2015.

Fig. 1 - At Vine Fresh Produce Project is the largest rooftop installation in Ontario under the FIT program (2,3 MWp). This project is currently the largest system in the world with an Enphase micro-inverter.

In 2013, the Yukon Territory released its micro generation policy that will reimburse customers for the amount of electricity exported to the grid at a rate reflective of the avoided cost of new generation in the territory. This program will offer a tariff of 21 cents for grid connected and 30 cents on diesel generation micro grids up to 5 kW on shared

transformer, 25 kW on a single transformer and up to 50 kW on a case by case approved by the local utility [4].

The Northwest Territories (NWT) has launched a Solar Energy Strategy to install solar systems with the capability to supply up to 20 percent of the average load in NWT diesel communities for 2012-2017 [5]. The province of Saskatchewan's net metering rebate provides up to 20 % of system costs for installations up to 100 kW for environmental preferred technologies including photovoltaics to a maximum of 20 000 CAD per eligible net metering project for a limited period ending on November 30, 2014.

Alberta's micro generation regulation was reviewed in 2013. This in a non-incentivized market where the recent increase in the price of electricity (30 % over the last 6 years) and the decreasing cost of solar PV makes solar electricity nearly competitive. Enmax, a utility, has initiated a Micro Renewable Energy Program to simplify the financing and installations of Solar PV residential rooftop systems [6].

British Columbia was the first province to adopt a Net Metering Policy in 2004. In 2013 a progress report was released that provided an update of the BC Hydro Net Metering Program and a regulatory scan to benchmark /compare to similar programs across Canada and selected programs in the USA [7].

INDUSTRY STATUS

Canada's solar sector has experienced continued significant investment over the last 4 years. Employment in PV-related areas in Canada has grown with a 2012 labour force estimated at over 3 900 compared to 2 700 jobs in 2009. The Ontario government projects 6 000 jobs will be created from the four year FIT procurement targets [8]. In 2013 The Solar PV Module manufacturing industry in the Province currently accounted for over 1 900 full time direct jobs in the design, manufacturing and testing of modules, while the PV inverter industries in the Province provided an additional estimated 250 jobs. Racking, the other major segment of manufacturing, accounts for approximately 700 jobs.

In 2012, a Sector Profile for Solar Photovoltaics in Canada [9] was published. It reported on the state of the PV market including various incentives in place, describing the PV supply chain, key manufacturers, economic impacts, workforce capability and the state of R&D initiatives in Canada.

MARKET

PV power capacity in Canada grew at an annual rate of 25 % between 1994 and 2008. In recent years this growth was 202 % in 2010, 49 % in 2011 and 50 % in 2012 due to the Ontario incentive programs.

A number of building integrated PV applications have also been successfully designed and constructed across the country. Building Integrated PV (BIPV) is a very promising technology since it can simultaneously produce electricity and act as a component of the building envelope. The city of Toronto established a working group to engage both the PV and building industries. For example, Eclipsall has been working with Neudorf Glass Inc and other partners to design and install BIPV system in Canada. As the price for BIPV decreases, this application segment is predicted to grow significantly, especially in Toronto and other major cities where there is the industry capacity to design green buildings [10].

Recent information from industry suggests module pricing to be approximately 1,00 CAD per watt. This can be compared to 6,18 CAD in 2003. This represents an average annual price reduction of 20 % over a 10-year period.

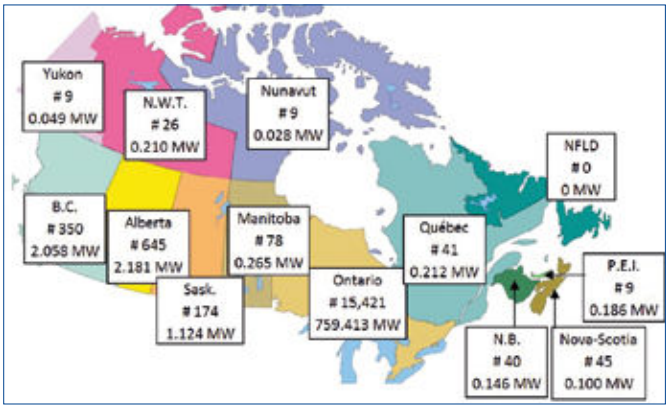


Fig. 2 - Map showing the Canadian provinces, the capacity (megawatt) and the number of utility interconnected PV Systems in 2012.

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. As the cost of electricity increases and the cost of solar turn-key installations decreases, trends indicate that Solar PV power will reach grid parity in most jurisdictions in Canada by 2022.

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CHINA

PV TECHNOLOGY AND PROSPECTS

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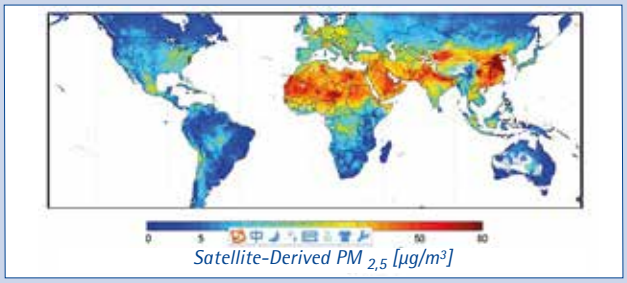
GENERAL FRAMEWORK

China now is facing serious pressure on its energy supply and GHG emission, therefore, China has to make great efforts to alleviate the problems and must complete its energy structure transformation in the next 20-30 years. Renewable energy (RE) development is the basic strategy in China for energy sustainability and GHG reduction. Solar PV will play a key role in the future energy structure transformation in China.

NATIONAL PROGRAM

In 2013, the total domestic PV installation was about 12,0 GW, which is more than the government announced number early this year (10,0 GW) due to the high installation of LS-PV in western China. All developers want to obtain the FIT of 1,0 CNY/kWh, which will expire on January 1, 2014. The installed LS-PV power plants are 8,3 GW, distributed PV is about 3 GW and off grid PV is about 500 MW. PV installation in China is estimated below:



Satellite-Derived PM $_{2,5}$ [μg/m³]

Fig 1 - World PM 2,5 Pollution Map and Smog in Beijing.

TABLE 1 – DOMESTIC PV INSTALLATION BY SECTORS IN 2013

2013 DOMESTIC PV MARKET BY SECTORS					
NO.	MARKET SECTOR	ANNUAL INSTALLED (MWP)	SHARE (%)	CUMULATIVE INSTALLED (MWP)	SHARE (%)
1	Rural Electrification	400	3,39	500	2,66
2	Communication & Industry	40	0,34	100	0,53
3	PV Products	60	0,51	120	0,64
4	Building PV	3 000	25,42	5 390	28,67
5	Ground Mounted LS-PV	8 300	70,34	12 690	67,50
	Total	**11 800**	**100,00**	**18800**	**100,00**

During 2007-2012, the cost of PV was reduced sharply and in 2013, the PV price was kept stable and was only a little bit lower than the previous year.

TABLE 2 – PRICE REDUCTION PV DURING THE LAST 7 YEARS

YEAR	2007	2008	2009	2010	2011	2012	2013
CUMULATIVE INSTALLATION (GWP)	0,10	0,14	0,30	0,80	3,50	7,00	15,00
MODULE PRICE (CNY/WP)	36,0	30,0	19,0	13,0	9,0	4,5	4,2
SYSTEM PRICE (CNY/WP)	60,0	50,0	35,0	25,0	17,5	10,0	8,0-9,0
REASONABLE TARIFF OF PV (CNY/KWH)	3,50	3,00	2,50	2,00	1,15	1,00	0,9-1,0

In 2013, the National Energy Administration (NEA) adjusted the market targets of PV and wants to promote distributed PV as a priority. The updated cumulative PV target is 35 GW by the end of 2015, but according to the real installation of 2013 and the cap set by NEA for 2014, the real cumulative PV installation by the year of 2015 will definitely reach at least 40 GW. The target for 2020 is set at 100 GW.

TABLE 3 – NEAR-TERM TARGET FOR SOLAR PV (2015, 2020)

TARGETS FOR CUMULATIVE INSTALLATION OF SOLAR POWER (GW)				
Market Sectors		2013	2015	2020
Distributed PV	Rural Electrification	0,50	1,0	10,0
	Communication and Industry	0,10	0,5	4,0
	PV Buildings	5,39	18,0	42,0
LS-PV and Others	Large Scale PV (LS-PV)	12,69	20,0	40,0
	PV Products	0,12	0,5	4,0
Total		18,80	40,0	100,0
Share of LS-PV (%)		67,5	50,0	40,0

TABLE 4 - PV MARKET TARGET AND ANNUAL PROGRESS FORECAST

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Annual Installed (GW)	0,5	2,7	3,5	11,8	10,2	11	12	12	12	12	12
Cumulative (GW)	0,8	3,5	7,0	18,8	29	40	52	64	76	88	100

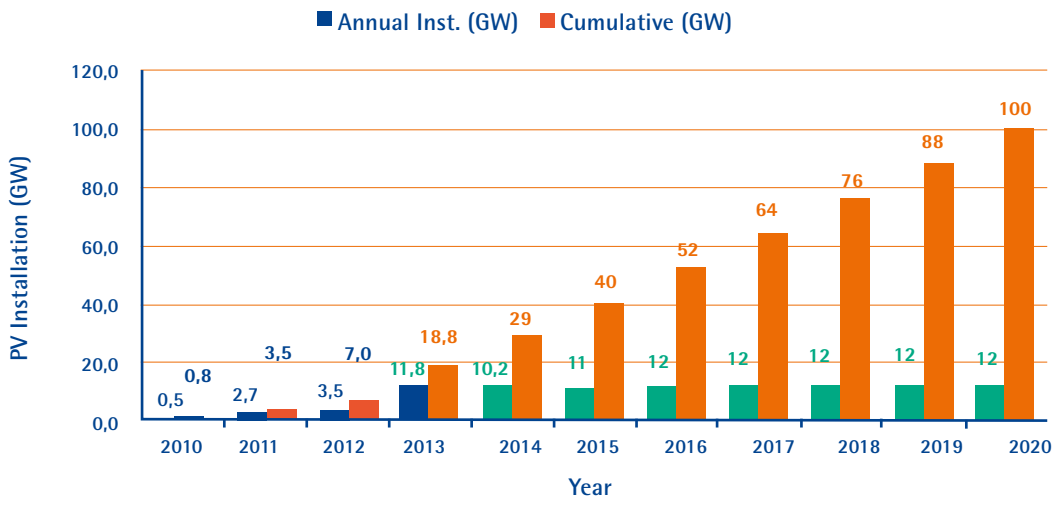


Fig. 2 - PV Market Target and Annual Installation Forecast.

TABLE 5 – THE 2014 PV CAP SET BY NEA

PROPOSED CAP OF DOMESTIC PV INSTALLATION IN 2014				
NO.	PROVINCE	DISTRIBUTED PV (MW)	LS-PV (MW)	TOTAL (MW)
1	Jiangsu	1 000	200	1 200
2	Shandong	1 000	200	1 200
3	Zhejiang	1 000	200	1 200
4	Hebei	600	400	1 000
5	Guangdong	900	100	1 000
6	Henan	550	200	750
7	Xinjiang	50	600	650
8	Qinghai	50	500	550
9	Anhui	300	250	550
10	Inner-Mogolia	50	500	550
11	Gansu	50	500	550
12	Shannxi	100	400	500
13	Ningxia	100	400	500
14	Shanxi	100	350	450
15	Hubei	200	200	400
16	Jiangxi	300	80	380
17	Fujian	300	50	350
18	Beijing	200	100	300
19	Hunan	200	50	250
20	Liaoning	200	50	250
21	Tianjin	200	20	220
22	Xinjiang Army	0	200	200
23	Shanghai	200	0	200
24	Jilin	100	50	150
25	Guangxi	100	50	150
26	Yunnan	10	100	110
27	Hainan	20	90	110
28	Heilongjiang	50	50	100
29	Sichuan	20	80	100
30	Tibet	10	50	60
31	Guizhou	30	30	60
32	Chongqing	10	0	10
	Total	**8 000**	**6 050**	**14 050**

N.B.: This data is the ceiling set by NEA, which means it cannot be higher, but could be lower.

(1) (2) (3) (4)

Fig. 3 - High Efficiency PV Modules Developed by Chinese PV Companies. Numbers refer to manufacturers listed in Table 6, below.

RESEARCH AND DEVELOPMENT (R&D)

The Ministry of Science and Technology (MOST) is the government unit in charge of PV R&D. The average annual investment for R&D from MOST is about 500 MCNY and the supported fields cover all of the manufacturing chain: Poly-Si, wafer, solar cells, PV modules, thin-film technology, CPV, energy storage, BOS components and system engineering. During the last decade, PV has had significant progress in R&D in China. Several leading companies have developed high efficiency and low cost PV products. Trina Solar, CSUN, Yingli Green Energy, Canadian Solar, SunTech, Silevo, etc., have all reached 20-21 % cell efficiency and 30 MW production scale.

For thin-film technology, Advanced Solar Power (ASP) developed a 30MW CdTe manufacturing line and all manufacturing facilities are domestic made. The average module efficiency produced by ASP is 12% and the highest module efficiency reaches 13%. The cost of CdTe module made by ASP is only 0,6 USDcents/Wp.

TABLE 6 – SPECIFICATIONS OF CHINESE MADE HIGH-EFFICIENCY PV CELLS

NO.	MANUFACTURER	TYPE OF PV CELL	SPECIFICATIONS
(1)	Silevo, Hangzhou	N-Type Tunneling Junction Cells	N-Type, Cell Efficiency: 21 % ; Cell Temperature Coefficient: -0,22 %. Tech. Source: Silevo, US.
(2)	Trina Solar,Changzhou	N-Type Back-Contact	N-Type, Cell Efficiency: 21 % ; Domestic Made Manufacturing Facilities: 70 %. Tech. Source: Trina Solar
(3)	CSUN, Nanjing	P-Type PERC Cells	P-Type, Cell Efficiency: 21 %; Domestic Made Manufacturing Facilities: 90 %. Tech. Source: CSUN
(4)	YGE, Baoding	N-Type Laser-Holled Back Contact	N-Type, Cell Efficiency: 20,4 % ; Domestic Made Manufacturing Facilities: 70 %. Tech. Source: ECN, Netherland
(5)	SunTech, Wuxi	Pluto P-Type Cells	P-Type, Cell Efficiency: 20 % ; Domestic Made Manufacturing Facilities: 70 %. Tech. Source: SunTech

PV INDUSTRY DEVELOPMENT

China has been the largest producer of PV modules in the world since 2007. In the last two years, the Chinese PV industry has suffered attacks from anti-dumping, over-capacity and low-price competition. Sharp shake-out started in early 2012 and now, many companies have to get out of the game. Chinese PV module and cell manufacturers had numbered to more than 300 companies but have now been reduced to less than 100 companies. The over-capacity problem will be solved through market competition and shake-out and the Chinese PV industry will become healthier in future.

The total PV grade poly-silicon produced in 2013 was about 82 000 Tons. China is now the largest poly-Si producer in the world, but still needs to import nearly 80 000 Tons from other countries. The situation of the PV industry in China is shown below:

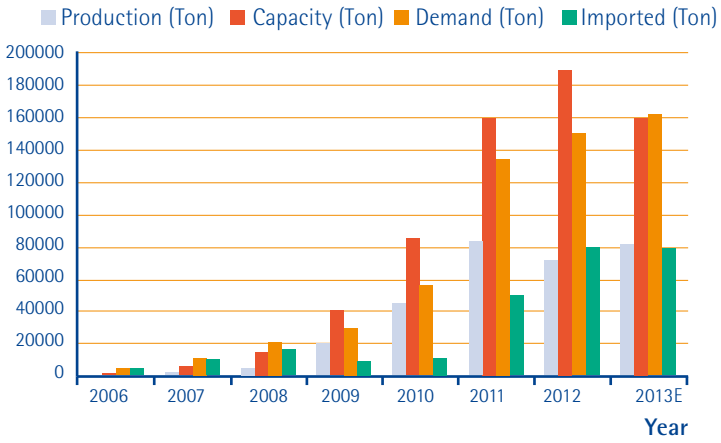


Fig. 4 - PV-Grade Poly-Si Industry Situation in China.

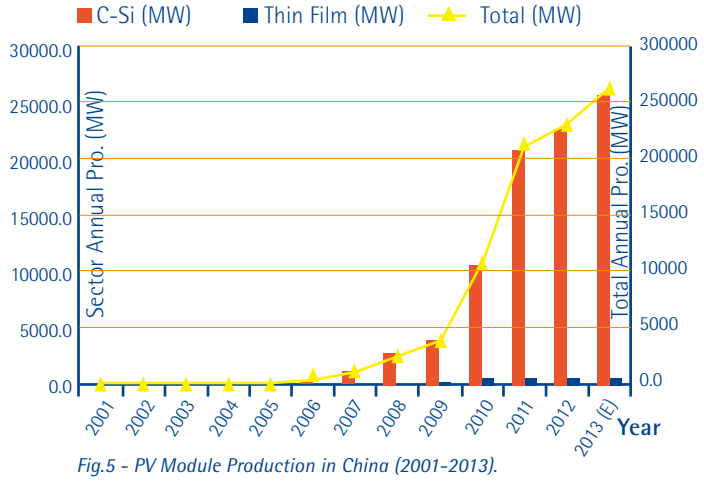


Fig.5 - PV Module Production in China (2001-2013).

TABLE 7 – DOMESTIC CAPACITY AND PRODUCTION OF POLY-SI (2006-2013)

YEAR	2006	2007	2008	2009	2010	2011	2012	2013E
Production (Ton)	287	1 093	4 685	20 071	45 000	84 000	71 000	82 000
Capacity (Ton)	1 500	5 000	15 000	40 000	85 000	160 000	190 000	160 000
Demand (Ton)	4 686	10 597	20 400	29 250	56 000	134 000	150 000	161 000
Imported (Ton)	4 399	9 504	15 715	9 170	11 000	50 000	79 000	79 000
Share of Import (%)	93,88	89,69	77,03	31,35	19,64	37,31	52,67	49,07

TABLE 8 – ANNUAL PV MODULE PRODUCTION (2001-2013E)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
C-Si (MW)	3,0	4,0	10,0	44,0	138	426	1 060	2 550	3 911	10 473	20 592	22 500	25 500
Thin Film (MW)	1,6	2,0	2,0	6,0	8	12	28	50	100	327	565	500	500
Total (MW)	4,6	6	12	50	146	438	1 088	2 600	4 011	10 800	21 157	23 000	26 000

TABLE 9 – MODULE PRODUCTION BY TOP 13 MANUFACTURERS (MW)

NO.	MANUFACTURER	2012	2013
1	Yingli Green Energy	2 359	3 200
2	Trina Solar	1 674	2 400
3	JA Solar	985	1 800
4	Canadian Solar	1 620	1 700
5	Jinko Solar	924	1 400
6	Hanwha SolarOne	872	1 300
7	ReneSolar Ltd.	748	1 200
8	Hareon Solar	900	1 000

NO.	MANUFACTURER	2012	2013
9	Changzhou Yijing		1 000
10	SunTech	1 665	600
11	CSUN		480
12	Risen Energy Co.		400
13	Zhejiang Sunflower		400
14	Others	10 553	9 120
	Total	22 300	26 000

INCENTIVE POLICIES

The China RE Law went into effect on January 1, 2006 to support RE and it was updated in 2009. There are two funds which can be used to support RE, established before 2013. One is the RE Surcharge collected from all electricity end users to support RE power plants (Large scale PV, wind farm and biomass power) through Feed-In Tariff (FIT). The other is the Special RE Fund directly controlled by the Ministry of Finance to support distributed PV: PV Building Project and Golden-Sun Demonstration, with about 10-20 BCNY available each year. The status of government supported projects is listed below:

TABLE 10 – GOVERNMENT SPONSORED PV PROJECTS

LARGE SCALE PV		
PHASES	APPROVED CAPACITY	FEED-IN TARIFF
First Bidding 2009	2 projects, 20 MW	FIT = 1,0928 CNY/kWh
Second Bidding 2010	13 projects, 280 MW	FIT = 0,7288-0,9907 CNY/kWh
2011 FIT	2 000 MW	FIT = 1,15 CNY/kWh
2012 FIT	2 000 MW	FIT = 1,0 CNY/kWh
Total (until 2012)	4 300 MW	
Financial Source	**Surcharge for Renewable Energy**	
PV BUILDING PROJECT		
PHASES	APPROVED CAPACITY	SUBSIDY TO CAPITAL (CNY/W)
1st phase, 2009	111 projects, 91 MW	BIPV 20, BAPV 15
2nd Phase, 2010	99 projects, 90,2 MW	BIPV 17, BAPV 13
3rd phase, 2011	106 projects, 120 MW	BIPV 12, CNY/W
4th phase, 2012	250 MW	BIPV 9, BAPV 7,5
Total (until 2012)	About 550 MW	
Financial Source	**Special Fund for Renewable Energy**	
GOLDEN SUN DEMONSTRATION		
PHASES	APPROVED CAPACITY	SUBSIDY TO CAPITAL (CNY/W)
1st Phase 2009	140 projects, 304 MW	PV Building 14,5 off-grid 20
2nd Phase 2010	46 projects, 272 MW	PV Building 11,5 off-grid 16
3rd Phase 2011	129 projects, 692 MW	C-Si 9.0, a-Si 8.5
4th Phase 2012	155 projects, 1 709 MW	PV Building 5,5, off-grid >7,0
Total till 2012	2 977 MW	
Financial Source	**Special Fund for Renewable Energy**	
PV BUILDING PROJECT AND GOLDEN-SUN DEMONSTRATION		
November 2012	2 830 MW	BIPV 7, BAPV 5,5
Total Installed and Approved PV by the End of 2012		
10 657 MW		

Starting the second half of 2012, China launched a series of incentive policies to boost PV market expansion. Such policies are characterized by a shift from initial subsidy to capital cost, to the subsidy to PV output by feed-in tariff (FIT). The following is a summary of the series of supporting policies:

1) On July 7, 2012, the National Energy Administration (NEA) released the "12th Five-Year Plan for Solar Power Generation" (No. 194 [2012] of NEA), specifying the national short- and mid-term development on PV development, which has now been adjusted as "China's PV accumulative installed capacity will reach 35 GW by 2015 and 100 GW by 2020. "
2) On October 26, 2012, the State Grid Corporation of China (SGCC) rolled out the "Relevant Opinions and Regulations on Grid Connection for Distributed PV" (No. 1560 [2012] of SGCC), removing the barriers to grid connection of electricity generated by distributed PV power projects.
3) On August 9, 2013, the NEA released the "Notice on Carrying out Construction of Distributed Solar PV Power Generation Demonstration Zones" (No. 296 [2013] of NEA), which approved a total of 18 demonstration zones aimed at achieving a capacity of 749 MW by 2013 and total demonstration capacity of 1 823 MW by 2015. This marked the official launch of efforts to scale up distributed solar PV power generation in China.
4) On July 24, 2013, the Ministry of Finance (MoF) released the "Notice on Relevant Issues concerning the Policy of Subsidizing PV Power Generation Based on Output of Electricity Generated" (No. 390 [2013] of MoF), specifying the principle for issuing solar PV tariff subsidies and offering a solution to the delays in paying subsidies over the past few years.
5) On August 22, 2013, the NEA and China Development Bank (CDB) jointly issued the "Opinions on Supporting Financial Services for Distributed PV Generation" (No. 312 [2013] of NEA), which proposed a plan for supporting distributed PV projects' financing and establishing a financing platform.
6) On August 26, 2013, NDRC released the "Notice on Matters Regarding Adjustment to Electricity Price Surcharge Standard for Renewable Energy and Environmental Protection Electricity Price" (No. 1638 [2013] of NDRC), raising the RE price surcharge from 0,8 cent/kWh to 1,5 cents/kWh and hence generating a 40 BCNY subsidy fund per year for supporting RE power generation, which may fully satisfy the need of covering RE power generation subsidies by 2015 (with an installed wind capacity of 100 GW, solar PV capacity of 35 GW, biomass capacity of 13 GW and solar thermal power capacity of 1 GW).
7) On August 27, 2013, NDRC issued the "Notice on Giving Play to the Role of Price Leverage in Promoting Healthy Development of the Solar PV Industry" (No. 1651 [2013] of NDRC), a document specifying the long-expected FIT policy for PV generation based on solar zones and the subsidy standard for distributed PV.
8) On August 29, 2013, the NEA issued the "Management Rules for PV Power Plants" (No. 329 [2013] of NEA), which clarified the application procedures and administrative methods for large-scale PV power plants.
9) On September 27, 2013, MoF and SAT (State Administration of Taxation) jointly issued the "Notice on PV Power Generation VAT Policy" (No. 66 [2013] of MoF), providing for a reduction of 50 % VAT for PV electricity sales (from 17 % to 8,5 %).
10 On November 18, 2013, the NEA issued the "Management Rules for Distributed PV Projects" (No. 329 [2013] of NEA), which clarified the application procedures and administrative methods for distributed solar PV projects.

Of the above-mentioned policies, the most important, as shown in the following table, is the subsidy standard for zoned FITs and the subsidy standard for distributed PV. The detail of such policy is listed below:

TABLE 11 - NEW FITS FOR PV POWER PLANTS AND THE SUBSIDY LEVEL FOR DISTRIBUTED PV

SOLAR IRRADIATION ZONE	PV POWER PLANT	DISTRIBUTED PV BENEFITS	
	FIT	SUBSIDY FOR SELF-CONSUMED PV ELECTRICITY	SUBSIDY FOR SURPLUS PV ELECTRICITY FEED-BACK TO GRID
	(CNY/KWH)	(CNY/KWH)	(CNY/KWH)
I	0,90	Retail price of grid-electricity + 0,42	Whole-sell Tariff of coal-fire power + 0,42
II	0,95		
III	1,00		

The FIT for PV Power Plants is set according to local solar resources; the relationship between solar resources and FIT is described below:

TABLE 12: NEW FIT POLICY BASED ON ANNUAL EQUIVALENT UTILIZATION HOURS (EUH)

RESOURCE ZONE	ANNUAL GROUND-SURFACE GLOBAL IRRADIATION		IRRADIATION ON INCLINED PV SURFACES	ANNUAL EUH	EUH FOR IRR CALCULATION	FEED-IN TARIFF
	MJ/M2	KWH/M2	KWH/M2	HRS/YEAR	HRS/YEAR	CNY/KWH
I	5 400-7 500	1 500-2 000	1 725-2 300	1 380-1 840	1 500	0,90
II	4 500-5 400	1 240-1 500	1 389-1 680	1 100-1 345	1 200	0,95
III	< 4 500	< 1 240	1 320	1 056	1 000	1,00

The main points of the aforementioned Notice on Solar PV Prices are as follows:

(1) Three zoned benchmark PV feed-in tariffs: 0,90 , 0,95 and 1,0 CNY/kWh;
(2) A 0,42 CNY/kWh subsidy is available for both self-consumed distributed PV electricity and the surplus electricity;
(3) Surplus electricity generated by distributed PV will be purchased by the grid company with local standard wholesale rates of coal-fired power (approximately 0,35 ~ 0, 45 CNY/kWh);
(4) In principle, the period of execution will be 20 years.

Newly released policies include: Government plans, Feed-in tariffs & subsidy standards, funding sources, rules of subsidy issuance, grid connection, financing, taxation, demonstration projects and project application & management rules. By such a complete series of supporting policies, the Chinese PV market will be expanded according to the plan and the targets will be definitely reached.

COPPER ALLIANCE

THE COPPER ALLIANCE'S ACTIVITIES

FERNANDO NUNO, PROJECT MANAGER, EUROPEAN COPPER INSTITUTE

Fig. 1 – Molten copper (Photo: Copper Alliance).

Fig. 2 – Copper tubes (Photo: Copper Alliance).

Fig. 3 – Copper wires (Photo: Copper Alliance).

The Copper Alliance develops and defends copper markets. Its policy, advocacy, education and partnership initiatives are based on copper's superior technical properties and its potential to accelerate the energy transition. It is supported by 43 industry members who are active in various areas of the copper production chain.

Headquartered in New York, NY, USA, the organization has divisions in Asia, Europe and Africa, Latin America, and North America. It contains a network of regional offices and copper promotion centers in nearly 60 countries, which propagate the Copper Alliance™ brand and are responsible for program development and implementation, in close cooperation with their partners. Through this international network, ICA has built out a group of approximately 500 program partners from all over the world.

SUSTAINABLE ENERGY

Energy and copper need each other. Indeed, electrical applications are the largest market for copper, and there is a growing understanding that copper is essential in achieving sustainability for the energy system. Its high electrical conductivity is a favourable attribute for the construction of renewable energy systems and the manufacturing of energy efficient motors, transformers, and cables. One of the main aims of the Copper Alliance is to accelerate the transition to a sustainable energy economy. For this reason, it created Leonardo ENERGY (www.leonardo-energy.org), which is the Copper Alliance brand for advocacy and education in sustainable energy.

Leonardo ENERGY (LE) actively supports a low carbon economy by facilitating information exchange, promoting good practices, engaging professionals, stimulating market development, and managing policy initiatives. Furthermore, LE runs information campaigns on the importance of copper in sustainable energy systems.

The following are a few LE initiatives in the field of renewable energy:

- Analysis of how to make the electricity system more flexible and able to cope with variable electricity production;
- Promotion of industrial demand side management (facilitating the integration of renewables on the grid);
- Development of a Sustainable Energy Policy Syllabus & Checklist;
- Development of a strategic agenda for renewables (risk database, public acceptance, etc.);
- Dissemination of best practices on renewables through application notes, webinars and e-learning programs.

PV RELATED ACTIVITIES

Copper Alliance supports PV development through various streams:

- Market intelligence reports;
- Involvement in standardization activities at IEC level;
- Advocacy on new business models for PV (e.g. the promotion and support of the Grid Parity Monitor: http://www.leonardo-energy.org/photovoltaic-grid-parity-monitor);
- E-learning courses on designing, installing and operating PV systems.

COPPER ALLIANCE INVOLVEMENT IN IEA PVPS ACTIVITIES

The Copper Alliance actively participates in the IEA PVPS ExCo meetings. Moreover, it contributes in disseminating IEA PVPS messages and educational material. For example, the IEA PVPS reports are published on the Leonardo ENERGY website, which attracts a substantial number of visits. Finally, the Copper Alliance contributes to the work of IEA PVPS Task 1, particularly in the field of business models and economic analysis.

DENMARK

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

Fig. 1 - 6 kWp mono crystalline PV integrated as shading system in the facade of the school Engelsborgskolen in Copenhagen, developed by Gaia Solar.

Fig. 2 - 306 kWp PV system on the roofs of the hospital, Sygehus Sønderjylland, in Danish city Aabenraa. All hospitals in this region are equipped with PV systems.

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. The energy plan was finally agreed upon in March 2012 by a broad coalition of parties inside and outside the government. The plan, which reaches up to 2020, was further detailed in the government's energy statements of May 2012 and April 2013.

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 2012, more than 30 % of the national electricity consumption was generated by renewable energy sources including incineration of waste. Ongoing research, development and demonstration of new energy solutions including renewable energy sources have high priority in the proposed energy plan, the main objectives being the development of a future environmental benign energy system completely free of fossil fuels. Renewable energy technologies, in particular wind, thus play an important role with PV still seen as a relatively costly RE technology to be prioritized when found more competitive.

Regions and municipalities are playing an increasingly more active role in the deployment of PV as an integral element in their respective climate and energy goals and plans, and these organisations are expected to play a key role in the future deployment of PV in the country.

NATIONAL PROGRAM AND IMPLEMENTATION

Denmark has no unified national PV programme, but a number of projects supported mainly by the Danish Energy Authority's EUDP programme and via the Public Service Obligation (PSO) of Danish transmission system operator, Energinet.dk, a fully government owned body; Energinet.dk administers two programs of relevance for PV, e.g. ForskVE (mainly demonstration) and ForskEL (mainly R&D). A couple of public funds also support PV related projects, mainly supporting market entrance.

Net-metering for privately owned and institutional PV systems was established mid 1998 for a pilot-period of four years. The net-metering scheme was extended in late 2002 for another four years up to end 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, at a level of approx. EURcents 0,30/kWh primarily because of various taxes – combined with dropping PV system prices proved to be able to stimulate PV deployment seriously during 2012, as the installed grid connected capacity in 2012 grew from about 13 MW to approx. 380 MW; a growth rate of about 30 times. For PV systems qualifying to the net-metering scheme, grid-parity was reached in 2012.

This dramatic growth gave rise to political debate towards the end of 2012, and the government announced a revision of the net-metering scheme inter alia, thus reducing the net-metering time window from one year to one hour. During the first half of 2013, a series of new regulations were agreed upon politically; this because the consequences of the new regulations were not fully clear at the time the decision was made and follow up measures were found to be necessary. By June 2013, the new regulations were finally in place including transitory regulations, effectively putting a cap on future PV installations under

Fig. 3 - 2,4 MW ground mounted system divided into 5 strings. The system is developed by Sveigaard Ltd. and located near by the city of Herning.

the net-metering scheme in terms of an overall maximum installed capacity of 800 MW by 2020. For municipal PV installations, the cap was set at an additional 20 MW by 2020.

The above mentioned uncertainties as to net-metering regulations in the first half of 2013 and the general reduction in benefits of the revised net-metering scheme put a damper on the market, and in 2013 about 150 MW installed capacity was added; leading to a total installed capacity of around 530 MW by end of 2013. The amount of PV installations not applying for the net-metering scheme but operating in the "own consumption mode" appears to be growing, but no firm data is available yet.

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

The Skive municipal project has implemented 1,6 MW in total on municipal buildings, and the municipality expects a post-project expansion of PV installations, albeit at a lower speed, by end of project medio 2013. Other municipalities and regions have taken up Skive's example.

The PVIB project on the island of Bornholm has contributed to a total installed capacity of more than 5,5 MW by end of 2013, mostly in the form of roof-tops and municipal installations. The BIPV project originally targeting 5 MW or a PV penetration of 10 % in the local grid system is integrated into the EU EcoGrid project that is investigating the future Smart Grid of Europe. The last phase of the PVIB project launched in the second half of 2013 targets an additional 1,5 to 3 MW, potentially reaching a PV penetration on Bornholm of about 17 %.

RESEARCH AND DEVELOPMENT

R&D efforts are concentrated on silicon processing, crystalline Si cells and modules, polymer cells and modules, as well as power electronics. R&D efforts exhibit commercial results in terms of export, in particular for inverters, but also for custom made components.

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

INDUSTRY AND MARKET DEVELOPMENT

A Danish PV industrial association (Dansk Solcelle Forening) was established in late 2008. With about 70 members, the association has provided the emerging PV industry with a single voice and is introducing ethical guidelines for its members. The association has formulated a strategy aiming at 5 % of the electricity for private household coming from PV by 2020, but is now revising this target due to the high market growth rate in 2012, and to a certain extent in 2013.

The inverter manufacturer Danfoss Solar Inverters has continued its successful market presence during 2013, mainly in terms of export but has had to reduce its staff as a consequence of the declining European PV market.
A couple of Danish module manufacturers each with an annual capacity of 5-25 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 in 2012, the number of market actors quickly increased, but many upstarts have disappeared again during 2013.
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 2013 is very difficult to estimate with any degree of accuracy due to the commercial secrecy surrounding the above mentioned business developments. However, the business volume of about 150 MW on the domestic market is estimated to be at around 260 MEUR and combined with exports, the estimate is around 350 MEUR.

The cumulative installed PV capacity in Denmark (including Greenland) has been estimated to be at a bit more than 530 MW, by the end of 2013.

FUTURE OUTLOOK

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

The future market development for PV in Denmark will strongly depend on the impact of the revised net-metering scheme, including caps mentioned above. The emerging market sector of PV installations for own consumption is growing and is so far not burdened by taxes; there is no firm data on this new submarket.

EUROPEAN COMMISSION

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

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

EUROPEAN ENERGY POLICY FRAMEWORK

Renewable Energy Progress Report

The adoption of the EU's 2009 Renewable Energy Directive created a strong, stimulating policy framework for the growth of renewable energy. It contains legally binding renewable energy targets for each country of the EU for 2020, as well as requirements to simplify grid and administrative procedures, and to facilitate the growth of renewable energy.

The Commission's March 2013 Progress Report [1] showed that all Member States have implemented policies to encourage growth, and renewable energy grew strongly. PV energy production alone has increased from 7,4 TWh/year (just before the Directive) to almost 45 TWh/year (2011). Over the same period, total renewable energy production has grown from 1 465 TWh to 1 725 TWh, i.e. 260 TWh/year. In the majority of EU countries, this strong initial growth has raised renewable energy production above the expected trajectory towards the targets established by the Directive[n] (Fig. 1).

That said, analysis suggests that further measures will be needed for Member States to stay on track towards their target. The legal transposition of the Directive has been slower than desirable and the trajectory grows steeper in the coming years, so that in reality most of Member States' effort will be needed towards the end. Other reasons for concern include the failure to fully address barriers to the uptake of renewable energy: administrative burden and delays still cause problems and raise project risk for renewable energy projects; slow infrastructure development, delays in connection, and grid operational rules that disadvantage renewable energy producers all continue and all need to be addressed by Member States.

Deviations from the trajectory towards their target constitute a deviation from Member States' own national action plans, and the Directive requires Member States to immediately revise their plans and to demonstrate how they will return to the trajectory. If the measures proposed are deemed inadequate then the Member State can be taken to court for infringing upon the Directive.

The changed economic climate has clearly had an impact on the development of new renewable energy projects. One important change is the increased cost of capital in general. Another is the increase in risk resulting from Member State changes to support schemes. The importance of support schemes is such that the Commission is to propose detailed guidance on the reform and structure of support schemes.

Support Scheme Reform

To the extent that the EU drive for renewables has stimulated a global interest, production capacity -in particular for PV- has grown around the world, and production costs have dropped significantly. Reform is indispensable, as support schemes should adjust to the falling cost of renewables. That is necessary for both complying with State aid rules and minimizing costs to consumers and industry. However, this should be done without reducing investor confidence.

The Commission's guidance on support schemes and reform is intended to ensure a stable, transparent, *credible* support framework in order to build investor confidence. Moreover, support schemes must ensure renewables are deployed cost- effectively, with incentives to reduce generation costs whilst avoiding *over*-compensation and overly generous rates of return. The support scheme framework can also help integrate renewable energy generation into the broader energy market. This is important given the expectation that renewable energy sources should compete on a level playing field with a phase-out of subsidies as they become more competitive. This is part of what is called the phase of responsibility, where, with new, harmonised network codes which no longer discriminate renewables, and with coupled EU electricity markets, renewable energy producers will be able to bear the costs of balancing grid - together with market costs and risks - like all other generators [2].

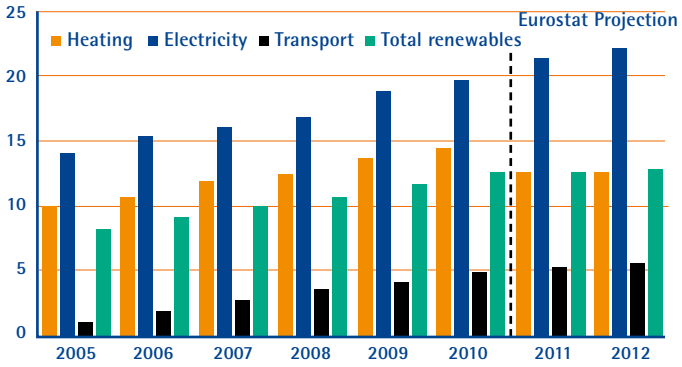


Fig. 1 - Trend in EU Renewables - Sectoral and total growth of renewable energy in the EU[n].

A 2030 Framework for Climate and Energy Policies

The Renewable Energy Directive proposes a review to prepare a post-2020 policy framework in 2018. However, indications on the nature of a 2030 policy framework are already needed to steer investment decisions of today, given the long life of most energy investments. For this reason, the Commission published already in 2013 its Green Paper on a 2030 framework for energy and climate, and launched a major public consultation exercise addressing the role of climate policies, the scope for further decarbonisation in different sectors, the interaction with renewable energy and energy efficiency policies, the impact on energy costs, electricity prices and public budgets. All these factors have to be weighed in establishing the new framework. Most of the current discussion is focusing on whether a climate policy and climate instrument – the EU emissions trading scheme – would be sufficient to drive the transformation of the energy sector that is needed for both climate and energy policy objectives, or whether a further renewable energy target is also needed to ensure the current growth rate of renewable energy markets in the post-2020 world. The Commission intends to propose the new policy framework in a Communication by the end of 2013.

[n] *To note that the EU interim 2011/12 total RES target was 10,7 %*

DEPLOYMENT

In the year 2012, 16,5 GW of new photovoltaic capacity was installed in the European Union (it was 22 GW in 2011), bringing the cumulative photovoltaic capacity to more than 68,6 GW [3]. In some EU Member States, the PV capacity represents already a relevant share of the total installed capacity. In Germany, for instance, in 2012 renewables accounted for 23 % of total power generation. In that year, German solar PV capacity increased by 7,7 GW, bringing cumulative capacity to around 33 GW, while cumulative wind capacity reached about 31 GW. In Italy, in the same year 2012, the photovoltaic cumulative capacity rose to 16,4 GW. Notably, in June 2013, the installations under Italy's FIT scheme reached the annual budgetary cap. In Spain, the economic challenges and the new regulations affecting renewable energy generation have moderated the installation of new photovoltaic power, which has reached a cumulative capacity of 4,5 GW. In France, in 2012, the cumulative PV capacity slightly surpassed 4 GW. The other EU countries with cumulative installed photovoltaic capacity above the 1 GW mark are Belgium (2,6 GW), Czech Republic (2 GW), UK (1,7 GW) and Greece (1,5 GW).

Considering that more than 30 GW have been installed in the world during 2012, it appears that Europe is losing its leading role in driving the global market and that the leadership is migrating towards Asia (mainly China) and America. Incidentally, China is reaching the state of dominating not only supply but also demand for solar products, a situation that will likely last for many years to come. The combined effect of reductions of the support schemes, the introduction of caps, and restricted access to credit has reduced the growth of photovoltaic installations in Europe.

A second element is the harsh and thorough consolidation, with a number of bankruptcies, re-structuring programmes, factory closures and buy-outs, which has hit the European renewable energy arena, and in particular the solar sector. At global level, the Chinese industry also appears less strong than before while the US industry is still in the game. The adopted business model (i.e. vertically integrated companies versus companies specialized on specific segments of the value chain) often makes the difference. Relevant in this regard is the Commission Decision of 2 August 2013 accepting an undertaking offered in connection with the anti-dumping proceedings on imports of crystalline silicon photovoltaic modules originating in China. The settlement sets a minimum price and a volume limit on EU imports of Chinese solar panels until the end of 2015. Chinese manufacturers that take part will be spared the EU duties which are intended to counter below-cost sales [4].

A further element is that the increasing deployment of variable renewables in the EU adds to the challenges for their integration and their balancing in the electricity system. The pioneering phase of "install and forget," was mostly focused on capacity growth and kWh-generation, with limited orientation to consumer demand. During that phase, renewable electricity was easy to integrate because it was a minor share of total production. We have now reached the phase of "responsibility," which requires economic efficiency to integrate the growing share of renewable electricity into the energy system. The situation is not homogeneous in Europe. There are countries which are already integrating and balancing well significant shares of variable electricity. Robust interconnections, both internal and with neighbouring countries, are a crucial enabler to deployment. But they might not be sufficient. Additional technical and regulatory solutions are to be implemented to effectively handle increasing shares of renewable electricity [5].

A fourth element to consider is the economic break-even point for residential photovoltaic installations, which is impacting directly on current reflections concerning the feed-in tariff schemes. The price parity of solar with the retail price of electricity is diverse, in accordance with the heterogeneity of the European electricity market and the quality of the solar resource [6]. The so called grid parity for photovoltaics - defined as the moment when PV LCOE becomes competitive with retail electricity prices - has likely been reached in several countries, including a relevant portion of Italy, Spain, and Southern France. This fact does not mean that photovoltaics does not need policy measures anymore. On the contrary, policy measures are still needed to reduce administrative barriers and improve regulatory mechanisms in order to allow PV self-consumers to feed their excess generation into the grid in exchange for compensation (either monetary compensation or energy compensation). In a nutshell, wherever grid parity is an economic reality, policy measures should create the proper frameworks to adapt the energy system to the increasing importance of distributed generation. Nonetheless, it is worth recalling that grid parity remains overall a quite ephemeral point to catch. As is well known, LCOE is calculated with simple equations, requiring some data (capital and O&M cost, solar resource, etc.) and some assumptions (economic lifetime of the installation, interest rate during the lifetime, etc.). Assumptions can substantially affect the results of the calculations. Additional uncertainties come from the retail electricity prices. In some cases, retail electricity prices are kept artificially low; while real generation costs are higher (several European islands provide examples of this). In summary, while grid parity is an appealing concept for studies and for making quite attractive graphs, it is difficult to handle from policymakers' and regulators' points of view.

RESEARCH AND DEMONSTRATION PROGRAMME

The 7th Framework Programme

The EU's 7th Framework Programme for Research, FP7 (2007-2013), received a higher budget than the previous programme, and has run for seven years. Calls for proposals based on topics identified in the work programme have been published on an annual basis. Seven calls for proposals have been published in the years from 2007 to 2013, including the last call in 2013. Material development for wafer-based silicon devices, photovoltaics based on solar concentration, and manufacturing process development have attracted relevant European funding. Significant funding has also been made available for thin-film technology and for the development and demonstration of new concepts and new approaches for building construction elements based on photovoltaic (Figure 2).

The photovoltaic projects granted under the calls from 2007 to 2012 have been described previously [7]. The FP7 2013 calls for proposals have been published on 10 July 2012, addressing three main PV topics: 1. *High efficiency c-Si photovoltaics modules* (call: FP7-ENERGY-2013-1; topic ENERGY.2013.2.1.1 - deadline: 28/11/2012), 2. *Support to key activities of the European Photovoltaics Technology Platform (PV TP)* (call: FP7-ENERGY-2013-IRP; topic ENERGY.2013.2.1.2 - deadline: 08/01/2013), and 3. *Integrated research programme in the field of photovoltaics* (call: FP7-ENERGY-2013-IRP; topic ENERGY.2013.10.1.5 - deadline: 08/01/2013).

Topic 1 has resulted in the funding of one project, HERCULES, which will receive an EU contribution of 7,0 MEUR. HERCULES already started, will develop innovative n-type monocrystalline-Si device structures based on back-contacting and formation of alternative junctions, as well as related structures including hybrid concepts (homo-heterojunction). Under Topic 2, the project *PV TP SEC III* has been granted an EU contribution of about 490 000 EUR. The main objective of *PV TP SEC III* is to ensure that – through the promotion of cooperation among all the relevant actors in the PV sector - in the upcoming decisive years the PV TP will still be a point of reference for the state-of-the-art of PV in Europe and worldwide, and will still be able to provide the sector with valuable reference documents. Finally, another project (CHEETAH) has been granted under the topic on the Integrated Research Programme, with an EU contribution of about 10,0 MEUR. Within CHEETAH, all the members of the Joint Programme on PV of the European Energy Research Alliance (EERA) will focus on solving specific bottlenecks in the implementation of developed technologies in the European PV industry.

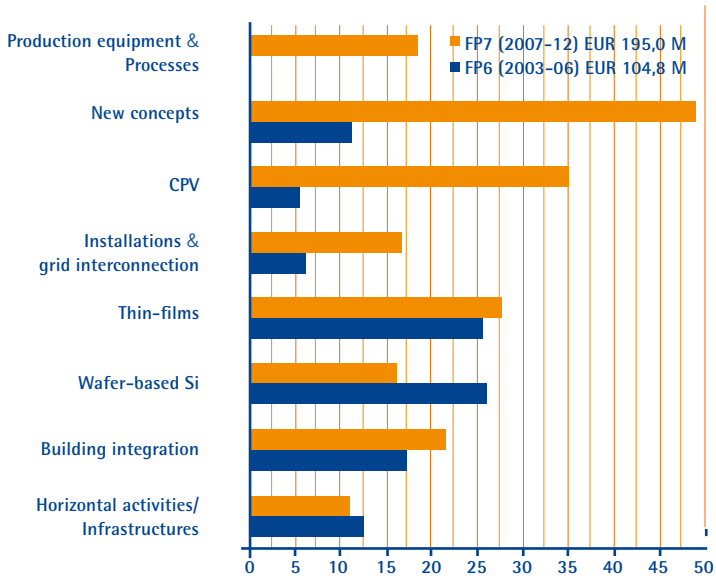


Fig. 2 - Comparison of the investments in photovoltaics made under FP6 and FP7 in the period 2003-2012 (Euro Million).

INTELLIGENT ENERGY – EUROPE

The Intelligent Energy – Europe (IEE) programme supports collaborative projects in which EU organizations from at least three differentcountries cooperate with the aim to reduce non-technological market barriers in the fields of renewables and energy efficiency. IEE projects are selected to contribute to the implementation and further development of EU policies and legal frameworks, by helping to create more favourable market conditions for renewable energy technologies, including PV. The first IEE programme ran from 2003 to 2006 and the second IEE programme (2007-2013), which had a budget of 730 MEUR, has now launched its last call for proposals, but valuable project results will continue to be produced for at least another three years (until 2016). For the future, it is anticipated that such "market uptake" projects will be supported by the Horizon 2020 programme.

A series of PV projects has been funded since the beginning of the IEE programme, and an overview of several recent projects was given in 2012 [9]. Details of all projects supported by IEE can be found in the IEE project database http://www.eaci-projects.eu/iee/page/Page.jsp.

The IEE programme has also supported projects on capacity building, training and certification of installers of small scale RES systems, including PV [9]. These projects have provided valuable inputs to the EU Member State authorities, helping them to meet their obligations under the Renewable Energy Directive (Art 14). These projects have also provided inputs to the IEE initiative *BUILD UP Skills* (www.buildupskills.eu), which supports the training and qualification of craftsmen, on-site construction workers and systems installers for sustainable energy solutions in buildings. Under this initiative, all EU Member States are developing national roadmaps for training and qualifying their craftsmen on high energy performance solutions for the building sector, including the installation of renewable energy systems such as PV.

Since 2010, IEE has provided "project development assistance" (PDA) funding to local and regional public authorities in order to help them to develop into "bankable" projects the investments which they have foreseen and adopted in their sustainable energy action plans. Such PDA funding was provided initially through the ELENA (European Local ENergy Assistance) initiative of the European Investment Bank (EIB). However, since 2011, a similar initiative MLEI (Mobilising Local Energy Investments) has been launched within each annual IEE Call.

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

Horizon 2020 is the new framework programme for research and innovation for the 2014-2020 period. The financial envelope for the implementation of Horizon 2020 is set at about 77 BEUR in current prices [8]. Horizon 2020 is structured along three strategic objectives: 'Excellent science', 'Industrial leadership', and 'Societal challenges'. With a budget of about 24 BEUR, the first objective - 'Excellent science' - includes funding for the European Research Council (ERC) and the Marie Curie Actions, investments in Future and Emerging

Technologies (FET), as well as support for the access to and networking of priority research infrastructures across Europe. With a budget of about 17 BEUR, the second objective - 'Industrial leadership' - is intended to help make Europe a more attractive location to invest in research and innovation. It includes major investments in key industrial technologies such as Information and Communication Technologies (ICT), nanotechnologies, biotechnology, and space. This objective will also provide EU-wide support for innovation in SMEs with high growth potential. Finally, with a budget of about 30 BEUR, the third objective - 'Societal challenges' - focuses on six key areas for the lives of European citizens: health, demographic change and well-being; food security, sustainable agriculture, marine and maritime research, and the bio-based economy; secure, clean and efficient energy; smart, green and integrated transport; climate action, resource efficiency and raw materials; inclusive, innovative and secure societies. The specific objective of the "secure, clean and efficient energy" challenge, with an allocation of about 5,9 BEUR, is to make the transition to a reliable, affordable, publicly accepted, sustainable and competitive energy system, aiming at reducing fossil fuel dependency in the face of increasingly scarce resources, increasing energy needs and climate change. Along these lines, Horizon 2020 continues the EU support for the development of efficient, reliable and cost-competitive solar energy systems, emphasizing the challenge for their integration in the electricity system.

EUROPEAN SOLAR INDUSTRY INITIATIVE OF THE SET-PLAN

The Solar European Industrial Initiative (SEII) of the Strategic Energy Technology Plan (SET Plan) continues to work on the main priorities in the PV and concentrating solar power (CSP) fields.

The ERA-NET action called SOLAR-ERA.NET (www.solar-era.net) was launched. The first set of joint calls for proposals was published, with a total public funding of 12 MEUR. Several proposals were submitted (47 in the PV field and 13 in the CSP field). The evaluation is currently in progress and the first successful projects are expected to start in early 2014.

The SEII 2013-2015 Implementation Plan for PV was finalised. It focuses on three pillars: performance enhancement and energy cost reduction (with regard to wafer silicon technologies, thin-film and emerging/novel technologies, CPV, BIPV, balance of system); quality assurance, long term reliability and sustainability; and electricity system integration (with regard to large scale deployment and solar resources and monitoring).

The Communication on Energy Technologies and Innovation adopted on 2 May 2013 called for the development of an Integrated Roadmap under the guidance of the SET Plan Steering Group [9]. The Integrated Roadmap should: (1) Address energy system and innovation chain integration, (2) consolidate the updated technology roadmaps of the SET Plan, (3) cover the entire research and innovation chain from basic research to demonstration and support for market roll-out, and (4) identify clear roles and tasks for the various stakeholders such as EERA, the European Industrial Initiatives (EIIs), the European Institute of Technology (EIT) and other relevant actors like universities, investors and financiers. The objective of the Integrated Roadmap is to prioritise the development of innovative solutions which will respond to the needs of the European energy system by 2020, 2030 and beyond.

CONCLUSIONS AND PERSPECTIVES

The increasing deployment of variable renewables in the EU results in new challenges for their integration in the electricity system. The pioneering phase of "install and forget" is over. We have now reached the phase of responsibility, requiring economic efficiency to integrate the growing share of renewable electricity into the energy market. This is important, given the expectation that renewable energies should compete on a level playing field with a phase out of subsidies as they become more competitive. With new, harmonised network codes which no longer discriminate against renewable energy, with coupled EU electricity markets, renewable energy generators should become increasingly able to bear the costs of balancing the grid -together with market costs and risks- like all other generators. Whilst some large scale PV generators in the sunniest parts of the EU are already able to do this to a significant extent, it will of course take longer in the Northern regions, and special conditions or schemes – possibly providing business opportunities for "aggregators" - may be required to encourage investments in PV systems by individual householders and "PV prosumers" for some time to come.

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EPIA

THE EUROPEAN PHOTOVOLTAIC INDUSTRY ASSOCIATION'S ACTIVITIES
FRAUKE THIES, EPIA'S POLICY DIRECTOR
IOANNIS-THOMAS THEOLOGITIS, IEA PVPS TASK 13 EXPERT, EPIA
MANOËL REKINGER, IEA PVPS TASK 14 EXPERT, EPIA

Fig. 1 - EPIA Booth at the 28th EU-PVSEC in Paris, France, October 2013.

EPIA – the European Photovoltaic Industry Association – is **the voice of the photovoltaic industry in the European PV markets**, 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, EPIA is actively engaged in:

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

PV KNOWLEDGE CENTRE

EPIA keeps its Members informed and up-to-date on the PV industry with targeted business intelligence on markets, industry and technologies. EPIA is 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
- Increasing the awareness about the quality and reliability questions
- Synthesising and publishing data in EPIA reports
- Representing and carrying EPIA messages in workshops, projects and conferences
- Representing EPIA in IEA PVPS Task 1 (markets and communication), Task 12 (sustainability), Task 13 (performance & reliability) and Task 14 (grid integration)

Fig. 2 - EPIA Quality Workshop during the Intersolar Fair 2013, Munich, June 2013.

COMMUNICATION ACTIVITIES

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

- 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's publications, which are considered vital reference tools in the photovoltaic world:
  - *Global Market Outlook for Photovoltaics* (annual publication)
  - *Connecting the Sun*: grid integration challenges and solutions
  - *Solar Photovoltaics Competing in the Energy Sector* – On the road to competitiveness
  - *PV Observatory*: Policy Recommendations
- 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 to spread the word about important initiatives and efforts to influence policymakers on PV.
- Events throughout the year, including various conferences, workshops and other knowledge-sharing events for the benefit of its Members.
  - EPIA Annual General Meeting (Members only)
  - EPIA Market Workshop (Members only)
  - Events during major fairs in Europe

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 & Communication Working Group** involves Members in EPIA policy activities on EU policy developments and related EPIA activities.
- The **Sustainable Development Working Group** gathers and communicates mostly technical knowledge on subjects related to sustainability topics.
- The **National Associations Task Force** to promote best practices for PV policies, to coordinate on policy and communications activities and to gather policy and market data.

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: Strategic PV Analysis & Outreach

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

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

EPIA co-chaired this Task until 2011, which took-off during 2008, after its launch in 2007. Today, EPIA is represented in this task by the chair of the EPIA Sustainable Development Working Group.

Task 13: Performance and Reliability of Photovoltaic Systems

EPIA has started to collaborate on Task 13 in 2013, bringing its experience in a field of expertise that has been identified as crucial for the future of the PV industry and disseminating effectively the results of the Task through its industry channels.

Task 14: High Penetration of PV Systems in Electricity Grids

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

General Support to IEA PVPS

EPIA hosted IEA PVPS at its booth during the Intersolar Europe Fair in June 2013. In addition, the "Ensuring Robust PV Market Development with Declining Financial Support: the Role of New Business Models Workshop," during the 28th EU-PVSEC in Paris, France, in September 2013 was co-organized by EPIA and IEA PVPS Task 1.

FRANCE

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

GENERAL FRAMEWORK AND IMPLEMENTATION

The development of photovoltaic applications in France has benefited from the government policy of feed-in tariffs since 2006. In 2013, the French capacity of grid-connected photovoltaic installations reached a cumulative power of 4,6 GW, close to the government's goal set for 2020 of a volume of 5,4 GW by the 2009 PPI Act. Faced with the rapid growth of the French PV sector, the government revised its promotion measures in 2010 (revision of feed-in tariffs and calls for tenders for large projects). The revision took into account both the decreasing prices of PV modules on the international market and the modest impact of the policy on French industry; it also meant to bring about a better control of the cost borne by the CSPE tax which is financed by electricity subscribers. The level of feed-in tariffs reflects the priority given to building integrated installations up to 100 kW. PV systems over 100 kW and under 12 MW are subject to calls for tender. In addition to purchase rates, individuals who install a PV roof on their main residence are eligible for a tax credit. This tax credit measure ended on 31 December 2013.

The French ministries of Ecology, Research and Economy are the main public actors of the promotion at the national level. The ministries rely on public organisations such as ADEME, ANR, Bpifrance (formerly OSEO) or CRE, the organisation in charge of PV calls for tenders, to carry out the policy. Regional councils, departmental councils and municipalities can also put forward their own support measures targeted at the types of projects that contribute to local development. In 2013, during the preparatory phase of the new Energy Transition Act the Government acknowledged the contribution of renewable energy. The law will be passed in 2014 and will determine the new attitude of government support for renewable energy. The self-consumption/self-production issue may require legislative changes. The government currently targets 5,4 GW of cumulative installed capacity by 2020. The objective of the new measures set in 2013 could reach 10 GW installed by 2020. In April 2013, ADEME recommended 16 GW. Regional Councils plan the installation of 16 GW and the industry suggests 20 GW by 2020.

Various factors, including the global oversupply of modules and the economic crisis have affected the pace of French market development: 0,8 GW grid-connected in 2011, 1,1 GW in 2012 and about 0,6 GW in 2013. During this period, the sector lost thousands of jobs, particularly in the area of small installers who saw in PV an opportunity to diversify their business. During the period 2012-2013, the restructuration of the photovoltaic cell and module industry affected the production dynamics of these basic components. On the implementation side, while major energy companies remained involved in PV projects of all power ranges new development companies were set up to respond to tenders.

NATIONAL AND REGIONAL PROGRAMMES

In early 2013, the Ministry of Ecology, Sustainable Development and Energy (MEDDE) introduced several measures to reactivate the sector affected by the economic crisis. The Ministry suggested doubling target capacity up to 1 000 MW per year (Table 1). The feed-in tariff

Fig. 1 - Grid-connected cumulative photovoltaic power in the French departments shown at the end of September 2013, 4 478 MW and 310 000 PV systems (Source: SOeS, Nov. 2013).

schedule was simplified so as to put an end to the distinction among the different building categories. T4 tariff for simplified building integration (ISB) increased by 5 % and T5 tariffs for any other application (not building integrated) decreased by 20 %. All tariffs became eligible for a bonus of up to 10 % if the PV systems using PV modules were manufactured in the European Economic Area. One should bear in mind that the quarterly decrease in tariffs is based on the number of grid-connection requests from the previous quarter. The new government measures include a 20 % cap on annual decrease in tariffs. Table 2 shows the evolution of tariffs during the year 2013. For the first time the 20 % cap reduction was achieved in the T4 category of simplified roof integration (ISB) projects in the 9 kW to 100 kW range.

In March 2013, the Ministry of Ecology through the French Commission for Energy Regulation (CRE) decided to launch a new call for tenders for PV systems with a capacity over 250 kW. The call, with a targeted volume of 400 MW, is intended to be equally shared by two types of innovative technologies: a) Ground-mounted concentrator PV power plants as well as systems with solar tracking systems and, b) mature technologies applied to car park shades and large roofs. For ground-mounted systems, the tender will focus on installations on brownfields, old quarries or landfills, etc. so as to avoid conflicts of use, particularly with farmland. The tender will value the cost-competitiveness of the projects on offer, but also their contribution to the protection of the environment and climate, as well as research, development and innovation. These criteria are intended to support the French PV sector in the context of unfair competition.

Fig. 2 – Halle Pajol, low energy building, 500 kW on a reclaimed railway facility in Paris (Photo: Jourda Architect).

Concerning medium-sized rooftop installations with a capacity of 100 kW to 250 kW, the Ministry decided to continue calling for tenders with improved conditions for a total volume of 120 MW a year, divided into three submission periods of 40 MW (October 2013, February 2014 and June 2014). Apart from the selling price of electricity, the tender will also pay particular attention to the project contribution to climate protection by integrating a carbon evaluation in the manufacturing process of the photovoltaic modules. According to the Ministry, all the new measures will generate investments of over two billion Euros and will create or maintain about 10 000 jobs. Annual cost for the community is under control and estimated between 90 MEUR and 170 MEUR, or about 1 EUR to 2 EUR per year per household.

The measures above are an emergency response to the development of the French PV sector in a country engaged in the general construction of energy transition. The national debate on energy transition in 2014 will define a new set of stable and durable measures for the development of solar and other renewable energies.

PV calls for tenders between 100 kW and 250 kW were published in October 2012 and December 2012 and led to the selection in May 2013 of 138 new projects with a total of 30 MW.

The call for tenders for PV projects over 250 kW published in March 2013 showed the keen interest of the industry in this field: The French Commission for Energy Regulation (CRE) selected 355 projects totalling 1 721 MW although final approval by the Ministry of Ecology is planned to be limited to 400 MW. Among the selected bids, 187 projects are ground-mounted tracking systems (1 236 MW), concentrator PV projects amount to around 136 MW, while traditional ground-mounted power plants reach around 94 MW. 30 projects up to 4,5 MW (67 MW) are to be installed on car parking lots. As for PV rooftop installations, 103 projects (up to 3 MW each) total 168 MW and 4 projects (from 3 MW to 12 MW) amount to 20 MW.

Several Regional councils: Aquitaine, Bourgogne, Rhône-Alpes, Poitou-Charentes, etc., have issued calls for tenders for installing self-consumption PV systems. Municipalities encourage the development of new ecological buildings. For example, the city of Paris inaugurated a noticeable low energy building on a reclaimed railway facility (18th district), 15 April 2013, which houses a youth hostel, library, theatre, and gym, etc. The 500 kW project installed under the 2012 call for tenders was allowed a feed-in tariff of 150 EUR/MWh (Figure 2).

TABLE 1 – ANNUAL TARGET PROPOSED BY THE MINISTRY OF ECOLOGY (JANUARY 2013)

POWER CATEGORY AND APPLICATION	SUPPORT MEASURE	ANNUAL TARGET (MW)
0 – 9 kW Building integration (IAB). Residential applications and small roofs	Quarterly revised feed-in tariff	200 MW
9 kW – 100 kW Simplified building integration (ISB). Roofs up to 1 000 m²	Quarterly revised feed-in tariff	200 MW
100 kW – 250 kW Roofs 1 000 m² to 2 500 m²	Calls for tenders (simplified)	120 MW
Over 250 kW Large roofs, ground-mounted installations	Calls for tenders	~ 400 MW

TABLE 2 – APPLICABLE PV FEED-IN TARIFFS AS OF Q1-2013 AND Q4-2013 (EUR/KWH)

PV SYSTEM TYPE AND TARIFF CATEGORY	PV POWER (W)	TARIFF* Q1-2013 (EUR/KWH)	TARIFF* Q4-2013 (EUR/KWH)	ANNUAL DECREASE (%)
T1 Building-integrated photovoltaic systems (IAB)	P ≤ 9 kW	0,3159	0,2910	7,9 %
T4 Simplified building-integrated systems (ISB)	P ≤ 36 kW 36 kW < P ≤ 100 kW	0,1817 0,1727	0,1454 0,1381	20 %** 20 %**
T5 Other installations	0 kW < P < 12 MW	0,0818	0,0755	7,7 %

**Tariffs increased by 5 % or 10 % for modules manufactured in the European Economic Area.*

***Cap on annual decline 20 % reached for the first time in 2013.*

RESEARCH AND DEVELOPMENT

In France, R&D activities cover the full spectrum of topics and include most of the industrial and public research laboratories working in public/private partnership.

Research topics aim at increasing conversion efficiency of components and reducing costs.
ADEME manages nine projects of the 'AMI PV' R&D programme launched at the end of 2009. Projects are in their final stage and will be assessed as of 2015. A second 'AMI PV' programme is in preparation. The AMI programmes are part of the major government initiative 'Investment for the Future' (*Investissements d'avenir*). In 2013, ADEME issued a new call for research projects, 'Optimized Integration of Renewable Energy and Demand-side Management of Electricity' (deadline for applications March 2014).

The French National Research Agency (ANR) carried on funding PV research within the 'PROGELEC 2011-2013' programme (Renewable Electricity Production and Management). Seven photovoltaic projects were selected in 2013, in addition to the ten chosen in 2011 and 2012.

The 16th call for tenders of the French Single Inter-ministerial Fund (FUI) selected a new project called I3BC2 to develop new ion implantation equipment to produce PV cells with rear side contacts.

The National Solar Energy Institute INES (CEA, CNRS, CSTB and University of Savoie) is the main solar energy organisation operating in France. Its PV R&D activity covers crystalline silicon (from feedstock to cells), organic materials, PV modules, PV components, systems, as well as storage and building applications.

The *Institut Photovoltaïque d'Île-de-France* (IPVF) was created by associating public research teams from the CNRS and École Polytechnique and industry laboratories (Total, EDF, Air Liquide, Horiba Jobin Yvon and Riber). The construction of a new building on the Research Campus of Paris-Saclay was agreed in October 2013. The partners jointly pursue R&D activities in thin film materials, processes and machinery and, develop advanced concepts for high efficiency cells and modules. Both the INES and IPVF Institutes participate in training. Other public laboratories from the CNRS, universities and engineering schools contribute to the work.

R&D is funded by national public agencies such as ADEME, ANR and Bpifrance (formerly OSEO, in charge of the Single Interministerial Fund, FUI). Regional councils can also contribute to projects.

The CNRS and the Federation of PV Research Labs (FedPV) organised the 3rd *'Journées nationales du PV'* (JNPV), from 3 to 6 December in Dourdan (91). Most of the R&D community attended the event. Round tables were webcast.

The 'Renewable Energy in the Service of Humanity' Conference, jointly organized by ADEME, CNRS and UNESCO, reactivated the universalistic ambition of the 1973 Congress. International attendance gathered on 3 October 2013 at the UNESCO headquarters in Paris; the very place where solar energy was internationally acknowledged 40 years ago.

The 28th European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC) took place in Paris/Villepinte (30 September to 4 October 2013). Parallel technical conferences such as those organised by IEA/PVPS and EPIA delivered valuable technical information.

INDUSTRY AND MARKET DEVELOPMENT

Companies work in all parts of the value chain. In 2013, contraction of the French market had a serious impact on company results.
Cell and module production capacity expansion plans were put on hold, but the concentrator photovoltaic (CPV) cells and modules sector and the solar tracker sector maintained their development. Soitec company with CEA and ISE partners published a record four-junction cell based on III-V compound semiconductors with a conversion efficiency of 44,7 % at a concentration ratio of 297 suns.

Fig. 3 – 100 kW installed on the roof of the building of the Cooperative processing and packaging sea salt in the Île-de-Ré (Photo: Solarsit).

France has two long-standing cell/module manufacturers: Photowatt (now owned by EDF ENR) manufactures ingots, wafers and cells. Its new module production facility will be operational in 2014. Tenesol/SunPower (formerly Tenesol, now owned by SunPower/Total Group) manufactures modules with high efficiency silicon cells. MPO Energy and Irysolar run crystalline silicon PV cell pilot lines. EMIX, manufactures ingots, SolarForce and S'tile prepare wafers with proprietary techniques. Altogether there are ten PV c-Si module manufacturers, serving a wide range of markets. Their annual production capacity stands at around 600 MW. Bosch Solar, a German company, decided to interrupt PV module production both in France and Germany. Thin film amorphous silicon modules are manufactured by Free Energy Europe and Solems and target small power applications. Industrial development occurs at Nexcis in thin-film CIGS materials.

MARKET DEVELOPMENT

As of the end of September 2013, the cumulative grid-connected PV power reached 4 478 MW with approximately 310 000 systems (Table 3). A volume of 420 MW was connected in the first three quarters of 2013 (statistics from SOeS, Nov. 2013) showing a drop of 59 %, compared to the same period in 2012. 70 % of the added capacity came from PV rooftop systems in the range of 36 kW to 100 kW and large PV systems over 250 kW (outcome of calls for tenders). Figure 1 gives an indication of the distribution of PV installations on French territory (as at 30 September 2013).

Industrial associations noted that the new measures introduced by the government in early 2013 had a limited effect on boosting the French PV sector.

Trade fairs such as the 'Bepositive/RE Exhibition' (Lyon, February 2013) or Energaïa (Montpellier, December 2013) were attended by fewer PV participants than in previous years, but it was generally acknowledged that business contacts were more productive.

2014 is very important for the future of PV development. PV professional associations are concerned by the preparation of the Energy Transition Act to be discussed in the first semester of 2014. Such issues as the integration of renewables into the electricity grid and the feed-in tariff measures are on the agenda. The law should be passed by the end of 2014.

TABLE 3 – GRID-CONNECTED CAPACITY AS OF 30 SEPTEMBER 2013

POWER CATEGORY	CUMULATIVE NUMBER AS OF 30 SEPT. 2013	CUMULATIVE POWER AS OF 30 SEPT. 2013 (MW)	NUMBER OF INSTALLATIONS Q1 TO Q3 2013 (THREE TRIMESTERS)	INSTALLED POWER Q1 TO Q3 2013 (THREE TRIMESTERS) (MW)
0 – 3 kW	259 743	693	14 809	42
3 kW – 9 kW	23 348	134	6 913	43
9 kW – 36 kW	14 463	355	1 218	30
36 kW – 100 kW	6 503	485	1 420	121
100 kW – 250 kW	4 956	860	39	6
> 250 kW	916	1 950	38	178
Total	**309 929**	**4 478**	**24 437**	**420**
		Estimate as at 31 December 2013: 4 600 MW		*Annual estimate for 2013: 600 MW*

Source: SOeS after ERDF, RTE, SEI and main ELD.

GERMANY

PHOTOVOLTAIC BUSINESS IN GERMANY - STATUS AND PROSPECTS

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

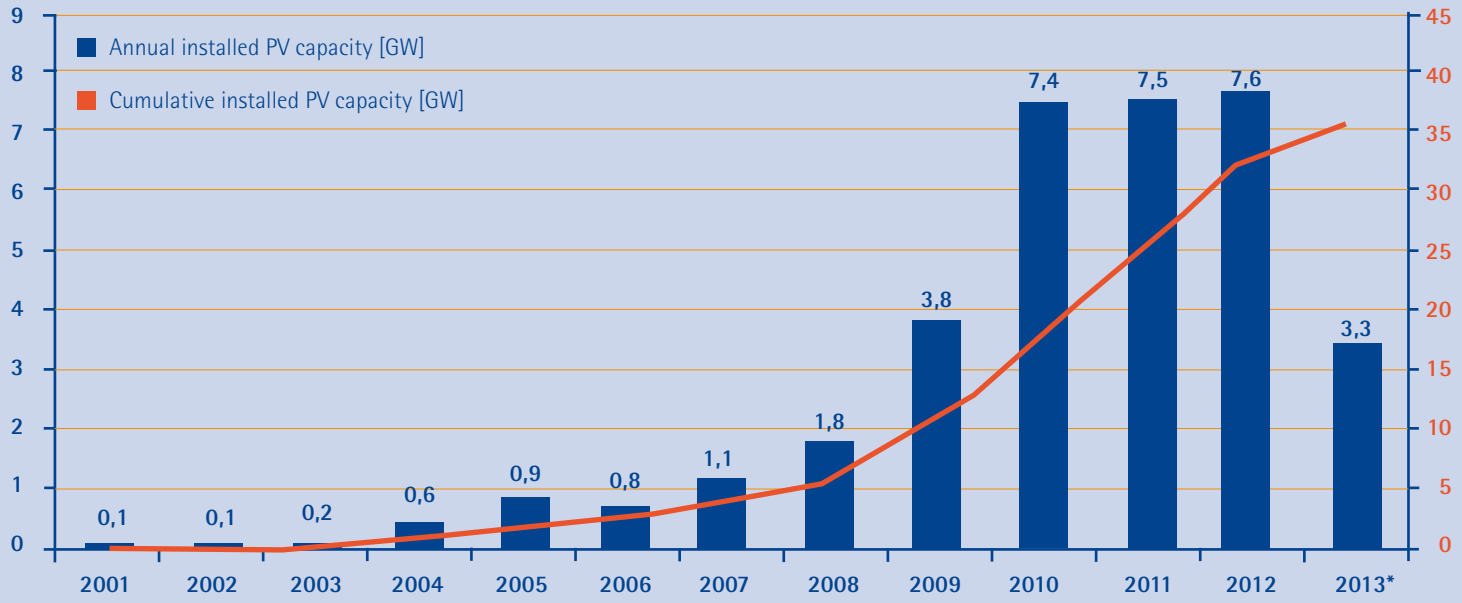

*Fig. 1 - Development of grid connected PV capacity in Germany, *first estimate as of January 2014.*

GENERAL FRAMEWORK AND IMPLEMENTATION

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

The goals are to be reached firstly by efficient energy use and secondly by the use of renewable energies. The German Energy Concept states that renewable energies will contribute the major share to the energy mix of the future. With respect to the electricity supply, the share for renewable energies has reached approx. 25 % of the gross consumption of Germany in 2013. The aim of the German Energy Concept is to reach 35 % in 2020 and 80 % in 2050.

Photovoltaic (PV) is a major part of this development driven by the Renewable Energy Sources Act (EEG) [2] on the one hand and a noticeable decrease of system prices on the other hand. A capacity of 3,3 GW PV power has been newly installed in Germany in 2013 (see Figure 1). This results into a total installed PV capacity of 35,7 GW connected to the electricity grid and puts Germany on top of the list of countries with the highest total PV installations world-wide. Subsequently, PV contributed 29,7 TWh (approx. 5 %) to the annual gross electricity generation. More than half of the increase of renewable electricity production can be allocated to PV.

The EEG accelerated the installation of grid-connected PV systems in Germany significantly. In addition, the decrease of system prices continues which makes PV systems economically more and more attractive. An analysis published by BSW-Solar, the German Solar Industry Association, shows that the average price for PV rooftop systems of less than 10 kW arrived at around 1 500 EUR/kW in the last quarter of 2013 [3]. This means, system prices have been reduced by 66 % in the last six years. The Levelized Costs of Energy (LCOE) for a small rooftop PV system in Germany are around 0,15 – 0,18 EURcents / kWh whereas the electricity price for private households is around 0,25 EURcents / kWh. Therefore, investments in PV installations are becoming attractive even without financial support by a Feed-in-Tariff.

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

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*	2014*
EURcents/ kWh	50,6	48,1	45,7	57,4	54,5	51,8	49,2	46,75	43,01	39,14	28,74	24,43	17,02	13,68

** adjusted by a flexible monthly degression rate between 1 – 2,8 % throughout the year*

Fig. 2 – 150 kWp photovoltaic system on the rooftop of the German Chancellery (Photo: BSW-Solar/Langrock).

NATIONAL PROGRAMME

In Germany, the responsibility for the renewable energies has been with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) until the end of 2013. In order to streamline the German energy policies the new federal government decided to concentrate all energy related activities within the Federal Ministry for Economic Affairs and Energy (BMWi). Up to now, the main driving force for the PV market in Germany is the Renewable Energy Sources Act (EEG 2012). 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 (FiT) for them. However, due to the successful but very fast increase in PV and wind energy generation additional amendments to the EEG are announced from the new German Government for the second half of the year 2014.
For PV, the FiT depends on the system size and whether the system is ground mounted or attached to a building. It includes a monthly adapted degression rate of the FiT, which depends on the previously installed PV capacity. This procedure tends to stimulate a yearly installation of 2,5 – 3,5 GW. Details on the development of the FiT can be found in [4]. Table 1 shows the development of the FiT for small rooftop systems (< 10 kW) since 2001 [5]. All rates are guaranteed for an operation period of 20 years. The FiT terminates at a total installed PV capacity of 52 GW. Meanwhile, the EEG contains measures for the integration of PV systems into the grid management.

In addition to the above mentioned support scheme for renewable energies, a new 25 MEUR market stimulation program has been introduced to boost the installation of local stationary storage systems in conjunction with small PV systems (< 30 kWp) [6].

RESEARCH AND DEVELOPMENT

Research and Development (R&D) is conducted under the 6th Programme on Energy Research "Research for an Environmental Friendly, Reliable and Economical Feasible Energy Supply" [7] which came into force in August 2011. Within this framework, the BMU as well as the BMBF (Federal Ministry of Education and Research) support R&D on different aspects of PV. The main parts of the programme are administrated by the Project Management Organisation (PtJ) in Jülich.

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 like Building Integrated PV (BIPV), recycling or research on the ecological impact of PV systems.

In 2013, the BMU support for R&D projects on PV amounted to about 48,7 MEUR shared by 242 projects in total. That year, 53 (2012: 85) new grants were contracted. The funding for these projects amounts to 44,6 (68,3) MEUR in total. The budget reduction is explained by the fact that the phase of granting new projects under the "Innovation Alliance PV," see below, was terminated in 2012.

Details on running R&D projects can be found in the BMU "Annual Report on Research Funding in the Renewable Energies Sector" [8] or via a web-based database of the Federal Ministries [9]. The German contributions to the PVPS Tasks 1, 9, 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 two focal points of engagement:

- A joint initiative of BMBF and industry addresses the development of organic solar cells.
- Additionally, the BMBF funds the development of the cluster "Solarvalley Mitteldeutschland" as part of the Federal High-Tech Strategy. This cluster comprises most of Germany's PV industry and received federal grants of 40 MEUR from 2009 until 2013.

Innovation Alliance PV – a Joint Initiative of BMU and BMBF

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

The approval procedure took place in 2011 and 2012. Currently 19 R&D projects are in progress. The recent outcomes of all projects have been presented at a workshop held 29th of April 2013 [10].

FuE for Photovoltaic – a Joint Initiative of BMU and BMBF

To support the momentum stimulated by the Innovation Alliance PV, a new joint initiative of BMU and BMBF has been launched in 2013. The aim of this program "FuE for Photovoltaic" is to support R&D activities especially with participation of the German PV industry in the fields of:

- economical operation of grid-connected and off-grid PV system solutions including energy management and storage systems,
- efficient and cost effective production concepts including the introduction of new materials and production monitoring systems, and
- introduction of new PV module concepts with a special focus on quality, reliability and life time.

A sum of 50 MEUR is allocated by the ministries to be increased by an equivalent sum expected as contribution from industry. The approval procedure of 10 joint projects will start in 2014.

INDUSTRY AND MARKET DEVELOPMENT

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

- 47 manufacturers of silicon, ingots, wafer, cells, and modules,
- 20 inverter manufacturers,
- 200 PV material and equipment suppliers,
- more than 50 PV research institutes,
- and additional manufacturers of balance-of-system component manufacturers.

This list shows that the German PV industry is positioned along the whole value chain. During the last years, equipment and production companies became the most experienced ones worldwide. In August 2013, a workforce of more than 87 000 people was employed in the PV industry [11].

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[3] *BSW-Solar fact sheet (in German) "Statistische Zahlen der deutschen Solarstrombranche (Photovoltaik)", December 2013, see http://www.solarwirtschaft.de/fileadmin/media/pdf/2013_2_BSW_Solar_Faktenblatt_Photovoltaik.pdf*

[4] *Feed-in Tariffs for 2014 can be found at www.bundesnetzagentur.de*

[5] *The amended Feed-in Tariff (FiT) program went into effect on April 1, 2012. For PV system installations up to 10 kW capacity, the new FiT from January 1st, 2014 will be 13,68 € ct / kWh. For roof top installations up to 40 kW capacity, the new FiT will be 12,98 € ct / kWh, up to 1 MW the FiT is 11,58 € ct / kWh and for installations up to 10 MW on roof tops or ground installed systems the FiT amounts to 9,47 € ct / kWh. No reimbursement is paid for installations greater than 10 MW. A monthly degression rate is fixed quarterly depending on the previous installation capactiy. The FiT scheme will run up to 52 GW.*

[6] *Market stimulation program for local stationary storage systems in conjunction with small PV-systems: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-%28Inlandsf%C3%B6rderung%29/PDF-Dokumente/6000002700_M_275_Speicher.pdf*

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

[8] *BMU brochure "Innovation Through Research – 2011 Annual Report on Research Funding in the Renewable Energies Sector", see http://www.erneuerbare-energien.de/fileadmin/ee-import/files/english/pdf/application/pdf/broschuere_innovation_forschung_2011_en_bf.pdf*

[9] *Research project database, see http://foerderportal.bund.de*

[10] *Program status meeting Innovation Alliance PV, 29th April 2013: http://www.innovationsallianz-photovoltaik.de/fileadmin/redakteur/pdf/Statuskolloquium_InnovationsallianzPhotovoltaik_Programm.pdf*

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

ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE
GIDEON FRIEDMANN, PH.D., TECHNOLOGIES & RENEWABLE ENERGY SECTION MANAGER
MINISTRY OF NATIONAL INFRASTRUCTURE, ENERGY & WATER RESOURCES

GENERAL FRAMEWORK

In 2009, the Israeli government set a target of 10 % Renewable Energy electricity production (of the actual supply). There is no potential for hydropower generation in Israel, whereas in most of Europe this is a significant part of the clean energy. Of this, 35 % was expected to come from PV systems. In light of the dramatic decrease in the cost of PV systems, it is now expected that a much higher percentage will come from the PV sector.

Approximately 332 MW of PV systems were installed by the end of 2013, of which 243 MW came from 9 300 small installations (e.g. private homes), and 89 MW from medium size installations. Almost 200 MW of additional medium size installations are very close to grid connection. The capacity factor in Israel for PV is considerably higher than in Europe and stands around 18 % for actual production on an annual average.

Government support is given in the form of a guaranteed Feed In Tariff (FIT) for 20 years. FITs vary by project nature, size and other parameters. FITs have decreased considerably over the last couple of years, and are expected to continue their decline. The current FIT for PV systems ranges from 0,45 to 0,7 ILS (0,13 – 0,2 USDcents). Because the FIT includes a subsidy, there are quotas (Caps) for each renewable energy category. Currently, the Ministry of infrastructure is trying to increase the quotas for PV systems, in order to achieve the goal of 10 % RE production by 2020.

GOVERNMENT POLICY CONSIDERATIONS

Review of the present policy is currently underway. It is being attempted to assign monetary value to the benefits of renewable energy. Work on this subject was also done by a special governmental committee headed by Dr. Eugene Kandel. The main benefits of PV are:

- Energy Security by Diversification. Israel is highly dependent on natural gas.
- Emissions Reduction
- Guaranteed Prices over Time

The Ministry is pressing on with the idea that when taking the above into account, PV systems are close to grid parity. However, although PV systems in the summer produce electricity when it is needed the most, this is not the case in the winter. This, and the lack of guaranteed availability, will prevent PV systems from becoming a large source of Israel's electricity production, because their value decreases with increased penetration. Only when storage becomes a practical solution will this change.

RESEARCH AND DEVELOPMENT

The Ministry of National Infrastructure, Energy and Water supports R&D under 3 main programs:

- Direct support of academic research. Support is 100 % of research that has won in the annual tender.
- Support of startup companies. Support is 62,5 % for projects with technology innovation.
- Support for Demonstration and Pilot programs. Support is 50 %. This is meant for field deployment of novel technologies. Demonstration can also be supported under a special dedicated cap for electricity production. In this case the payment is through the FIT over 20 years.

Among the current companies supported are:

- **SunBoost** is developing a low cost optical collector, a booster, for increasing the annual output of conventional ground and flat roof PV installations by 10 % to 15 %. The boosters' design overcomes challenges that prevent the use of mirrors for this task. The second picture shows light from a flashlight reflected by a prototype booster onto the wall.

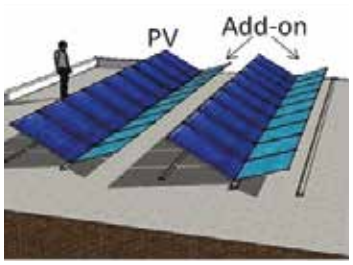

Fig. 1 – SunBoost optical collector.

Fig. 2 – SunBoost prototype booster

- **Burning Solar** is developing a single unique Carbon-based structure, which enables building a wide-spectrum multi-junction with very high conversion efficiency (goal is to reach >25 %). The raw material is inexpensive, abundant, and environmentally friendly (non-toxic). The process is based on the principles of nanotechnology and a variable carbon element structure.

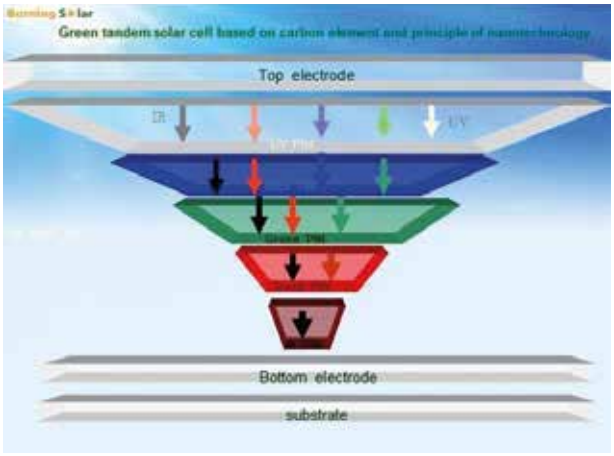

Fig. 3 – Burning Solar's green tandem solar cell based on carbon element and principle of nanotechnology.

- **Matalon Energy Sources** uses the sun energy to track the sun both as the source of energy for the device, as well as the controlling mechanism – based upon simple equilibrium of electric forces. The company is operating several grid connected facilities, with its main focus on a 300 KW field test of over 150 separate units tracking the sun.

Fig. 4 – Matalon Energy Sources suntracking systems.

- **SolarBead** developed a High Voltage DC Optimizer (DCBead), harvesting the energy from individual substrings in the PV panel and generating the high voltage required to feed a central inverter, allowing parallel connection of panels. In urban environment the DCBead produces more energy from PV panels than other power optimizers. It is also useful in case of partial shading and damage to single cells.

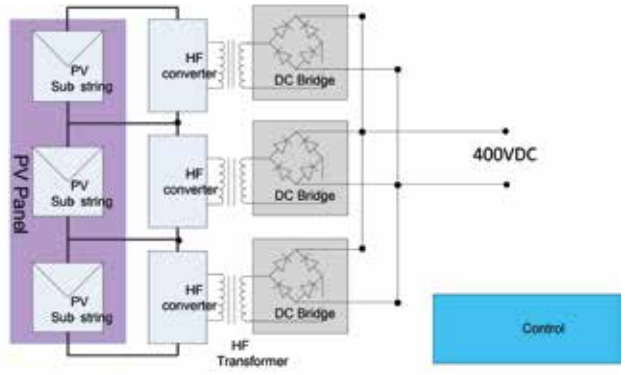

Fig. 5 – Solar Bead's High Voltage DC Optimizer (DC Bead).

ITALY

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

Fig. 1 – 1 544 kWp PV plant at Nola (NA), using General Solar Flexible Modules (thin film on flexible support) (Photo: GSE, Gestore del Sistema Elettrico).

Fig. 2 - 123 kWp PV plant at Argenta (FE), using DERBISOLAR flexible modules (thin film on flexible support) (Photo: GSE, Gestore del Sistema Elettrico).

GENERAL FRAMEWORK

2013 has been marked by the conclusion of the "Conto Energia" Programme in Italy. In fact, in June 2013 the annual budget limit for PV incentive tariffs of 6 700 MEUR per year has been reached. Accordingly, pursuant to a Governmental Decree, the Programme was officially concluded a month later, leaving just enough time to complete the PV facilities already under construction. In this situation of discontinuity and above all of uncertainty, the total power that has been installed during 2013 (1 461 MW) results significantly lower with respect to what was installed in the previous year (3 646 MW).

In particular, a preliminary evaluation of PV technology in Italy gives a cumulative installed and operating photovoltaic power of 17,6 GW and an overall photovoltaic electricity production of 22 146 GWh, corresponding to about 7 % of the national electricity consumption (317 144 GWh), with a peak of 10,7 % in September, while for few midday hours in June 2013 the power delivered by photovoltaic plants has reached the value of the national electrical load.

Taking into account all renewables, on an annual basis, the contribution of "new renewables" (solar, wind) reached 11,7 % which increases to 29,9 % when including hydroelectric, while fossil fuel generation's decline still continues.

Whereas photovoltaics in Italy is approaching competitiveness due to good radiation values and the high cost of the electricity bill, an important factor that currently hampers the further development of this technology is represented by the inadequacy of the grid in some regions of southern Italy, where the installed power of wind turbines and PV is almost the same order of magnitude as the peak load.

NATIONAL PROGRAMME

The "Conto Energia" Programme has represented, a long-standing sustained approach to stimulation of the Italian market since 2005.

The Programme has been articulated in five phases and the last one was officially concluded in June 2013 when the annual budget limit for incentive tariffs of 6 700 MEUR per year was reached.

More recently, the Italian Council of Ministers approved the decree called "Destination Italy," which contains a series of provisions that relate to the renewable energy sector. Specific measures that provide a spreading of incentives for wind and photovoltaic plants are considered. The package also includes a speech on the withdrawal of electricity and a mandate dedicated to the Authority for Electricity and Gas (AEEG) for the two-part tariff adapted to market changes that can be induced by the development of renewable energy and photovoltaics.

In particular, the new measures will allow a savings of 850 MEUR a year on the electricity bill, of which 150 MEUR will be intervention on the "dedicated withdrawal." The government did not disclose further details about how the incentives will actually be counted or how the dedicated withdrawal will be reorganized. According to these measures, it seems that the payment of incentives would be delayed from 20 to 25 years and the reduction in spending on incentives would be offset by the issuance of bonds. This new mechanism should partially displace the incentives of the first 15 years to the last 10 of 25 years (maintaining the amount of incentives not received in previous years). A series of unspecified incentives are also provided to those owners that wish to modernize their plants.

The decree, which comes into force with its publication, will now have to be converted into law by Parliament within 60 days (by the end of February 2014).

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

Fig. 3 - 12 kWp PV plant at Borgoricco (PD), using SAINT-GOBAIN SOLAR rigid modules on tiles (SI crystalline cells) (Photo: GSE, Gestore del Sistema Elettrico).

ENEA is the main PV Research organization operating in Italy. Its most significant fields of interest are: Crystalline silicon, Cu2O solar cells, microcrystalline Si devices, micromorph tandem solar cells, as well as concentrators' technologies.

RSE is carrying out activities in research and development on high efficiency single and triple junction solar cells (InGaP/InGaAs/Ge) for terrestrial and concentrator applications, within the frame of the Italian electric system research programme RdS (Ricerca di Sistema) and in the European projects "APOLLON," "SOPHIA" and "SUN on CLEAN." Furthermore, RSE is involved in components' characterization and performance evaluation of PV innovative systems, as well as in research and demonstration activities for electrification of remote communities, again within 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 17 602 MW were installed and operating in Italy at the end of 2013.

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

- BIPV 2 563 MW
- BAPV 6 548 MW
- PV (other, on ground) 8 464 MW
- CPV 27 MW

A marginal sector that continues to growth slowly is represented by PV off-grid non-domestic applications that reached about 12 MW while domestic applications since they were built in the 80s, result in being almost completely decommissioned.

INDUSTRY STATUS AND MARKET DEVELOPMENT

The production of photovoltaic cells has been drastically reduced in 2013 due to the stop to production of important national operators. The production capacity of the modules has remained stable compared to 2012, thanks to the full operation of the 3Sun company in Sicily, a joint venture between Enel Green Power and Sharp Solar and some small operators. On the whole, a total capacity production around 800 MW has been estimated.

In the field of BOS components, in Italy, 8 companies manufacture inverters for on-grid and off-grid applications. During 2013 their production capacity has been around 7 000 MW.

FUTURE OUTLOOK

Even if the national market stimulation initiative (Conto Energia Programme) was extinguished in July 2013, thus restraining the entire PV market, it is expected that in Italy PV installations will not be stopped, although they shall be considerably reduced. In fact, the Italian Government has been formally asked to insert some proposal in the new National Energetic Strategy to accompany photovoltaics towards "grid parity."

As highlighted by several PV operators, the development of PV in Italy without incentives could happen by initiatives at no cost to public finances, such as:

- Clear rules for the sale of the produced electricity;
- the simplification of the authorization process for PV installations;
- a major focus on self-consumption of produced energy though electric storage;
- fiscal bonus for PV investment costs as well as for the creation of job opportunities in PV activities.

Regarding the first point, the Italian Authority for Electricity and Gas has updated the rules for exchanging energy with the grid for relatively small plants up to 200 kW. Moreover, a consultation concerning the regulation of connection services, measurement, transmission, distribution, dispatching and sale aspects has been undergone; in the case of the private grid, both for single users and with more consumption units and industrial production units of electrical energy functional for the production process.

Besides, it is widely recognized that the simplification of the authorization process and specific measures at no cost to public finances (i.e., tax credit) accompanied by the good solar radiation values, especially in the southern region of Italy, will be able to support the achievement of grid parity. In this contest, in March 2013, the Italian Agenzia delle Entrate (Inland Revenue) has officially noted the applicability of 50 % deductions on the installation of photovoltaic plants up to 20 kW for residential applications and for energy self-consumption, up to a spending limit of 96 000 EUR for each installation.

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

JAPAN

PV TECHNOLOGY STATUS AND PROSPECTS

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

Fig. 1 - MAZDA Zoom-Zoom Stadium Hiroshima (Hiroshima City, Hiroshima Prefecture) Kyocera (mc-Si) 100 kW.

GENERAL FRAMEWORK

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

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

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

3) Enhancement of the Use of Electricity Generated from New and Renewable Energy Sources: 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 sources. The obligation amount of new and renewable energy use has been decided.

4) Fundamentals of the National Energy Strategy: Basic Energy Plan (formulated in 2010)
The above-mentioned Basic Law on Energy Policy Making aims to set a basic plan regarding energy supply and demand (Basic Energy Plan) in order to promote measures on the energy supply and demand on a long-term basis, comprehensively and systematically. The Basic Law on Energy Policy Making also requires the deliberation on the necessity to change the Basic Energy Plan every three years at minimum. Discussion to revise the current Basic Energy Plan revised in 2010 was terminated in December 2013 and the new Basic Energy Plan is scheduled to be compiled and approved in 2014. The new Basic Energy Plan to be formalized stipulates that the national government will accelerate the introduction of renewable energy as much as possible over the next 3 years and promote grid enhancement, rationalization of regulations, cost reduction and research and development of renewable energy.

5) Short- to Mid-term Strategy for PV Technology Development: "PV2030+ (Plus)" Roadmap for Technology Development of PV Systems (formulated in 2004 as PV Roadmap Toward 2030 (PV2030), reviewed and revised in 2009 as PV 2030+ (Plus)).
Goals for technology development of PV cells/ modules and systems were set from a mid-term perspective for the period up to 2025 with a longer-term perspective towards 2050.

6) Long-term Strategy for Technology Development of PV Systems: Cool Earth Energy Innovative Technology Plan (formulated in FY 2007 (March 2008))
"Innovative PV Power Generation" was selected as one of the 21 themes of innovative technology development which should be emphasized. The goal was set to increase the conversion efficiency of solar cells from the current levels of 10 ~ 15 % to over 40 % and to reduce the cost of PV power generation from the current level of 46 JPY/kWh to 7 JPY/kWh.

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

8) Obligation to Purchase Surplus Electricity Generated by PV Systems: "Act on the Promotion of the Use of Non-fossil Energy Sources and Effective Use of Fossil Energy Source Materials by Energy Suppliers" (enacted in 2009, effective until June 2012)
The basic purchase price of surplus electricity generated by PV systems for FY 2009 and FY 2010 was set at 48 JPY/kWh. The figure for FY 2011 and FY 2012 was reviewed and reduced to 42 JPY/kWh. From July 2012, the program is replaced by the Feed-in Tariff (FIT) program under the Renewable Energy Law.

9) Obligations to Purchase the Electricity Generated by Renewable Energy at Fixed Rates for the Feed-in Tariff (FIT) Program: Renewable Energy Law (enacted in 2011)
The FIT program took effect on July 1, 2012. (Details of the FIT program are described in the National Program section below).

10) Electricity Market Reform: The Policy on Electricity System Reform (approved by the Cabinet on April 2, 2013)
The national government decided to proceed with electricity market reform to achieve: i) Securing the stable supply of electricity; ii) suppressing electricity rates to the maximum extent possible and iii) expanding choices for consumers and business opportunities based on three pillars: i) Extension of cross regional coordination of transmission operators; ii) full competition in retail and power generation and iii) establishment of the neutrality by unbundling of transmission/ distribution sectors.

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

2013 was the second year since the initiation of the FIT program started in July 2012 and the 2013 Japanese PV market achieved significant growth from 1,7 GW level in the previous year to 6,9 GW level. The Japanese PV market formerly led by residential PV applications shifted to the balanced market structure with the growth of non-residential sectors consisting of PV applications for public, commercial and industrial facilities, as well as utility-scale applications by the FIT program that is supposed to bring promising prospect for stable growth.

Thanks to the formation of several core market segments without dependence on the residential PV market, Japan's PV industry now covers service and business sectors utilizing PV power generation or offering installation and integration in addition to manufacturing sectors mainly producing PV cell/modules, as well as an industrial framework for full-fledged dissemination of PV power generation which has been established rapidly. Especially business activities of PV power producers aiming at selling the PV power under the FIT program are outstanding and the dissemination framework in Japan drastically changed from the one the suppliers drive to the one PV power producers drive. This shift of the leading sector PV power generation dissemination, from the efforts of suppliers to the business of PV power producers created opportunities for new business, research, development and a virtuous cycle of PV dissemination is expected.

Demand growth of PV systems in Japan resulted in the significant change of PV module manufacturers business strategies in Japan and their production framework shifted to target the domestic market, reduced exports and increased the imported amount of PV modules produced in the overseas production bases formerly targeting overseas countries. In addition to these trends, Japanese PV manufacturers started and increased the PV modules procurement from overseas manufacturers. Overseas PV modules and inverters manufacturers are entering into the Japanese market where significant growth is expected, one after another, in order to break dependence on the stagnant European PV market.

In the PV industry's downstream service sector, companies from a wide variety of industries are actively entering the PV market as EPCs and power producers to sell electricity. The downstream PV sector can be divided into two: i) EPC sector which covers from designing to construction of PV systems; and ii) power sales sector which sells electricity generated by PV systems. A lot of PV manufacturers, inverter manufacturers, heavy electric machinery manufacturers, electrical equipment and construction companies are entering the EPC sector. Since there is a wide range of grid connections from low-voltage grid connection to extra high-voltage grid connection, various companies from small and local companies to large companies are entering this sector across the nation.

As for power producers selling electricity, they can be divided into two: i) Pure-play power producers who are dedicated to power generation; and ii) companies who install PV systems on their own land or on rooftops of factories and offices in order to gain income from selling power, in addition to their own line of business. Depending on the size of installation spaces, the power generation capacity widely varies from the 10-kW level to 100-MW level. Specifically, companies from the real estate industry, warehouse/ transportation/ logistics industry, railway industry, trading companies, supermarkets and convenience stores, large-scale retailers, communications companies, as well as gas and oil companies, are actively entering the PV power sales business.

Fig. 2 - Yamada Expressway Service Area (rest area), West Nippon Expressway (NEXCO-West) (Asakura City, Fukuoka Prefecture) Mitsubishi Electric(mc-Si) 1 MW.

As mentioned above, the PV industry is expected to evolve itself into a new industry that plays a part of the energy industry via enhancement and advancement of its players consisting of manufacturing sectors and downstream service sectors; following the reduction of PV system price and stabilization of the domestic PV market driven by the further dissemination of the PV power generation.

NATIONAL PROGRAM

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

METI is taking initiative in supporting dissemination of PV systems for residential and public/ industrial applications including utility-scale PV power applications by support measures including the following:

1) Subsidy for supporting introduction of residential PV systems (budget: 119,4 B JPY for multiple-years from FY 2011 to FY 2013)

METI implements subsidy programs for the individuals and companies who install residential PV systems. The amount of subsidy for the FY 2013 was 20 000 JPY/kW or 15 000 JPY/kW. The PV systems with the price between over 20 000 JPY/kW and 410 000 JPY/kW are eligible for 20 000 JPY/kW subsidy for the maximum output capacity of PV modules by kW. PV systems with the price between over 410 000 JPY/kW and 500 000 JPY/kW are eligible for 15 000 JPY/kW subsidy for the maximum output capacity of PV modules by kW. There are requirements for PV systems eligible for the subsidy, such that maximum output capacity of a PV system must be less than 10 kW and that the PV module conversion efficiency must be above a certain level. In FY 2013, a total of 172 640 PV systems were approved to receive the subsidy in the period between April and September 2013. The average installed capacity and the average price of these PV systems were 4.56 kW/system and 425 000 JPY/kW, respectively. For supporting the introduction of residential PV systems, the "Subsidy for Project to Form a Fund to Support the Introduction of Residential PV Systems as Restoration Measures," which was formed as a fund in FY 2011, was terminated by the end of FY 2013. Accordingly, there will be no subsidy for residential PV systems afterwards. The only support program for residential PV systems in FY 2014 onwards is the Feed-in Tariff (FIT) program.

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

One and a half years have passed since the FIT program for renewable energy power generation facilities took effect on July 1, 2012. In FY 2013, the tariffs were set lower than those of FY 2012. The tariffs and periods of purchase are set as follows: i) 37,8 JPY/kWh (incl. tax) for PV systems with the capacity of 10 kW or more for the period of 20 years; and ii) 38 JPY/kWh (incl. tax) for PV systems with the capacity below 10 kW for the period of 10 years. The tariffs are reviewed every year. The purchase costs are evenly shared by all the electricity users. However, some entities who consume extraordinarily large amounts of electricity, such as companies engaged in manufacturing, are exempt from this cost sharing.

Under the FIT program, as of November 30, 2013, total capacity of approved PV systems with the capacity below 10 kW, between 10 kW and below 1 MW and 1 MW or above are 2 155 MW, 9 524 MW and 14 546 MW, respectively, amounting to 26 226 MW in total.

Since it takes time for large-scale PV systems to start operation after they are approved, only 6 258 MW of PV systems started operation as of the end of November 30, 2013.

3) Subsidy for introducing renewable energy power generation systems as part of restoration measures (budget: 31,6 BJPY, multi-years from FY 2011 to FY 2015)

In order to create employment in the renewable energy industry and stimulate its related industries in the areas damaged by the Great East Japan Earthquake, subsidy has been provided for introducing renewable energy power generation facilities such as PV systems in the disaster-stricken areas. For PV systems, either 10 % or less of the eligible cost or 80 000 JPY/kW, whichever is lower, is subsidized. The upper limit of the subsidy is 500 MJPY per year or maximum 1 BJPY per system for multiple years. To be eligible for the subsidy, it is required that the system should have the output capacity of not less than 10 kW, or have the combined output capacity of not less than 10 kW of plural systems installed at more than one sites (the average output capacity per site must be 4 kW or larger). In FY 2011, 70 PV systems with a total output of approximately 140 MW were selected whereas 665 PV systems with a total output of approximately 880 MW were selected in FY 2012.

(2) The Ministry of the Environment (MoE)

In FY 2013, MoE largely increased the budget for the "Green New Deal Fund," a fund established in FY 2012 to promote introduction of renewable energy in local communities to 24,5 BJPY from 12,1 BJPY in FY 2012. For the "Project for Developing Technology to Prevent Global Warming (competitive funds)" and the "Project for Development and Demonstration of Technologies to Enhance Measures to Reduce CO_2 Emissions," 7,4 BJPY was appropriated in the FY 2013 budget to support private companies, public research institutes and universities which conduct technology development and demonstrative researches on low carbon transportation and low carbon houses and offices utilizing new and renewable energy including PV. In FY 2013, projects for development and demonstrative researches on PV-integrated building materials, etc. were selected to receive the subsidy. "Eco Lease Business Promotion Project for Households and Businesses," which subsidizes leasing interest payments to low-carbon equipment, has also been continued. In FY 2013, the "Demonstration Model Project to Control Storage Batteries for the Introduction of Renewable Energy," the "Survey Project to Improve Electric Grids to Expand the Introduction of Renewable Energy" and the "Fund to Support Establishment of Social System to Improve the Value of Low Carbon" were established as new projects. Furthermore, the "Project to Establish a Fund to Promote Investment in Low-carbon in Local Communities" has also started, which is designed to invest in and support interest payment for low-carbon projects in local communities through the establishment of a fund. MoE selected a 2-MW PV project, etc., as the first project to invest in.

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

MLIT has been promoting PV systems installation in green government buildings for central ministries and agencies, as well as their related facilities, in local areas equipped with PV systems and other new and renewable energy systems. For the private sector, MLIT invited proposals for projects which aim to reduce CO_2 emissions at houses and buildings such as office buildings, in the urban environment and the transport sector, and also implemented a subsidy program to aid a fixed amount or a part of the maintenance cost. Furthermore, MLIT supports the efforts to realize zero-energy homes by upgrading the energy-saving performance of the building frame and equipment of the houses or by utilizing renewable energy systems.

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

MAFF implements a subsidy program to install PV systems at facilities for agriculture, forestry and fisheries, in order to promote introduction of renewable energy into these industries. MAFF implemented a project to comprehensively promote renewable energy for the revitalization of agricultural, forestry and fishing villages. Through this project, MAFF is supporting efforts to promote/ support commercialization of renewable energy by private organizations and local public organizations. In FY 2013, MAFF selected approximately 30 projects to provide the subsidy. Also in 2013, MAFF decided to permit the installation of PV systems on farmland, which makes it possible to continue farming by setting up poles to install the PV systems, for the limited period of three years. These installations are called "Solar Sharing."

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

MEXT continued the "Super Eco School Demonstration Project" which was initiated in FY 2012 to promote the realization of zero energy at public school facilities. This demonstration project subsidizes 50 % of the renovation cost for introducing renewable energy power generation systems such as PV systems for the project period of three years. In addition to three municipalities selected in FY 2012, two municipalities, Moriyama City of Shiga Prefecture and Shizukuishi Town of Iwate Prefecture were selected in FY 2013. MEXT also provides subsidy for the installation of PV systems through the Eco School Pilot Model Project, improvement of functions of public school facilities, as well as the renovation work of both interior and exterior of schools in order to build environmentally-friendly facilities in private schools. For public schools, MEXT provides subsidy (50 % subsidy) to install PV systems and storage batteries. It is expected that 19,7 % of public school facilities nationwide had PV systems installed in FY 2013.

(6) Local governments and municipalities

In addition to the national support measures, efforts by local governments and municipalities play an important role for supporting the dissemination of PV systems. In 2013, 1 267 out of approximately 1 740 local governments and municipalities were offering subsidy programs for the installation of residential PV systems. Most of the programs provide subsidy ranging from 10 000 JPY/kW to 50 000 JPY/kW. There are some local governments such as Tokyo Metropolitan Government (TMG) which require PV systems to be installed together with Home Energy Management Systems (HEMS). For the installation of industrial PV systems, some local governments offer subsidy programs or loan programs at preferential interest rates.

R&D, D

New Energy and Industrial Technology Development Organization (NEDO) continued R&D Projects known as, "R&D for High Performance PV Generation System for the Future," "R&D on Innovative Solar Cells" and "Development of Organic Photovoltaics toward a Low-Carbon Society" under the FIRST Program (Funding Program for World Leading Innovative R&D on Science and Technology) in 2013.

Under the "R&D for High Performance PV Generation System for the Future," following the results of interim evaluation of the program conducted in 2012, a project on silicon feedstock manufacturing was finished and 4 new projects including development of the CZTS solar cell were started in 2013, in addition to the existing research projects on crystalline silicon solar cells, thin film silicon solar cells, CIS and other polycrystalline compound semiconductor solar cells, dye sensitized solar cells (DSCs) and organic solar cells (OPV). These projects are conducted by consortiums with industry-academia partnership.

Under the "R&D on Innovative Solar Cells" that will be finished in March 2015, 4 research projects continued in 2013: i) Post-silicon solar cells for ultra-high efficiencies (multi-junction solar cells); ii) novel thin film multi-junction solar cells with a highly-ordered structure;

and iii) thin-film full spectrum solar cells with low concentration ratios and iv) high-efficiency concentrating solar cells, a joint research of European Union (EU) and Japan.

As for organic PV (OPV) technology, the project known as, "Development of Organic Photovoltaics toward a Low-Carbon Society (FIRST Program)," led by the University of Tokyo, has been continued.

Most of research programs will be finished at the end of FY 2014 (March 2015) and NEDO has started planning of R&D programs for the next phase, starting in FY 2015.

Meanwhile, the following two fundamental R&D programs by Japan Science and Technology Agency (JST) under the Ministry of Education, Culture, Sports, Science and Technology (MEXT) have been continued: i) Photoenergy Conversion Systems and Materials for the Next Generation Solar Cells and ii) Creative Research for Clean Energy Generation Using Solar Energy. In addition to these projects, as a part of efforts under "Advanced Low Carbon Technology Research and Development Program (ALCA Program)," fundamental research projects aiming at developing solar cells with significantly higher conversion efficiency in comparison to existing technologies or achieving lower cost were conducted mainly by universities. In the area of "Solar Cell and Solar Energy Systems," a total of 18 projects including 5 new projects started in 2013 are underway. MEXT also promotes "FUTURE-PV Innovation Projects" through JST; aiming at highly efficient silicon nano-wire solar cells. This is led by Tokyo Institute of Technology (TIT) as one of the efforts under the 2012 "Program to Establish an Innovative Energy Research Center." Research activities under the projects will be conducted at Fukushima Renewable Energy Institute (described below) from April 2014 and the start of full-fledged research works are expected.

In October 2013, the National Institute of Advanced Industrial Science and Technology (AIST) established a new research center, "Fukushima Renewable Energy Institute" that AIST made efforts for its preparation in Koriyama City, Fukushima Prefecture. In the institute, projects of research and development of renewable energy technologies and their applications such as PV power generation and hydrogen energy will be conducted. In the area of PV power generation, technological development of crystalline silicon solar cells and demonstration of PV systems are promoted. The construction of the buildings was expected to be completed end 2013 and full-scale activities will be started in April 2014, after the relocation of equipment from AIST Tsukuba Center is finished.

While most demonstration activities on practical application of PV power generation are conducted in several demonstration projects aiming at realizing smart communities, NEDO is implementing 2 demonstration projects on the practical application of developed technologies and application technologies of PV systems.

Under "Leading Technological Development for Commercialization of Organic PV," started in FY 2012, NEDO selected 6 projects in FY 2012 and 3 projects in FY 2013 for pilot production and demonstration of DSCs and OPVs, in order to demonstrate those solar cells in the real environment and identify issues.

In FY 2013, NEDO started a new 3-year demonstration project, "Demonstration Project for Diversifying PV Application," in order to extend the application area of PV systems. 12 projects were selected to demonstrate installation technologies for agricultural lands, tilted slopes, water surface and power generation efficiencies, as well as BIPV technologies in November 2013. In addition to these, METI implemented the "Demonstration Project on Developing Power Output Forecasting Technology of PV Power Generation" as one of the measures to enhance power system infrastructure for the use of PV power generation.

Furthermore, demonstration projects on smart communities were also implemented in Japan and overseas while PV systems were installed in the projects in a large volume. These projects are for the purpose of developing localized technologies to correspond to the specific needs in diversified countries and regions in consideration of global business developments. Demonstration projects implemented in FY 2013 are listed below.

- Demonstration of Next-generation Energy and Social Systems (FY 2010 ~ FY 2014): Yokohama City of Kanagawa Prefecture, Toyota City of Aichi Prefecture, Keihannna Science City of Kyoto Prefecture and Kitakyushu City of Fukuoka Prefecture;
- Demonstration Tests of Next-generation Energy Technologies (FY 2011 ~ FY 2014): Smart Campus of Mie University in Mie Prefecture, *Huis Ten Bosch* (amusement park) in Sasebo City of Nagasaki Prefecture, Project to make use of regional resources in Minamata City of Kumamoto Prefecture, Wakaba Daiko Smart Grid Town in Tottori City of Tottori Prefecture, Ocean front smart community in Fukuyama City of Hiroshima Prefecture and Kashiwanoha Campus of the University of Tokyo in Kashiwa City of Chiba Prefecture, Smart City in Hitachi City of Ibaraki Prefecture;
- Japan-U.S. Smart Grid Collaborative Demonstration Project (FY 2010 ~ FY 2013): New Mexico, USA;
- Japan-U.S. Collaborative Demonstration Project for World-leading Remote Island Smart Grid (FY 2011 ~ FY 2014): Maui Island, Hawaii, USA;
- Smart Community Demonstration Project (FY 2011 ~ FY 2015): Lyon, France;
- The Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies (FY 2012 ~ FY 2014): India;
- Smart Community Demonstration Project (FY 2011 ~ FY 2013): Gongqing City, Jiangxi Province, China;
- Smart Grid-related Technology Demonstration Project (FY 2011 ~ FY 2016): Malaga, Spain;
- Smart Community Demonstration Project in an industrial park (FY 2012 ~ FY 2015): Java Island, Indonesia;
- Smart Community Demonstration Project (FY 2013 ~ FY 2015): Manchester, UK.

INDUSTRY STATUS AND MARKET DEVELOPMENT

The annual PV installed capacity in Japan in 2013 was expected to attain approximately 6,9 GW, achieving a significant growth from 1,7 GW in 2012, whereas cumulative installed capacity at the end of 2013 was expected to reach around 13 GW. The installed capacity increased in 2013 in Japan, thanks to a steady growth of the residential PV market and a rapid increase in the non-residential PV market for public, industrial and utility applications supported by the FIT program.

In 2013, with the FIT program getting on the right track in addition to subsidy programs for residential PV systems, a wide variety of PV systems were installed in the Japanese PV market with the capacity ranging from small-scale residential PV systems to non-residential PV systems over 10 kW as well as MW-scale PV projects with the size of several megawatts to several dozens of megawatts. This is contributing to improving the industrial structure along with the changes in the dissemination structure. A diversity of companies entered the PV market. House manufacturers, distributors and installers are installing 10 to 50 kW PV systems to be connected to low-voltage electric grids, while EPCs, heavy electric machinery manufacturers, trading companies, integrators and financial businesses are conducting large-scale PV project development. In parallel, under the circumstances where more overseas companies are entering the Japanese market and prices of PV systems are dropping, companies are making efforts to reduce costs. Some companies are reviewing their PV business strategies including business reorganization or even withdrawal.

Meanwhile, Japanese PV manufacturers took significant advantage of the FIT program and experienced exponential growth in their PV shipment and sales. Still, they are not able to meet the strong demand. Accordingly, some overseas manufacturers achieved PV shipment of several hundreds of megawatts of PV cells and modules. In the Japanese market, imported PV modules accounted for 68 % of domestic shipment in the third quarter of 2013. New entries from Asian countries increased. Through business partnerships with Japanese companies, they provide a wide variety of products both for residential and non-residential PV applications. Some non-Japanese companies are focusing not only on the sale of products but also on business expansion across the PV value chain including the power generation business.

Meanwhile, Japanese PV manufacturers have advanced technology and product development and started launching new products with high added values. There are high expectations for the next-generation PV products in the near future.

On the other hand, some manufacturers closed their unprofitable factories home and abroad while others are enhancing OEM-based procurement of PV cells and modules. Thus, each company is taking measures to strengthen their PV business. Sharp has emphasized making proposals for high value-added products through promotion of high efficiency PV product development and enhancement of quality criteria. Sharp is also promoting business reorganization including downsizing of overseas operations while enhancing the power generation business with MW-scale PV projects. Kyocera, aiming to achieve production of over 1 GW per fiscal year, has been enhancing smart house-related products including HEMS and storage batteries, as well as strengthening the industrial PV system business for supplying high output PV modules. Panasonic established its Malaysia factory and started shipment of HIT PV modules whereas they decided to close a factory in Europe and to withdraw from raw materials business in the USA. Mitsubishi Electric launched new PV modules solely with single-crystalline silicon solar cells as well as new inverters, while focusing on the smart grid business. Solar Frontier established a joint venture to develop large-scale PV power plants, aiming to achieve 900 MW of production per fiscal year with the resumption of operations of a factory after temporary suspension of production. They also announced a plan to build a new factory in Miyagi Prefecture. On the other hand, Honda Soltec decided to withdraw from the CIGS PV business. Toshiba is strengthening the residential PV system business through launching building-integrated PV modules, while focusing on cultivating the MW-scale PV market in partnership with overseas companies.

In the area of silicon feedstock, a number of companies have continued restructuring of their business affected by dropping prices of PV cells and modules. However, a new phase of activities was also started such as partial start of operation in a Malaysian factory by Tokuyama.

In the area of PV components, many companies restructured their business by consolidating their factories home and abroad and shifting production. Meanwhile, proposals for new materials such as electrode paste, resin and glass are increasing thanks to the efforts for long-term reliability. Since the demand is growing in the market, components for the downstream PV sector including cables and power electronics materials are going well.

In the area of PV manufacturing equipment and measurement equipment, new products have been proposed to support improvement of performances of PV cells and modules. However, some companies are forced to reconstruct their business structure or to shift to a new area of business. As a whole, this area has been in a difficult situation.

In the area of BOS devices, companies in various industries are expanding their business thanks to a rapid growth of the Japanese PV market. The product lineup of inverters has expanded for both low-voltage and high-voltage applications in addition to residential applications. Under the brisk market conditions, overseas manufacturers have been entering the Japanese market one after another. Manufacturers of mounting structures are enhancing production, including production of steel. Manufacturers of concrete, aluminum and wood are also enhancing production. Also, proposals for structures to achieve low-cost installation and for assembly methods are on the rise. With the trend of promoting zero-energy buildings, manufacturers

Fig. 3 - Fujipream's Experiment Famland (Himeji City, Hyogo Prefecture) Tracking PV Systems: 30 kW, Greenhouse: 20 kW Fujipream (mc-Si).

of storage batteries are developing and launching new products. Moreover, companies engaged in connection boxes, cubicles, boosters, performance evaluation, operation and maintenance (O&M) and their related businesses are growing in full swing.

The PV utilization sector has been very active in business expansion. Announcements have been made on the start of operation of large-scale PV systems across the nation. Installation of residential PV systems experienced a slowed growth, losing momentum compared to that in the previous year. In FY 2013, the number of applications for subsidy was around 19 200 per month on the average. This is assumed to be attributable to the factors mentioned, including the fact that distributors are focusing on sales and installation of non-residential PV systems. Still, movement toward installing PV systems in houses as standard equipment remains strong, as part of achieving zero-energy houses and life cycle carbon minus (LCCM) houses. Thanks partly to the efforts by local governments, the roof leasing business has been gradually expanding, as well.

The EPC and PV system integration businesses are growing by emphasizing installation of non-residential PV systems including MW-scale PV projects. Some of them are dedicated to this line of business. Also, a variety of new PV-related businesses have emerged: services to visualize power generation status in response to the growing demand for energy management; demonstration and supply of energy creation and storage systems; measurement and monitoring of power generation volume; as well as the O&M business.

Financial, securities and insurance companies are increasingly supporting the expansion of PV installation. Local banks are offering a wider variety of loan programs and some are entering from abroad. Such efforts are contributing to forming project finance.

REPUBLIC OF KOREA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

DONGGUN LIM, KOREA NATIONAL UNIVERSITY OF TRANSPORTATION

Fig. 1 - 728 kW BIPV system located at Federation of Korean Industries Head Office Building, Seoul, Korea.

Fig. 2 - 3,6 MW PV power plant, Seoul, Korea.

GENERAL FRAMEWORK AND IMPLEMENTATION

Korea has to rely almost entirely on imports for its energy demand due to its poor indigenous energy resources. In 2012, the dependency rate on imported energy, including nuclear energy, was 96,0 %. The cost for imported energy amounted to 185,3 BUSD which accounted for 33,7 % of total inbound shipment. Korea energy resources are limited to low-quality anthracite, which accounted for less than 1 % of total primary energy supply.

On 10 December 2013, the Ministry of Trade, Industry and Energy reported "The Second National Energy Plan (2013-2035)" to the Trade, Industry and Energy Committee at the National Assembly. A 29 % reliance on nuclear power is lower than the target set by the previous government (41 %) but it is still 2,6 % higher than the current level (26,4 %). The government maintained the target for the supply of renewable energy at 11 %, the same as the target in the first energy plan. They also decided to provide more than 15 % of the electricity generated through a dispersed type power source in 2035. A dispersed type power source refers to small-scale power generation near the location of the demand, including private power generation of companies. Currently, only 5 % of the electricity is generated through the dispersed power source.

In 2013, Korea's government attempted to adopt two market-based regulations: The renewable portfolio standard (RPS) and the emission trading system (ETS). The RPS will require power producers with a capacity greater than 500 megawatts to generate 2 % of their total power from renewable energy sources and raise it to 10 % by 2022.

NATIONAL PROGRAMME

Korea has been making a strong effort to increase the renewable energy portion of its "national energy mix." The goal was announced in 2013. In the target scenario, the Korea's renewable energy share of primary energy supply will account for 4,3 % in 2015, 6,1 % in 2020 and 11 % in 2030. Currently, the renewable energy is estimated to account for about 2,6 % of total primary energy consumption.

Korea's national PV programs are categorized into two major sub-programs: Infrastructure-building programs and PV deployment programs. Three main programs are operating under the infrastructure-building programs: Certificate of PV systems, solar energy test-beds, and an overseas business supporting program. Additionally, five main programs are operating under the PV deployment programs: PV subsidy, home subsidy, regional dissemination, public building obligation, and RPS program.

(1) Certificate of PV Systems

The certification scheme for PV systems has been designed to guarantee the quality of systems manufactured or imported and enhance the reliability for users, thereby expanding the deployment of PV systems and helping create the foundation for growth. It focuses on promoting the commercialization of technologies that have already been developed and establishing the infrastructure for further deployment through performance evaluation and standardization.

(2) Solar Energy Test-bed

This program seeks to aid new companies struggling to commercialize their productions due to their lack of test-beds which are necessary for the production of the products (parts / materials) they have developed. To secure an advantageous position for these Korean companies in the rapidly expanding international market, it is mandatory to develop a systematic environment for testing.

(3) General Deployment Subsidy Program

The government provides subsidy for PV facility users to accelerate PV system deployment. The government supports up to 50 % of installation costs for PV systems with a capacity below 50 kW.

Fig. 3 - 600 kW BIPV system located at Changwon Solar Tower, Gyeongsangnam-do, Korea.

In addition, the government supports 80 % of the initial cost for special purpose demonstration and pre-planned systems in order to help the developed technologies and systems to advance into the market.

(4) Home Subsidy Program

This program was launched in 2004 and the exiting 100 000 Solar-Roof Installations Program was merged into this project. The government will support a certain portion of total installation costs. Although the 100 000 Solar-Roof Deployment Project was to install PV systems on residential houses, the One Million Green Homes Plan focuses on a variety of resources such as PV, solar thermal, geo-thermal, and small wind. In addition, there are several types of home which range from detached houses to apartment houses. Until the end of 2013, about 142 MW capacity and about 164 828 households were benefitting from this program. In 2013, the number of households that benefitted from this program was 25 409 and the installed capacity was about 20,6 MW.

(5) Regional Deployment Subsidy Program

In an effort to improve the energy supply and demand condition and to promote the development of regional economies by supplying region-specific PV systems that are friendly to the environment, the government has been promoting a regional deployment subsidy program designed to support various projects carried out by local government. The government supports up to 50 % of installation costs for PV systems, owned and operated by local authorities. Until the end of 2013, about 71,3 MW benefited from this program. In 2013, the installed capacity was about 11,4 MW.

(6) Public Building Obligation Program

New buildings from public institutions, the floor area of which exceeds 3 000 square meters, are obliged by law to use more than 10 % of their total expected energy use through installed renewable energy resource systems. Public institutions include state administrative bodies, local autonomous entities, and state-run companies. In 2013, approximately 3,7 MW was installed under this program.

(7) RPS Program

The RPS is a system that enforces power producers to supply a certain amount of the total power generation by new and renewable energy. The RPS replaced the FIT Scheme from 2012. A total of thirteen companies, including six electricity generation companies, five electricity generation business companies and two other corporates participated in RPS. In 2013, about 330 MW was installed under this program.

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

YEAR	2012	2013	2014	2015
CAPACITY (MW)	220	330	480	470

R&D, D

The government budget in 2013 for renewable energy R&D was 276,2 BKRW. The program mostly consists of industry-oriented research works in PV area. For the short-term commercialization, so many projects have been implemented with the subjects of high efficiency crystalline silicon solar cell, CIGS thin film solar cell, and solar module For long-term and innovative goalS, many projects have been implemented in the area of quantum dot, organic, and dye-sensitized solar cells.

INDUSTRY AND MARKET DEVELOPMENT

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

TABLE 2 – CAPACITY OF THE PV PRODUCTION CHAIN IN 2013

Poly-Si (ton)	Ingot (GW)	Wafers (GW)	Cells (GW)	Modules (GW)
70 000	2,94	2,59	1,68	3,07

Production of Feedstock and Wafer: Hanwha Chemical started production of poly-silicon feedstock with a capacity of 10 000 tons in 2013. OCI achieved its total production capacity of poly-silicon feedstock up to 42 000 tons. Woongjin Energy has an annual capacity of 1 GW in silicon ingots. Nexolon has a capacity of 1,5 GW in silicon wafers.

Production of Photovoltaic Cells and Modules: Hyundai Heavy Industry has a capacity of 600 MW and 600 MW in the c-Si solar cells and modules, respectively. Shinsung Solar Energy has a capacity of 350 MW and 150 MW in the c-Si solar cells and modules, respectively. LG Electronics has a capacity of 330 MW and 330 MW in the c-Si solar cells and modules, respectively. Samsung SDI started the operation of a R&D line for CIGS thin film PV modules. Samsung SDI achieved the world's highest efficiency (15,7 %) in a large area (1,44m^2) for CIGS thin film solar cell. Samsung plans to build a 200 MW production line next year, increase the capacity to 1,2 GW in 2015 and begin production in 2016.

Since the installation of 276 MW in 2008, PV installation continues to decrease, with about 92 MW installed in 2011. This is mainly due to the reduction of government budget, mainly in the FIT programs. In Korea, FIT was terminated at the end of year 2011. The RPS replaced the FIT Scheme from 2012. Under the RPS scheme, the Korea's PV installation marked a tremendous jump to 252 MW in 2012, which is about a 270 % increase over the previous year. About 442 MW have been installed in 2013 and the cumulative installed PV systems were about 1,47 GW.

MALAYSIA

PV TECHNOLOGY STATUS AND PROSPECTS

DATO' HAJI BADARUDDIN BIN MAHYUDIN, MINISTRY OF ENERGY, GREEN TECHNOLOGY AND WATER
MADAM DATIN BADRIYAH BINTI ABDUL MALEK, SUSTAINABLE ENERGY DEVELOPMENT AUTHORITY MALAYSIA

GENERAL FRAMEWORK AND IMPLEMENTATION

2013 marked the second anniversary of the feed-in tariff (FiT) programme in Malaysia. The FiT was implemented on 1 December 2011 by the agency designated, empowered by the law which is the Sustainable Energy Development Authority (SEDA) Malaysia. The FiT is enabled under the Renewable Energy Act 2011 whilst the establishment of SEDA Malaysia is under the SEDA Act 2011. Aside from SEDA Malaysia, the main actors involved in the Malaysian FiT framework are the Ministry of Energy, Green Technology and Water, the Energy Commission, the Distribution Licensees, RE developers, and the RE service providers.

FiT Programme: In Malaysia, the FiT portfolio covers four types of renewable resources which are: Biomass, biogas, small hydro and PV. Of the four renewable resources, PV has the fastest take up rate due to the ease of project implementation. As of end December 2013, SEDA Malaysia approved a total of 2,609 applications (191,90 MW) for PV and these constituted nearly 40 % of the total applications approved under the FiT programme.

Degression Rates: In Malaysia, the FiT programme has been designed with the incorporation of degression rates. On 28 March 2013, the degression rates were increased from 8 % to 20 % for installed PV capacities of more than 24 kW (non-individual). Additionally, degression rates for bonus criteria of locally manufactured or assembled PV modules and inverters were reduced from 8 % to 0 %.

FiT Funding: The FiT programme in Malaysia is funded through a special fund called the RE Fund. The RE Fund is contributed to by electricity consumers via the 1 % surcharge contribution imposed on electricity bills which amounts to a total collection of approximately 300 MMYR per year. Due to the constrained RE Fund, the FiT is designed with a cap for each renewable resource in, for efficient cash flow management. The collection of the RE Fund had been imposed since 1 December 2011. To alleviate the burden of the low income group, domestic electricity consumers with not more than 300 kWh of electricity usage per month are exempted from such contribution. On 2 December 2013, the Minister of Energy, Green Technology and Water announced the increase of surcharge on electricity bills for the RE fund from 1 % to 1,6 %, effective 1 January 2014.

NATIONAL PROGRAMME & MARKET DEVELOPMENT

The market development for grid-connected PV systems hinges mainly on the FiT programme. As of 31 December 2013, a total of 73,3 MW of PV projects were operational of which 15,54 MW were for the individual categories and 57,76 MW were for the non-individual categories which translated to 1 326 individual and 86 non-individual feed-in approval holders. The installed capacity in 2012 was 31,53 MW, hence the increase in PV capacity in 2013 was 41,77 MW, which was nearly a two-fold achievement compared to 2012. The market for off-grid PV systems is largely funded by the government to address rural electrification issues. Up-to-date information on PV quotas, FiT rates and operational capacity can be accessed via www.seda.gov.my.

INDUSTRY DEVELOPMENT

On the PV manufacturing front, Malaysia is one of the largest PV producers in the world with a total combined production capacity of 4 042 MW for wafers, cells and PV modules and a total employees of 9 280 for 2013. By 2014, the total combined production capacity is estimated to increase to 5 173 MW for wafers, cells and PV modules, 6 200 tonnes for polysilicon and the total number of employees is estimated to increase to 10 247. 96 % of the total production capacity for 2013 was derived from foreign direct investment (FDI) and only 4 % was from domestic direct investment (DDI). Figure 1 shows the major FDIs & DDIs in Malaysia and their brief manufacturing details.

NO.	COMPANIES	2013		2014		STATE
		CAPACITY (MW)	EMPLOYEES	CAPACITY (MW)	EMPLOYEES	
1	First Solar	1 300	3 200	1 550	3 500	Kedah
2	Hanwha Q-Cells	900	446	1 100	568	Selangor
3	AUO Sunpower	685	2 109	745	2 107	Malacca
4	Flextronics	400	1 076	400	1 063	Johor
5	MEMC	397	577	670	669	Sarawak
6	Panasonic Corp	199	1 007	358	1 298	Kedah
7	Malaysian Solar Resources	85	120	215	180	Pahang
8	TS Solartech	60	100	60	100	Penang
9	PV Hi-Tech Solar	15	12	55	24	Negri Sembilan
10	Solartiff	1	34	20	45	Trengganu
11	Tokuyama	-	599	6 200 tonnes	693	Sarawak
	TOTAL	**4 042**	**9 280**	**5 173**	**10 247**	

Fig. 1 - Major PV FDIs & DDIs in Malaysia.

Fig. 2 - A 5 MW Ground-mounted PV system, located in Sepang, Selangor.

Within the PV industry, there are over 100 PV service providers currently active in the market. The total estimated manpower involved in the PV service industry for 2013 is estimated to be 1 207; based on 25 employment positions created for each MW installed capacity of PV. The list of these PV service providers can be found in http://seda.gov.my/?omaneg=00010100000001010101000100001000000000000000000000&s=100 .

R&D, D

Figure 3 shows the list of universities and research institutes and their research area involvement in solar PV.

UITM	Performance of Selected Stand-Alone PV Systems, Impact of Ambient Parameters on PV Systems Output in Equatorial Climate, Stabilization Period and Assessment of Design Techniques for Thin-Film PV modules under Malaysian Weather, Sizing of Stand-Alone PV systems using ANN, and Development of SCADA for Application on PV Systems. (http://www.uitm.edu.my/index.php/en)
UM	Design of Grid-connected PV inverter 3-10 kW, Inverter - performance testing, PV integration and monitoring, Photocells testing. (http://www.um.edu.my/)
SERI, UKM	Advanced Solar Cell (Thin Film Silicon, CdTe, CIGS and organic solar cell including dye-sensitized solar cell), Solar Hydrogen Production System, Grid Connected Photovoltaic, Solar PV Hybrid Systems, Solar Power Regenerative Electrolyzer/Fuel Cell System, Charge controllers, Inverters, power quality, and Impact study on PV technology. (http://www.ukm.my/seri/)
UTAR	Pre-Commercialized Project on Grid Connected Dense Array Concentrator Photovoltaic System (CPV). (http://www.utar.edu.my/main.jsp)
UPM	Solar CPV pilot project. (http://www.upm.edu.my/)
UTM AND UTEM	Inverter quality control center: to test grid-connected PV inverter for power less than 10 kW., Study of partial shading problem for PV in tropical countries, Development of MPPT for PV inverters using soft computing methods, Design and construction of PV charging station for Electric Vehicle., Monitoring of performance of various PV technologies under tropical environment, Development of new "inverter efficiency index" for PV inverters for tropical regions., Partial shading solution based on hardware energy harvesting., http://www.utm.my/ ; http://www.utem.edu.my/web2012/ , Solar Resource Assessment and Forecasting, Characterization, Forecasting, Mapping (Ground Observed & Remote Sensing), and PV Performance and Reliability.
TNB RESEARCH	Design Optimization of PV Plant, Operation & Maintenance of PV Plant, PV Performance model, Optimization of PV Performance, Advanced PV Power Plant Design, and Solar Hybrid systems for rural electrification. (http://www.tnbr.com.my/)

Fig. 3 - Solar PV Researches by Local Universities and Research Institute.

MEXICO

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

Fig. 1- 75 kWp Grid Connected PV System at CICESE Ensenada Baja California, Mexico (Photo: Solartec).

Fig. 2 - 75 kWp Grid Connected PV System at CICESE Ensenada Baja California, Mexico (Photo: Solartec).

GENERAL FRAMEWORK AND IMPLEMENTATION

The Mexican legal, institutional and regulatory framework continues evolving towards a more favorable environment for renewable energy. On December 20, 2013, the Government of Mexico issued a Presidential Decree reforming several Articles of the Mexican Constitution dealing with energy matters. The aim of such reforms is the modernization of the Mexican Energy Sector which is expected to result in social, economic and environmental benefits for this nation. The National Energy Strategy 2013-2027 issued by the Energy Ministry (SENER) prioritizes the need to tap the potential of the country's renewable energy resources; government programs and national goals in this respect are expected to be included in the Special Renewable Energy Program to be published by SENER in the coming months.

In the PV arena, this year the Energy Regulatory Commission (CRE) issued a new Contract Model for the interconnection of the so-called "collective source of renewable energy." This is a modality of the Net Metering Scheme approved a few years ago for individual electricity consumers, in which a group of neighboring consumers, such as in a building or a condominium, join together to obtain a permit to install a PV plant for self-production of electricity. CRE has also created other pieces of regulation such as the technical requirements for the interconnection of PV power plants to the national electricity system. This is in view of the early, but fast growth, market of MW-size PV plants in Mexico.

NATIONAL PROGRAMME

The private sector is swiftly responding to this changing policy environment: Requests for permits to build around 2 GW of PV plants have been already filed with CRE and a 30 MW plant, built near the city of La Paz at the tip of the Baja California Peninsula, came on line this year. More projects are at various stages of development in other parts of Mexico. This multi-MW plant was permitted in the legal modality of Small Electricity Generator, in which all electricity produced must be sold to the national electric utility, CFE, for public service retailing.

PV applications for Net Metering in the domestic and commercial sectors keep also growing in numbers. Over 5 000 grid-connected systems were installed this year, which represents a 300 % increase with respect to the total number of installations in the year 2012.
PV applications in municipal, state and federal buildings are beginning to take place in response to the mandate of the 2008 Renewable Energy Law, albeit at a slower rate than in the domestic and commercial sectors.

R&D, D

In the field of R&D the Mexican Government is also creating new mechanisms to foster technological innovation and industrial growth. The Sustainable Energy Fund (SEF), a facility created by the 2008 Renewable Energy Law and jointly operated by SENER and the National Science and Technology Council (CONACYT), issued a call this year for proposals for the creation of a Mexican Innovation Center in Solar Energy (CEMIE-Sol). This call requires the CEMIE-Sol to be constituted by a network of already existing research centers with strong links to national industries in this sector. In November 2013, SEF officially announced that the proposal by the Renewable Energy Institute of the National Autonomous University (IER-UNAM) was the winner in this contest. It is anticipated that CEMIE-Sol will start operations by mid-2014, once all legal formalities have been cleared.

INDUSTRY AND MARKET DEVELOPMENT

In the case of rural electrification, the modality is shifting from the traditional solar home systems (SHS) toward PV powered micro-electricity grids. The national electric utility, CFE, has already installed a few pilots, 50 kWp of PV capacity each, to supply electricity in remote communities. Tenders for over a dozen more of such installations are expected to be let out for bids in the coming months.

All in all, it is estimated that the PV capacity installed in Mexico during the year 2013 was 60 MW, which brings the overall PV capacity in this country to around 112 MW. Should this growing trend continue, Mexico could become a major market for PV in the coming years.

In view of this, up until now, the few PV module assembling companies based in this country are rethinking their business strategies. One of them reported the purchase and installation of a PV cell manufacturing plant in central Mexico in 2013. Plans to set up manufacturing facilities in Mexico have also been announced by other companies.

THE NETHERLANDS

PV TECHNOLOGY STATUS AND PROSPECTS,
OTTO BERNSEN, RVO, ENERGY INNOVATION

Fig. 1 - Private house design by owner, M. de Graaf with 125 m² of solar panels (Photo: RVO).

GENERAL FRAMEWORK

Natural gas has been the main source of electricity generation in the Netherlands for decades, covering roughly 50 % of demand. However, in recent years there was a sharp decline in its share since gas is being replaced on the one hand by cheap coal imported from the Americas and on the other hand by renewable energy sources such as wind and solar power mainly from Denmark and Germany. The internal growth of solar power is steadily progressing over the last years but modest (over 0,2 % of total electricity consumption) compared to some of our close neighbours, such as Belgium and the UK. Germany is of course a special case concerning solar power. The Dutch electricity system is highly integrated in the European power market by continental interconnections and sea power cables to the UK and Norway directly. The Netherlands have the goal of 16 % renewables in 2020 but no specific targets for individual technologies. Nevertheless, the sector expects to have installed between 4 and 8 GWp by that time which would be 3 % - 6 % of the total electricity supply.

The solar market is a turbulent market for all parties involved; for installers, project developers, module producers and production machine suppliers. Falling prices have caused margins for companies to dwindle also in 2013 resulting in a further international consolidation within the industry. Still new companies keep emerging and breaking ground while existing ones have a high added value. Traditionally PV research is strong in the Netherlands and the amount being spent on R&D has stayed roughly the same in 2013, with over 30 MEUR allocated.

It is still too early to tell the amount of installed capacity in 2013 and it is hard to estimate since no obligations exist to register the amount installed or to have a digital "smart meter" in the Netherlands. Preliminary expectations are that in 2013 the domestic market again has grown substantially with at least another 255 MWp installed capacity to 650 MWp accumulated (based upon the PIR (Production Installation Register) in January 2014.

The different tax incentives for companies (EIA and VAMIL) continued and were joined by a specific incentive for household to replace roofing asbestos in homes and at the same, install solar panels. In August 2013, the solar subsidy scheme for households came to an end which was prolonged from 2012 and mounted to a total of 50,8 MEUR. It reached almost 90 000 households in the Netherlands and lowered the upfront investment significantly with a maximum of 600 EUR while also module prices kept falling. However, there are no intentions to renew this subsidy scheme. Therefore in the latter half of 2013 only the direct subsidies scheme "SDEplus" existed for solar systems larger than 15 kWp. Although few in number, these medium sized system are increasing in the Netherlands, especially on publicly owned buildings and in the agricultural sector. The main incentive for households at large is now net metering which was before limited to 5 000 kWh for each connection but as of the first of July 2013 this upper boundary was removed. How long this situation will remain is the subject of public debate.

NATIONAL PROGRAMMES

In 2013 the TKI Solar Energy, which is a public-private partnership, executed three national calls on integrated PV applications, wafer based crystalline technologies and thin film, and participated in an international joint call of the European Solar-ERA.NET. Over 30 MEUR was eventually allocated, coming from innovation budgets and the general framework for stimulating renewable energy SDE+.

The national program for the implementation of renewable energy sources (DEN) continued in 2013 with the activities focused on the

Fig. 2 - Prize winning design by BEAR ID (Photo: BEAR ID Holding).

quality and ease of installation. It covers topics such as permits, certification, incentives and public Information about the realities of solar PV in the market place. This program also organises the yearly Solar Tours which visits interesting PV applications and now expands just over the border into the state of Nordrhein-Westfalen in Germany. Together, with the solar power branch organisation Holland Solar the yearly "Sunday" is organised, a congress about both science and markets.

RESEARCH AND DEVELOPMENT ACTIVITIES

In 2013, 30 MEUR of public funding was allocated, which is roughly the same as in previous years. While PV research is traditionally strong in the Netherlands and overall expenditure stable, other countries are stepping up their research efforts. The top knowledge institute (TKI) Solar is by no means the only TKI funding project related to solar power. Solar projects can also be found in the TKI for high tech systems, the built environment and smart grids. Three more applied institutes are related to the TKI Solar, Solliance for Thin Film, SEAC for Building Integrated Solutions and the Silicon Competence Centre (SICC) for wafer based crystalline silicon solar cells.

Fundamental research is also sponsored by the national science foundation (NWO) and the institute for material sciences (FOM) which has a specialised lab on energy DIFFER (Dutch Institute for Fundamental Energy Research). The universities involved are; Nijmegen, Groningen, Utrecht, Wageningen, Twente, Delft and Eindhoven. Lecturers in solar power systems can also be found at the Fontys, HAN and Zuyd Academies.

INDUSTRY STATUS

The solar industry in the Netherlands is adapting to the turbulent market situation and overall employment in the sector has remained stable with large shifts between sectors in the industry. The amount of solar panels installed keeps rising and Dutch production machines are popular abroad. However, solar modules production has all but disappeared from the Netherlands, although there are initiatives for pilot plants and innovative production methods.

DEMONSTRATION PROJECTS

The phase of PV modules demonstration projects is all but over in the Netherlands. There is a wide interest for solar PV and the demonstration projects now tend to focus on grid and building Integration specifically while companies look for new exploitation models. In this sense, solar energy has arrived in the Netherlands but there is still room for improvement. Demonstration projects including PV systems can also be found in the Intelligent Grids Innovation Program (IPIN) where the emphasis lies on grid integration.

IMPLEMENTATION AND MARKET DEVELOPMENT

The amount of installed solar systems has again increased in 2013 notwithstanding the import limitations on Chinese modules. An early estimate of another 255 MWp installed capacity would bring the total accumulated amount to 650 MWp in the Netherlands.

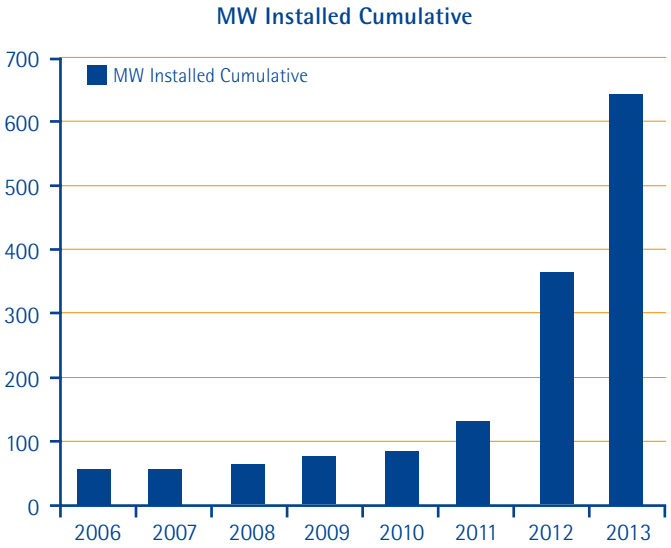

Fig. 3 - Total accumulated installed capacity MW/year in the Netherlands (PIR January 2014).

Expectations are that this will increase to somewhere between 4 and 6 GWp in 2020 which will mean a share between 3 % and 6 % of total electricity production in 2020.

Besides individual households and companies, cities and villages have become active using publicly owned spaces for medium sized solar plants up to a few MW/p. Consumers of these communal solar systems have to be located in the nearby area, determined by the postal codes. Very large solar plants remain difficult to realise in the Netherlands given the high population density. Nevertheless the very limited availability of ground surface can lead to innovative applications on the water, combined with infrastructure and in renovation projects in regions where population numbers are falling.

In 2013, an "Energy Agreement" was achieved between the different societal stakeholders. The main points for solar power systems concerned the removal of the ceiling (of 5 000 kWh/year) for net metering and a more advantageous tax regime for renewables. Still major legal obstacles exist for allowing a high percentage of solar power in the national grid. Therefore an experimental "legal room" is in preparation for 2014 where limited projects can experiment with the different legal constructions and regimes. Central in this experimental room will be the role and responsibilities of the so called "prosumer."

NORWAY

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

BJØRN THORUD, THE RESEARCH COUNCIL OF NORWAY

Fig. 1 and 2 - PV installation at Høgskolen i Hedmark, Avdeling Evenstad. 70 kWp system supplied by FusEn AS.

GENERAL FRAMEWORK

For decades, hydro power has been the main source of electricity generation, covering roughly more than 99 % of the Norwegian demand. Since the annual precipitation varies from year to year, and thereby also the power production, the Norwegian electricity system is highly integrated in the Nordic power market. Despite a net population increase in recent years, the power consumption is relatively stable, due to energy efficiency measures and reduced activity in the metal industry. Focus on environmental issues, security of supply, etc., has lead to an increased interest in renewable electricity production, such as wind and small hydro, but also in bioenergy and heat pumps as substitutes to electric space heating.

2013 was the second year of operation of the common Swedish-Norwegian electricity certificate market. The el-certificate market is a technology neutral, market-based support scheme for power generation from renewable energy sources. The market is designed to increase power generation from renewable energy sources in the two countries with a total of 26,4 TWh/year before 2020. The total power production in Norway in 2013 was 133 TWh, whereas only 128 TWh was consumed. By the end of Q3 in 2013, a total of 308 MW of new power production capacity had received approval for el-certificates. The new production capacity adds additionally 0,74 TWh/y to the Norwegian capacity and its supplied by wind- and hydro power only.

Enova SF, a public agency owned by the Ministry of Petroleum and Energy, was established in 2001 as an instrument to improve energy system efficiency and increase renewable energy production. Enova offers support schemes in the areas in which the greatest effect in the form of saved, converted, or generated clean energy can be achieved. Since the introduction of the el-certificate market, Enova only supports new power generation technologies, i.e. demonstration projects including immature technologies or technologies new to the Norwegian market. Renewable power generation from wind, hydro, PV, etc., will receive support from the el-certificate market.

Environmental qualities or aspects seem to become an increasingly important market parameter for actors in the Norwegian building and construction sector. Enova has a strong focus on energy efficient buildings and in 2013 Enova stopped supporting "passive" energy buildings as these solutions now seem to be financially viable without support. In 2014, a new support for buildings with even higher energy efficiency requirements has been released.

There are some signs showing that PV is used to strengthen the environmental performance of buildings. For example, the environmental assessment method for buildings BREEAM (Building Research Establishment's Environmental Assessment Method), that also represents a driving force behind PV, is more widely used. An additional motivation is the classification system for energy performance of buildings required for new buildings and related to sales, administered by the NVE (Norwegian Water Resources and Energy Directorate).

The entrance fee for the participation in the el-certificate market is minimum 15 000 NOK, and this amount is generally too high for owners of small PV-systems. Thus the Norwegian market remains without any particular public support schemes for PV systems. Thus, the main market for PV in Norway continues to be related to off-grid applications in addition to a few grid connected systems on buildings. A fair exception is the municipality of Oslo, who has announced that they will include PV systems in their environmental technology support program by 2014.

Fig. 3 - PV installation at Powerhouse Kjørbo. The picture is from the inauguration with the Minister of Local Government and Modernisation, Jan Tore Sanner (left) and head of the environmental organization Zero, Marius Holm (right).

NATIONAL PROGRAMME

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

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

However, in December 2013, Enova published a report on the Levelized Cost of Electricity (LCOE) of PV in different locations in Norway. The report is the most comprehensive report on this subject until now. Although the report states that the Norwegian PV system costs are artificially high due to an immature market, Enova has decided that PV is too expensive to receive governmental support.

RESEARCH AND DEVELOPMENT

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

The total NRC-funds for PV-related R&D projects were approximately 70 MNOK (8 MEUR) for 2013. Most of the R&D projects are focused on the silicon chain from feedstock to solar cells research, but also related fundamental material research and production processes. A growing supply business is also filling out the projects portfolio.

The Norwegian Research Centre for Solar Cell Technology has completed its fourth year of operation (www.solarunited.no). Leading national research groups and industrial partners in PV technology participate in the centre. The research activities are grouped into six work packages, five of which involve competence building: Mono- and multi-crystalline silicon, next generation modeling tools for crystallizing silicon, solar cell and solar panel technology, new materials for next-generation solar cells, and new characterization methods. The sixth is a value-chain project that will apply the findings of the other five work packages to produce working solar cell prototypes. The total Centre budget is 374 MNOK over the duration of the Centre (2009–2017).

This year, the centre's performance was subject to an evaluation performed by international experts. The evaluation showed that most of the goals set at the centre's startup of have been achieved. The activities within crystallization and solidification of Si, as well as the activities within detailed characterization were identified as the strongholds of the centre. As a consequence of the evaluation group's recommendations, these activities have been strengthened by adding a new work package on production of polysilicon by the chemical route. The new work package will give the research better control of the value chain and strengthen the work on high performance materials.

There are six main R&D groups in Norway's universities and institute sector:

- IFE (Institute for Energy Technology): Focus on polysilicon production, 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 and a polysilicon production lab, featuring three different furnace technologies have been established.
- University of Oslo (UiO), Faculty of Mathematics and Natural Sciences: The Centre for Materials Science and Nanotechology (SMN) is coordinating the activities within materials science, micro- and nanotechnology.
- NTNU (Norwegian University of Science and Technology) Trondheim: Focuses on production and characterization of solar grade silicon.
- SINTEF Trondheim and Oslo: Focus on silicon feedstock, refining, crystallisation, sawing and material characterisation.
- Agder University (UiA): Research on silicon feedstock with Elkem. Renewable energy demonstration facility with PV, solar heat collectors, heat pump, heat storage and electrolyser for research on hybrid systems.
- Norut (Northern Research Institute Narvik): Development of silicon based solar cells and includes the whole production chain from casting of silicon to solar cell modules. A lab for solar cell characterization was built in cooperation with Innotech Solar AS.

INDUSTRY AND MARKET DEVELOPMENT

The international PV market was further weakened in 2013. Falling unit prices and over-capacity on the supply side has led to corresponding production reductions and shut downs for the major Norwegian PV actors.

Renewable Energy Corporation (REC) REC – Renewable Energy Corporation, is involved in the whole value chain of solar cells, from raw materials to complete modules. In 2012, REC shut down all its production facilities in Norway and only the head office remained

Fig. 4 - PV installation at Powerhouse Kjørbo, delivered by Direct Energy. The system has a capacity of 310 kWp (See also www.powerhouse.no).

in Oslo. In 2013, REC was split into two different companies. The production of silicon gases and polysilicon is located in the new company REC Silicon, whereas the production of wafers, cells modules as well as the systems division is located in REC Solar. The production facility of REC Silicon is in the USA, while REC Solar has its factory in Singapore and the main office for its systems division is in Munich. The group in Oslo, Norway, was also shut down at the end of 2013.

Elkem Solar is based on the so called metallurgical route; Elkem Solar has invested in a silicon production plant in Kristiansand in southern Norway. With a design capacity of 6 000 tons of solar grade silicon per year, the plant started to ramp up production during 2009. The production technology is now tested and verified, and according to Elkem, it enables the company to produce silicon with just 1/4 of the energy consumption compared with traditional technology. During 2012 and 2013, Elkem Solar's solar grade silicon was in production for only 6 months. During the stand-still, Elkem Solar developed and tested an even lower cost and more environmental friendly production method for SoG-Si feedstock. In January 2014, Elkem announced that they would start production again.

NorSun AS manufactures high performance monocrystalline silicon ingots and wafers at its plant in Årdal on the Norwegian west coast. Annual production capacity at the company's facilities in Norway exceeds 320 MWp with around 170 employees. Capacity utilization in 2013 has been close the maximum, a situation continuing so far in 2014. A full financial restructuring was carried out in 2013. The market conditions continue to be challenging with very low prices due to global overcapacity.

Norwegian Crystals: In September 2013 the newly established company Norwegian Crystals acquired the former REC Wafer production facility for mono crystals in Glomfjord. The capacity of the factory is approximately 200 MW/y and by the end of the year the factory was able to ramp up to almost 50 % of its capacity. Norwegian Crystals produce mono crystalline silicon blocks for the international market.

Scatec Solar is a provider of utility scale solar (PV) power plants. The company operates in the whole value chain including project development, financing, engineering, construction and operation and maintenance. The company has its head office in Oslo, but operates in the international market. In the past years, Scatec Solar has built several power plants in Europe, but in 2013 a major milestone was achieved with the accomplishment of the first power plant in South Africa: The 75 MW Kalkbult Power Plant. Another 115 MW is under construction in South Africa.

Despite the fact that the number of employees in the solar business has been reduced with the shutdown of the REC and its factories, the number of solar companies has increased. In a survey done by the Energy21 Solar Task Force Group, it was found that the number of companies involved in the solar business had grown from 40 in 2010 to 52 in 2013.

IMPLEMENTATION

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

PV powered coastal lighthouses represents a significant user category. The Norwegian Coastal Administration (NCA) operates a total of 3 083 PV installations. The average is 110 Wp per installation, yielding a total installed PV capacity of 338 kW.

Aside from the leisure market, few new PV installations of significant size were installed in 2013. The largest grid connected system in 2013 was a 70 kWp roof mounted system at Høgskolen i Hedmark, Avdeling Evenstad. However, construction of even larger systems, such as the Powerhouse Kjørbo (310 kWp), started, and these systems will be grid connected in 2014. Contracts for other systems have been signed, and several people in the Norwegian solar community consider 2013 to be the year when they finally saw the beginning of a very small, albeit growing PV market in Norway.

Annual sales of PV systems in Norway in 2013 are estimated to be 620 kWp, mostly as stand-alone systems. The total installed PV capacity is estimated to be 10,57 MWp.

PORTUGAL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

JOÃO MACIEL, PEDRO SASSETTI PAES AND CATARINA CALHAU, EDP

Fig. 1 - 5 kWp residential microgeneration project.

Fig. 2 - 46 MWp PV plant in Amareleja, Portugal.

GENERAL FRAMEWORK AND IMPLEMENTATION

In April 2013, a revised Renewable Energy Action Plan - REAP (2009/28/EC Directive) was published. The main purpose of the revision was to adjust measures and goals to the current financial situation, as foreseen in the MoU signed between the Portuguese government and the International Monetary Fund, the European Commission and the European Central Bank.

In the scope of this revision, taking into account the electricity supply retraction observed over recent years, the goal for total renewable power capacity was reduced. Keeping in mind the target of 31 % for the overall share of energy from renewable sources in gross final consumption by 2020, the total renewable capacity target has been reduced from 19 200 MW to 15 800 MW.

Simultaneously, the main concern was to adjust the goals for different technologies taking into consideration the costs of each technology. Since hydro, wind and biomass energy generation technologies comprise lower costs, the goal for solar technologies was one of the most affected by this reduction. Concretely, the 2020 goal for solar installed capacity was reduced from 1 500 MW to 720 MW.

In the meantime, the legal process to grant connection points to the grid under the Independent Power Producer framework, regardless of the technology, has been officially suspended since 2012 (exceptions made for micro and mini-generation). According to the revised REAP this suspension will be reassessed in 2015.
In the meantime, the micro and mini-generation schemes continue, although feed-in-tariffs (FiT) have been cut over the years at a very high rate.

NATIONAL PROGRAMME

There are three major programs that concern grid-tied PV systems: the Independent Power Producer, the micro-generation scheme and the mini-generation scheme, all of which foresee a FiT, applicable to the total production.

The Independent Power Producer framework is currently officially suspended. This isn't a new situation, as over the years the government has adopted very specific tender procedures in the scope of this framework, for particular technologies, mainly for R&D purposes. Yet, there are still new PV systems being connected in the scope of this framework, which concern 2009 and 2010 tenders.

The micro-generation scheme is aimed at systems up to 5,75 kW (or 11,04 kW for condominiums). This initiative has been a success, with a total of 89 MW installed since it was launched in 2007 with a FiT of 650 EUR/MWh. FiTs have since been consecutively cut, and in 2013 new PV micro-generators were awarded a FiT of 196 EUR/MWh in the first eight years of operation and 165 EUR/MWh in the following seven years.

The mini-generation scheme is aimed at systems up to 250 kW and was launched in 2011. Since then, about 45MW of PV systems have been installed. The FiT is based on a bidding system with an upper limit, which has gone down from 250 EUR/MWh to the current 151 EUR/MWh, valid for 15 years.

TABLE 1 – 2013 PV FRAMEWORK

LEGAL FRAMEWORK	INDEPENDENT POWER PRODUCER (DECREE-LAW 312/2001 AND 225/2007) SCHEME CURRENTLY SUSPENDED BY DECREE-LAW 25/2012, TO BE REVISED IN 2015.	MINI-GENERATION (DECREE-LAW 25/2012 REVISING DL 34/2011)	MICRO-GENERATION (DECREE-LAW 25/2012 REVISING DL 118-A/2010 AND DL 363/2007)
Maximum capacity per system	No upper limit, but government may adopt specific tender procedures	250 kW	5,75 kW single or 3-phase;
Starting Tariff	**Building integrated** • Less than 5 kW – 470 €/MWh • 5 kW to 150 kW – 355 €/MWh **Ground based** • Less than 5 kW – 450 €/MWh • More than 5 kW – 317 €/MWh	**Premium tariff – 151 €/MWh** • 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) **Regular tariff – Market price**	**Premium tariff – 196 €/MWh** • Up to 3,68 kW production capacity or 11,04 kW (condominiums) and • Up to 2,4 MWh sold per year and **Regular tariff – Annual Low Voltage (LV) regulated tariff**
Starting tariff revision	Constant value based on formula incorporating technology and operation mode	Premium tariff revised down – 7 %/year	• Premium tariff revised down 130 €/MWh/year • Regular tariff revised annually
On-going update	Monthly updated at inflation rate	Fixed tariff for 15 years without inflation correction	**Special regime (Premium tariff)** • Fixed for the first 8 years after installation. Starting tariff in 2012: 196 €/MWh (- 130 €/MWh/year for subsequent years) • Fixed for the next 7 years of operation. Starting tariff in 2012: 165 €/MWh (- 20 €/MWh/year for subsequent years), **General regime (Regular tariff) – Annually set at LV regulated tariff**
Time frame	Tariff secured for 15 years or 21 MWh/kW capacity (becomes active for over 1 400 hours annual load factor)	Premium tariff secured for the first 15 years, after which will equal the market tariff	Premium tariff secured for the first 15 years, after which will equal the market tariff
Capacity cap	• Building integrated – 50 MW • Ground based – 150 MW (shared with CSP)	30 MW per year	11 MW per year
Other restrictions		• Up to 50 % of contracted consumption capacity can be connected 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 connected to the grid, 100 % for condominiums • At least 2 m2 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 most aspects of the PV value chain, such as alternative materials for solar cells, innovative manufacturing processes but also topics regarding PV systems and grid integration.

Applied research, demonstration and dissemination are performed in several institutions such as public research institutes (LNEG – National Laboratory for Energy and Geology), energy agencies (ADENE and regional agencies), utilities (EDP, the largest national energy company), private research institutes (INESC Porto – Institute for Systems and Computers Engineering) and private companies such as EFACEC.

Associations such as APISOLAR (Portuguese Association for Solar Industry), IPES (Portuguese Institute for Solar Energy) and APESF (Portuguese Association for Solar Photovoltaic Energy) are mainly focused in the promotion and protection of the solar energy sector. Most significant R&D projects underway, involving universities, national laboratories industry and utility consortiums include:

- WinDSC: Development of a Dye Sensitized Solar Cell, using an innovative seal, for potential application in BIPV. Consortium: FEUP (Porto University), EFACEC, CIN and EDP.
- CZTS Project: Joint development of CZTS technology. Consortium: LNEG, Crystalsol 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.
- SS-DSC: Organic Materials for Solar Cells. LNEG.

INDUSTRY AND MARKET DEVELOPMENT

The PV sector in Portugal has benefited from the programs launched by the Portuguese government, as PV installed capacity has registered a 67 % growth since 2003. This growth, especially concerning the micro and mini-generation systems, has fostered the creation of several SMEs, which work in the design, installation, operation and maintenance of PV systems.

Currently, there are over 500 companies working in this sector. However, the successive cuts of the FiT are raising some concern and there has been some pressure to develop a specific framework oriented for self-consumption systems, with and without power injection in the public grid.

Under the scope of micro and mini-generation schemes a decline of new installed systems is expected. Therefore, the future outlook of PV depends greatly on whether this new framework is published promptly and how effective it proves to be.

Fig. 4 - 46 MWp PV plant in Amareleja, Portugal

Cumulative PV Power Capacity Installed in Portugal (2004-2013)

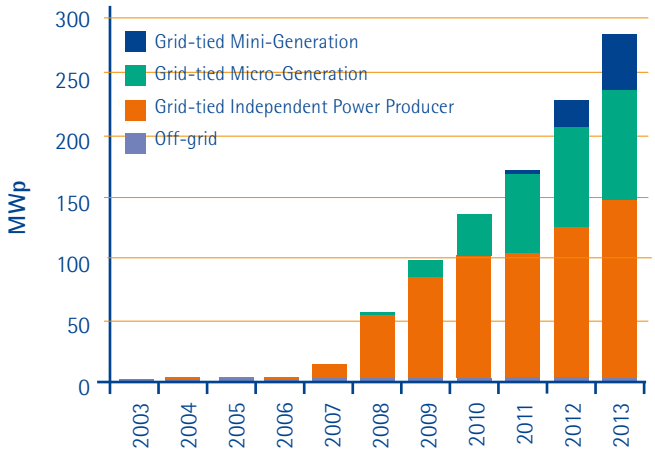

Fig. 3 - Cumulative PV Power Capacity Installed in Portugal (2004-2013).

TABLE 2 – CUMULATIVE PV POWER CAPACITY INSTALLED IN PORTUGAL (2004-2013)*

YEAR	OFF-GRID [MW]	GRID-TIED [MW]			TOTAL
		INDEPENDENT POWER PRODUCER	MICRO-GENERATION	MINI-GENERATION	
2003	2	0	0	0	2
2004	2	0	0	0	2
2005	2	0	0	0	2
2006	3	1	0	0	3
2007	3	12	0	0	15
2008	3	51	2	0	56
2009	3	82	14	0	99
2010	3	99	33	0	136
2011	3	103	63	0	169
2012	3	123	81	21	228
2013	4	143	89	45	281

**Remark: Data for off-grid installations is estimated.*

SPAIN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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

GENERAL FRAMEWORK

Photovoltaic solar energy deployment in Spain for 2013 has continued in the same mode as in 2012. A revision of the global panorama of electricity generated by renewable sources is shown in Figure 1, where the evolution in percentage of demand coverage since 2008 has been represented for the different renewable energies (Hydraulic, Wind, Solar Photovoltaic, Solar Thermoelectric, Renewable Thermal and other low carbon sources). For 2013, it is important to mention that the total demand coverage value already reached 41,5 %, representing almost 10 points more than in 2012. That important difference is mostly due to the hydraulic contribution (15,1 %) with 7 points more than in 2012 and wind energy (19,8 %), which is more than 2 points higher than previous year.

These results are related to the specifically good meteorological circumstances for these renewable energies and to the fall in electricity demand (2,3 %) in 2013. The classification and values correspond to the preliminary data reported by grid operator REE (Red Eléctrica de España) as of December 2013 for both peninsular and extra-peninsular territories.

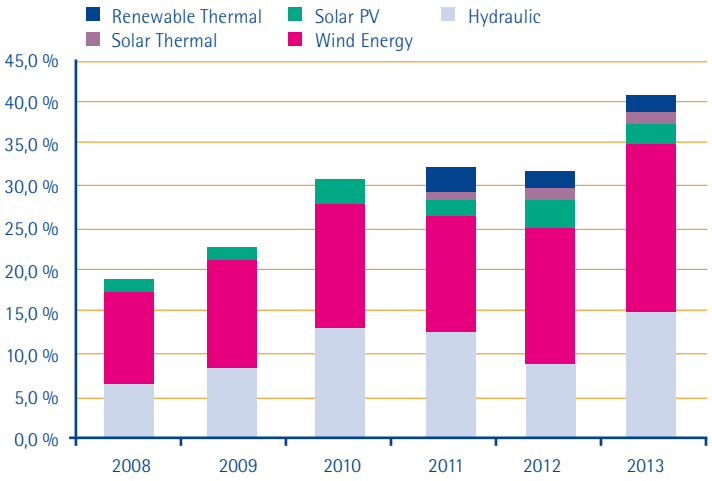

Fig. 1 – Spain's evolution of percentage of demand coverage from renewable energies during the last six years.

Specifically, photovoltaic solar energy is third in the ranking with a contribution to demand coverage of 3,1 %, a similar value than previous year, which is to be expected if we take into consideration that there has not been any big installation activity and only 287 MW new PV power added during 2013. Meteorological aspects also have influenced this.

From 2013 on, Spain is PV market grid connected, but without any feed-in tariff. Therefore, following the electricity prices, grid parity has been achieved in certain areas and for some distributed generation applications.

NATIONAL PROGRAMME

The National Programme for PV is aligned with consigns of the European Parliament concerning 20 % of primary energy supply coming out of RREE by 2020 (and 10 % for transportation). Goals proposed consider also energetic efficiency and a 2 % annual reduction of the final energetic intensity in the period between 2010 and 2020 (for a moderate economic growth).

In these circumstances, the objective of gross electricity generation out of RREE for 2020 was established at 38,1 %[1]. However, for 2013, based on the preliminary data from grid operator REE, the demand coverage out of RREE has been 41,5 % in generation and was accompanied by 2,3 % reduction that originated a lower demand. These numbers show that the goal established for 2020 has already been exceeded. Moreover, these values could be circumstantial due to the lower industrial activity in the country during the last year, lower demand. The more optimistic economic perspectives announcing the end of economical crisis might make a change in these numbers. However, if the situation remains as in 2013, goals should be revised and modified if necessary.

R&D, D

The traditional good R&D activity in Spain concerning photovoltaic solar energy continues, and for financing, apart from national programs, is now being focused on the new Horizon2020 calls.

In this sense, the Spanish photovoltaic technology platform FOTOPLAT has made an effort to align strategy with the European Energy Research Alliance (EERA) on its photovoltaic section. During 2013, FOTOPLAT has been renewed and a new board of directors and executive committee are trying to re-group efforts towards PV development in Spain. All players in the PV world, industries, technological centers, universities and public institutions dedicated to work on PV energy are welcome to participate. The idea is to mobilize the innovation activity in the whole PV sector and with that objective, the work has been reoriented in 3 different groups: **Technology, Markets** and **Strategy**.

The **Technology Group's** areas of interest are aligned with EERA (European Energy Research Alliance) premises in order to be ready for participation on new and promising calls coming for Horizon 2020. There are 6 technology subgroups dedicated to: Crystalline Silicon, Thin Film Technologies, Organic Photovoltaics, Systems, CPV and Infrastructures. Each subgroup is led by an institution with expertise in the subject and also well known worldwide.

The **Markets Group** has, apart from their goals of technology surveillance and market prospection, specific points concerning international standards and off-grid requirements. Finally, the **Strategy Group** has, as a long range objective, to contribute to saving the industry, the R&D and the installer companies that are still working on one hand, and to pave the way for initiating export activities in equipment, systems and services related to PV in general, on the other.

[1] PER 2011-2020, approbed by Ministers Council 11/11/2011

The platform is supported by Spanish Ministry of Economy and Competitivity (MINECO) and the Center for Technological and Industrial Development (CDTI).

Apart from the good orientation of the new recently launched FOTOPLAT, the main relevant activities concerning the R&D and D in Spain (CPV developments, BIPV products, upgraded metallurgical silicon use, OPV, etc.), have continued their development during 2013. However, some projects have suffered the poor performance of companies dedicated to PV components fabrication. The bankruptcy of PV cells and module manufacturer ISOFOTON (filed in August 2013) forced some changes in the R&D projects that they were leading or participating in. The same situation happened to the thin film PV module manufacturing company SOLIKER that was driving the Spanish PV technology platform before, as well as in the case of smaller equipment manufacturers that decided to quit R&D projects due to unsatisfactory perspectives of near market for their developments.

Nevertheless, the efforts in R&D continue showing good results. In this sense, new FP7th projects led by Spanish institutions have started last year. For example, the ETFE-MFM for development of a BIPV product based on ETFE polymer with lighting integrated on it, NANOMATCELL, for dye sensitized technology development and PVCROPS dedicated to cost reduction, reliability, operational performance, prediction and simulation of PV systems.

As can be seen, together with the innovation on new materials and products, the effort on development has continued on improving operation and maintenance of big plants already in production, and understanding the potential evolution of defects. This knowledge of the PV plants real performance for long periods of time and their optimization are going to be key aspects for driving the expected development of large size PV plants grid connected, announced at a "zero" feed-in-tariff. These are going to be the real demonstration of achieved grid parity.

Research and Development also exists in projects related to consumer products and lower cost/lower efficiency type of technologies.

IMPLEMENTATION

The installed PV capacity in Spain at the end of 2013 was 4,681 GW. This is 6,5 % higher than previous year. The absolute number of MW installed was 287. In that scenario, the total electricity produced by PV means has been 8,397 GWh (including extra-peninsular production), a 2,4 % more than the previous year, but the demand coverage due to PV has remained around 3,1 % (data from the grid operator REE). Figure 2 presents the evolution of installed PV in Spain.

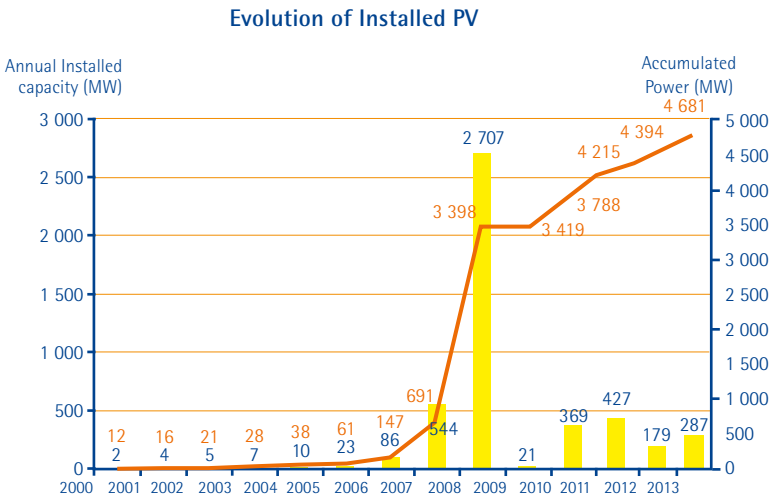

Fig. 2 – Evolution of PV power installed in Spain (Source: REE).

Historically, the rate of PV power installation in Spain has been driven originally by the feed-in-tariff conditions. After successive feed-in-tariff reductions, including retroactivity in some cases, since January 2012 there is no feed –in tariff at all. The drop in PV installed yearly is clearly related to this fact. However, out of the 287 MW installed in 2013, 67 MW are left from previous years when feed-in tariff still existed. Figure 3 shows the evolution of feed-in-tariff for the different types of PV plants in Spain during the last 7 years. Value comparison is done with respect to the average price ccEUR/kWh paid for electricity generated (pool price) as of 2013.

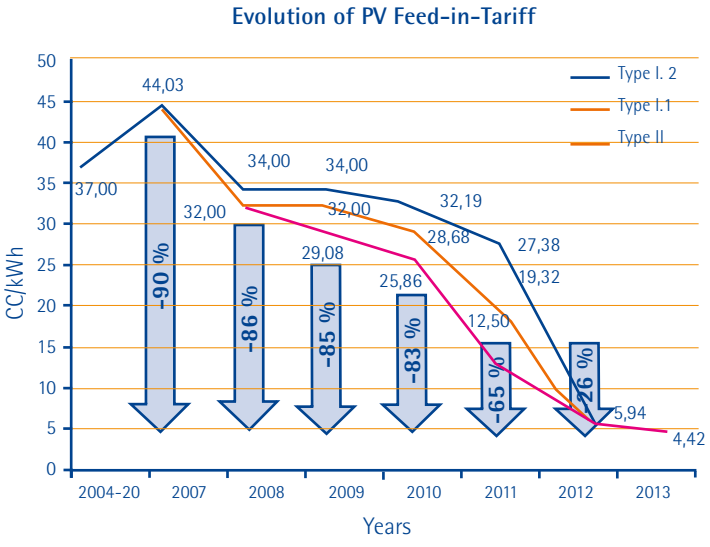

Fig. 3 – PV feed-in-tariff evolution in Spain (Source: UNEF).

The total 4,681 MW installed in Spain are split around the country, in an uneven way; mostly depending on the irradiation conditions of every region.

Figure 4 shows the capacity installed per autonomous community, as of December 2013. Castilla la Mancha (920 MW) and Andalucía (868 MW) are the Communities having the highest number of MW installed and are the same as in the previous year, which might be expected as they are also among the ones with the highest levels of irradiation (Figure 5).

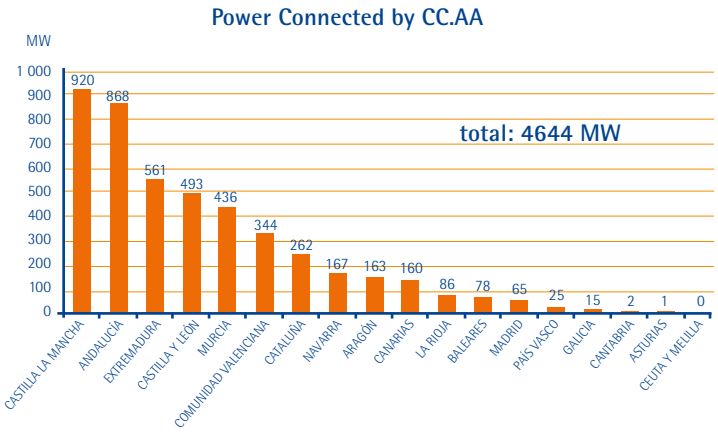

Fig. 4 - PV capacity installed per autonomous communities in Spain, 2013 (Source: CNE-UNEF).

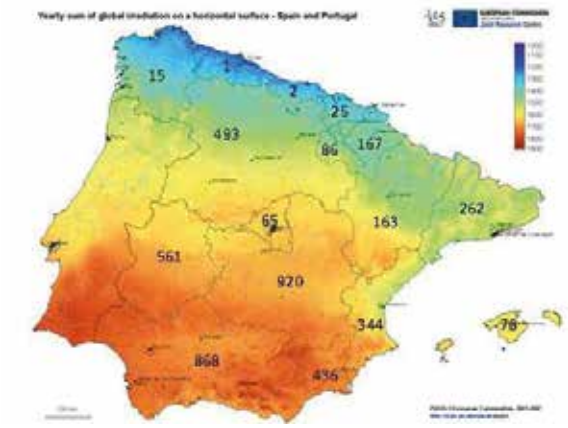

Fig.5 - PV power (MW) installed per autonomous community as of December 2013 (Source: CNE-UNEF).

INDUSTRY STATUS

During 2013, the photovoltaic industry in Spain has continued its reduction in activity with the closure of some more PV manufacturing facilities. T-SOLAR, thin film silicon manufacturer in Galicia, closed its activities after a few months of low or no production at all. In August 2013, ISOFOTON, the pioneer PV cells and modules manufacturing company, filed for bankruptcy after having tried to demonstrate profitability through various investors.

Fig.6 - BIPV installation in the "Lucía" Building, Miguel Delibes Campus of Valladolid University (2013) (Source: ONYX SOLAR).

As a summary, the manufacturing industry is following the same tendency as in Europe. Production is delocalized towards lower costs regions or closer to countries where the big plants are announced. Only a couple of start-up companies on the CPV technology (BSQ, Valldoreix Greenpower) or BIPV companies building projects all around the world (ONYX Solar) are the positive note in a quite sad panorama for the Spanish PV industry at the moment.

Concerning promotion and installation, most of Spain's big players are already global and they are installing all around the world. The activity of PV promoters and installers is in Eastern Europe, Central Asia, America, Africa and Middle East, which appear to be the areas under development.

Only some small installations (few MW or even kW) are still being developed in Spain.

MARKET DEVELOPMENT

Due to Spain's generally good irradiation conditions, the lower price of components and the high price of electricity, grid parity has been already achieved in some regions. In this situation, the potential development of the market in Spain could go two different ways: On one hand, those conditions allow to plan for installation of big sized PV plants (on the order of hundreds of MW) with the purpose of selling electricity to the grid at "pool" price. On the other hand, and also as a conclusion of the same circumstances, small industries, or private houses in good irradiated areas could install PV modules on their roofs or build houses with BIPV elements in order to take advantage of the irradiation to produce their own energy.

These could have been the ideal circumstances for PV development in some regions of Spain, even with the new regulation of January 2012 eliminating all feed-in-tariffs for PV.

The first option "Big PV plants - No feed-in-tariff - Grid connected" has been the object of a lot of interest already: As of December 2012, 38 GW out of a total of 168 plants had demanded access to the grid. The distribution of power was related to the high irradiation areas in the country.

- North West: 517 MW
- Central: 8,818 MW
- North East: 260 MW
- East: 1,339 MW
- South East: 6,204 MW
- South: 11,295 MW
- West: 9,465 MW

However, the steps for achieving the final grid connection documentation are various and complicated, and some of the plants have fallen off the list along the way. Out of that interest shown, the access filled was for 14,406 MW shared among 75 plants. In the next step, the final grid connection demand corresponded to only 10 plants. Finally, with all the documentation in order, the grid connection plants filled were 6 with a total of 2,200 MW.

As of December 2013 the only connection announcement in these circumstances corresponded to a 2,5 MW plant, the first step for a 10 MW plant to be built in Seville.

Fig.7 - First 2,5 MW PV plant grid connected at no feed-in Tariff in Seville (December 2013).

However, 2014 is expected to be the year for more announcements of plants starting operation in the same mode since the other complicated part of the equation, financing, appears to have better perspectives.

In the case of the small PV plants and installations for self-consumption, the long time expected net-metering regulation, when finally issued, has not been positive for the potential users. Even where grid parity was clearly attained, the mandatory taxes make the whole self-consumption business very uneconomical. In this sense, a big PV growth in that sector is not immediately expected. However, there is still hope on a modification of the established net-metering structure.

Both aspects can be the drivers of market development in the future. Moreover, as the local manufacturing industry has almost disappeared, the activity is not going to create a big benefit for the country, unless some recovery of it can be made.

Figure 8 shows the projections from IDAE (Institute for development and saving of energy) for yearly PV power installation until 2020, in order to accomplish the National Programme goals. This scenario does not seem to consider the option of big plants grid connected for market development, as a maximum increase per year is only 400 MW. On the other hand, those values appear to be quite high for self-consumption installations, as well.

Evolution of Annual and Accumulated PV Power

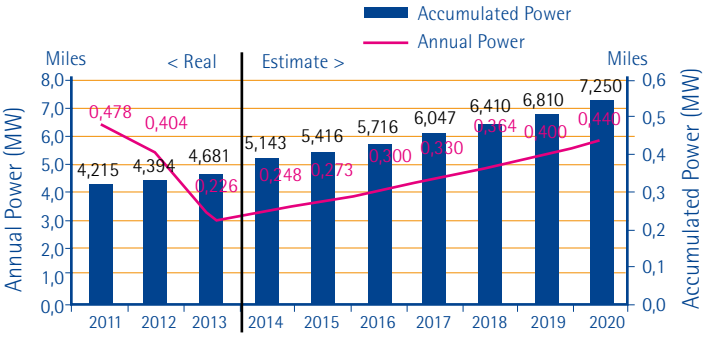

Fig. 8 – Annual and accumulated PV power evolution in Spain (Source: IDAE).

FUTURE OUTLOOK

The future outlook for PV technology in Spain might be considered with two different approaches:

- With the actual price of components and electricity prices, the big PV plants for selling energy to the grid are a clear opportunity.
- Unless the law changes and taxes for grid connection reduce, the expected self-consumption based on net-metering strategy has a difficult path for taking off. PV based energy efficiency in buildings initiatives and the micro-grid approaches might not have a bright future as a result of the established self-consumption regulation.
- The R&D community continues with a high level of activity and initiatives.

Finally, concerning the PV industry, the actual situation is not optimistic at all with respect to development in the country. However, the main PV players have started activity in the hot installation regions nowadays; some of them are even starting manufacturing activity there in order to take advantage of the local content requirement in the countries.

SWEDEN

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS
SARA BARGI, ENERGY TECHNOLOGY DEPARTMENT, SWEDISH ENERGY AGENCY
TOBIAS WALLA, ENERGY TECHNOLOGY DEPARTMENT, SWEDISH ENERGY AGENCY

Fig. 1- The first Swedish MW-installation was constructed during 2013. Solar trackers are rather untypical for Sweden, and the site is participating in a monitoring study (Photo: Bengt Stridh, ABB/Mälardalens högskola).

Fig. 2 - Solar panels on barn roof (Photo: PPAM.se Sweden AB).

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.

About 20 % of the PV installations in place in Sweden are 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 a capital subsidy was introduced in 2009, the number of grid-connected installations has increased rapidly. The original subsidy covered up to 60 % of the costs of a PV system, but following decreasing prices this level has been lowered to 35 % in 2013. The subsidy has been successful and the volume of applications is much greater than the available funds. The cumulative installed grid-connected power has grown from only 250 kW in 2005 to 34,7 MW in 2013. However PV still accounts for only 0,03 % of the Swedish electricity production.

A net-metering commission presented its results in June 2013. The result is that a net-metering scheme is not compatible with regards to the EU's VAT rules. For this reason the commission instead recommends a tax reduction on solar electricity. The proposal is now being processed by the Ministry of Enterprise, Energy and Communications.

There is solid public support for PV technology in Sweden, and about 80 % of the population thinks that efforts towards implementation should increase.

NATIONAL PROGRAMME

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

The Swedish Energy Agency is responsible for the national energy research programme. In 2012 a new research programme was launched, covering PV, concentrated solar power, and solar fuels. The budget was 3 MEUR for 2013 and will be raised from 2014 and onwards. So far, two different calls have been performed, one focusing on outstanding research, and one focusing on more applied research.

In 2013, a new call was finished in *SolEl-programmet*; an applied research program in cooperation with the industry. Five projects, all of them relevant to the current PV deployment in Sweden, were approved.

The Swedish Energy Agency funds solar cell research via its main energy research program, and a yearly total of about 4,5 MEUR are channelled to PV related research. Additional resources to PV research come from several research councils, universities and private institutions. Sweden is also a member in the newly formed Solar ERA NET, where a first call was held in 2013. A new pre-proposal call opened in January 2014.

R&D

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

Fig. 3 - Façade integrated thin film modules in the city of Uppsala (Photo: Thomas Zaar, White Arkitekter AB).

Fig. 4 - PV modules on several apartment buildings. 624 kW in total (Photo PPAM.se Sweden AB).

Comprehensive research in CIGS and CZTS thin film solar cells is performed at the Ångström Solar Center at Uppsala University. The objectives of the group are to achieve high performing cells while utilizing processes and materials that minimize the production cost and the impact on the environment. The Center collaborates with the spin-off company Solibro Research AB, and Midsummer AB.

At Lund University, the division of Energy & Building Design studies energy-efficient buildings and how to integrate PV and solar thermal into those buildings. There is research at the same university on multi-junction nanowire solar cells. The research is performed in collaboration with the company Sol Voltaics. Sol Voltaics is using nano-wires in order to enhance solar cell performance. They have developed a product called Solink in recent years which is designed to be compatible with existing crystalline silicon or thin film production lines.

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

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

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

INDUSTRY AND MARKET DEVELOPMENT

The installed capacity in Sweden in 2013 was 43,1 MW, with three times as much grid-connected installations compared to off-grid installations. These 43,1 MW can produce approximately 39 GWh in a year, which leaves a large potential for growth. It has been estimated that the potential for electricity produced by roof-mounted solar cells in Sweden amounts to several tens of TWh per year.

Today, there's only one active module producer, namely SweModule. Two years ago, in 2012, several other module producers in Sweden filed for bankruptcy, leaving only one producer left.

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

A growing number of small to medium-sized enterprises exist, that design, market and sell PV products and systems. Many of these companies depend almost exclusively on the Swedish market. The capital subsidy programme has resulted in more activity among these companies and since there has been a lot of interest from private households there are several companies that market products specified for this market segment. Several utilities are selling turnkey PV systems, often with assistance from PV installation companies.

SWITZERLAND

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

Fig. 1 - Cabane Tracuit. Off-grid alpine hut at 3 256 m. 11 kW PV-façade together with 1 500 Ah battery storage (Photo: Studer Innotec SA).

GENERAL FRAMEWORK AND IMPLEMENTATION

There is a general consensus in Switzerland that solar photovoltaics will play an important role in the long term future Swiss electricity supply. According to the official scenarios, 10 – 12 TWh should come from photovoltaics by 2050. Compared to the annual national electricity consumption of close to 60 TWh in 2013, this would represent close to 20 % of this value. The Swiss solar industry claims such contributions to be achievable much sooner than 2050.

In 2013, on the levels of Swiss policy and administration, work continued extensively regarding the preparation of the various measures in conjunction with Switzerland's phase-out of nuclear energy decided in 2011 in the framework of the new energy strategy 2050. These measures will have impacts on all levels from research to implementation and use, as well as regarding legislative and normative issues. Before coming into force, there will likely be a public vote on the new energy strategy, expected in 2016.

While the final form of the new energy strategy 2050 and its set of policy measures continue to be defined and shaped, a number of decisions have already been made by the national parliament in view of this strategy. These concern, for instance, an action plan for an increased energy research activity throughout all relevant energy technologies. In 2013, seven national energy research competence centres have been called for, six of which have been decided and established by the end of the year. The goal of these centres is to build up new permanent research capacities and institutional networks in the different technology areas. Alongside this structural measure, important additional financial means have been decided to support research activities in the different areas on the project level. Moreover, the financial means for pilot and demonstration projects have been further increased, aiming at speeding up the technology transfer from research into industrial processes, products and applications.

On the implementation level, support continues to be provided by a quickly evolving regulatory framework. In 2013, important decisions have been made by the national parliament in view of moderately accelerating the deployment of photovoltaic power systems in the short term, namely up to 2016. These measures are also meant to relieve a long waiting list in the feed-in-tariff scheme and should increase the overall efficiency of the support schemes. By the end of 2013, more than 20 000 systems were on this waiting list. The changes will come into force in early 2014. Besides the feed-in-tariff scheme used since 2009 with decreasing tariffs and increasing shares attributed to photovoltaics, systems between 2 and 10 kW will in the future benefit from a onetime investment subsidy and will not be supported in the feed-in-tariff scheme any longer. Systems between 10 and 30 kW may choose between the investment subsidy and the feed-in-tariff whereas systems below 2 kW will have no support at all at the federal level. Systems of 30 kW and more will continue to benefit from the feed-in-tariff as before. As an additional new element, self-consumption of the electricity produced will be allowed and accounted for.

The development of the photovoltaic sector in Switzerland builds on a strong research and technology base, a diversified 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

Fig. 2 - Farmhouse in Sempach , Switzerland. 171 kW roof-integrated PV system (Photo: Schürch-Egli AG).

Fig. 4 – Migros Logistics Centre, Neuendorf, Switzerland. 5,2 MW on-roof PV system (Photo: Tritec AG).

Fig. 3 - Office building from Flumroc Ltd. PV-façade and on-roof system, 128 kW in total (Photo: Viridén + Partner AG).

is defined by an energy RTD master plan updated every four years. The master plan developed by the Federal Commission for Energy Re-search (CORE) in cooperation with the Swiss Federal Office of Energy (SFOE) is based on strate-gic policy goals (energy & environment, science & education, industry & society) (www.energy-research.ch).

Concerning market implementation, the photovoltaic sector in Switzerland further developed in the year 2013, whereas the industrial activities suffered from the capacity and competition issues affecting the global PV industry. Nevertheless, activities in the Swiss PV supply industry remain high with an increasing emphasis on technology development and innovation. R&D activities in the public sector confirm this increasing trend. On the technology front, the key competence centres continued their efforts in their respective domains (solar cells, modules and systems) while increasing their cooperation with industry and on the international level.

The support of the national PV RTD programme can be expected to continue with a focus on innovative research activities, rapid technology transfer, industrial developments, new products for niche markets and ongoing international involvement. Due to the strong Swiss currency, global competition for the heavily export oriented industry remains an issue. Nevertheless, the efforts to bring Swiss technology to the market place continue. Efforts in the technology development will concentrate on short to medium term market oriented approaches and continuous quality assurance.

The strategy to promote international co-operation on all levels continued, 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.

With a strong research base in various PV technologies, an ongoing diversified industrial base along the entire value chain, an increasing market deployment activity and an overall favourable policy framework, the signs continue to be positive for an increased role of PV from research over industry all the way to the market.

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, process and product development, pilot and demonstration projects all the way to accompanying measures for market stimulation. On the technical level, thin film, tandem and heterojunction solar cells, their variations and building integration continue to be the topics of highest priority. The programme is organised along the entire value chain and addresses the critical gaps from technology to the market place. Thorough component and system analysis, as well as testing, aim at increasing efficiency and performance. Accompanying measures to raise the quality and reliability of photovoltaic power systems include work on standards and design tools.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In 2013, more than 75 projects, supported by various national and regional government agencies, the European Commission and the private sector, were conducted in the different areas of the photovoltaic energy system. Innovative solutions, cost reduction, increased efficiency and reliability, industrial viability and transfer as well as adequate market orientation are the main objectives of the technical R&D.

Fig. 5 - Ski station, Laax, Switzerland. 21 kW PV-façade with CIS modules (Photo: Solarmarkt GmbH).

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (crystalline silicon, 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 is being concentrated on micromorphous solar cells with a particular emphasis on silicon oxide intermediate reflector layers. Significant progress is also being achieved in the area of high-efficiency heterojunction silicon solar cells, reaching efficiencies above the 22 % mark. Industry co-operation has been extended with various companies. In 2013, with important support by the Swiss Confederation, CSEM (Centre Suisse d'électronique et microtechnique) has established a new photovoltaic technology centre in Neuchâtel. The mission of this PV technology centre is to accelerate the transfer of innovative PV technologies to the industry by an increased collaboration and a dedicated infrastructure.

With regard to CIGS solar cells, the Swiss Federal Laboratories for Materials Testing and Research EMPA focuses the work on high efficiency flexible CIGS cells on plastic and metal foils. As a highlight, a new record efficiency of 20,4 % was announced in 2013 for CIGS solar cells on plastic substrates, thus representing a substantial increase of the last record of 18,7 % achieved the year before. This efficiency record is slightly higher than that for CIGS cells on glass and in the range of best multicrystalline silicon solar cells.

For dye-sensitised solar cells, work continues at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. Important progress has been achieved at the Laboratory of Photonics and Interfaces at EPFL concerning perovskite-sensitized solar cells. Using sequential deposition for the formation of the perovskite pigment, solar cell efficiencies of more than 15 % were achieved in 2013 and have since reached values of 17 %. Perovskite-sensitized solar cells have thus demonstrated the steepest efficiency increase in recent years and attract a large interest by the global PV research community.

Organic solar cells are the research subject at the Swiss Federal Laboratories for Materials Testing and Research EMPA, the University of Applied Sciences in Winterthur (ZHAW) as well as at CSEM in the Basel region. In this technical area, CSEM coordinates the large European project Sunflower.

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. Related to BIPV systems in the market support schemes, the requirements for the recognition as BIPV systems have been clarified. Various other PV applications on built infrastructure, e.g. ski lifts or snow avalanche protections, have recently been proposed and realised in pilot installations.

As a recent topic rapidly gaining relevance in some countries and regions, grid integration has continued to generate interest and recent projects have extensively analysed the implications of PV on the distribution grid. Methods to considerably increase the share of PV in distribution grids have been identified based on detailed modelling work. High levels of PV penetration in distribution grids are thus no longer considered as insurmountable barriers.

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 Universities of Applied Sciences of Lugano and Burgdorf carefully evaluate products such as PV modules, inverters and new systems.

Fig. 6 - EPFL Campus, Lausanne, Switzerland. 2 MW on-roof PV systems featuring different kinds of technologies (Photo: Romande Energie).

The test infrastructure is continuously expanding and includes the accredited test centre for IEC module certification (Lugano, http://www.supsi.ch/isaac/swiss_pv_module_test_centre.html) as well as the largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf, www.pvtest.ch). Long term experience with the operation of photovoltaic power systems is carefully tracked for a number of grid-connected systems, ranging between 10 and more than 30 years of operation. Continuous development of system solutions has resulted in a number of industrial products well positioned in the export market.

Work continued on the second prototype of the solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard, André Borschberg and their team. Meanwhile, further flight ex-perience was gained with the first prototype with a flight across the USA. The solar powered boat PlanetSolar (www.planetsolar.org), after its tour around the world by solar energy completed in 2012, accomplished the 2013 DeepWater expedition, a scientific mission across the Atlantic ocean contributing to the understanding of the gulf stream relevant for climate research.

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 2013. The co-operation within the IEA PVPS programme has remained a further strategic activity.

Regarding international co-operation on the programme level, the new European SOLAR-ERA.NET project (www.solar-era.net) coordinated by Switzerland launched its first joint call for projects covering both PV and concentrated solar power (CSP) which had a high resonance in the research community. The response to the call from Swiss R&D groups was good with four full proposals in total, two from PV and two from CSP. The collaboration with the European Photovoltaic Technology Platform (www.eupvplatform.org) continued throughout the year, establishing a new strategy of this relevant European platform.

INDUSTRY AND MARKET DEVELOPMENT

For 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. Due to the fierce competition and the ongoing consolidation in the global PV industry, important changes have taken place in the Swiss PV industry landscape as well. Due to the decreased investment in new production facilities world-wide and slower market growth in Europe, the export volume of Swiss photovoltaic products has somewhat reduced. Due to a strongly growing domestic PV market at the same time, the export share is presently estimated at 50 % of the total turnover.

On the PV industry supply side, different products count among the world leaders. The largest equipment supplier for complete PV module manufacturing lines and advanced PV module technologies continues to be Meyer Burger. Leading wire-sawing machines are also produced by Applied Materials (AMAT) Switzerland. Roth & Rau, largely acquired by Meyer Burger, has intensified its Swiss R&D activities into heterojunction silicon solar cells. Measuring equipment for PV module manufacturers is produced by Pasan (now a part of Meyer Burger Group). Komax, another important player in the module manufacturing chain, has decided to sell its solar business in 2013. Solar plugging systems are offered by Multicontact as well as Huber & Suhner.

Industrial activities evolve in the field of process equipment and products based on thin-film technology. TEL Solar (previously oerlikon solar), while continuing operations throughout 2013, has recently announced to withdraw from the PV module production business. In 2013 also, AMAT and TEL have announced their worldwide merger planned for 2014, leading to one of the most important global suppliers of the semiconductor industry.

Flisom, a company active in the CIGS technology, has announced the funding for a 15 MW pilot production in Switzerland. Flisom continues to work closely with the Swiss Federal Laboratories for

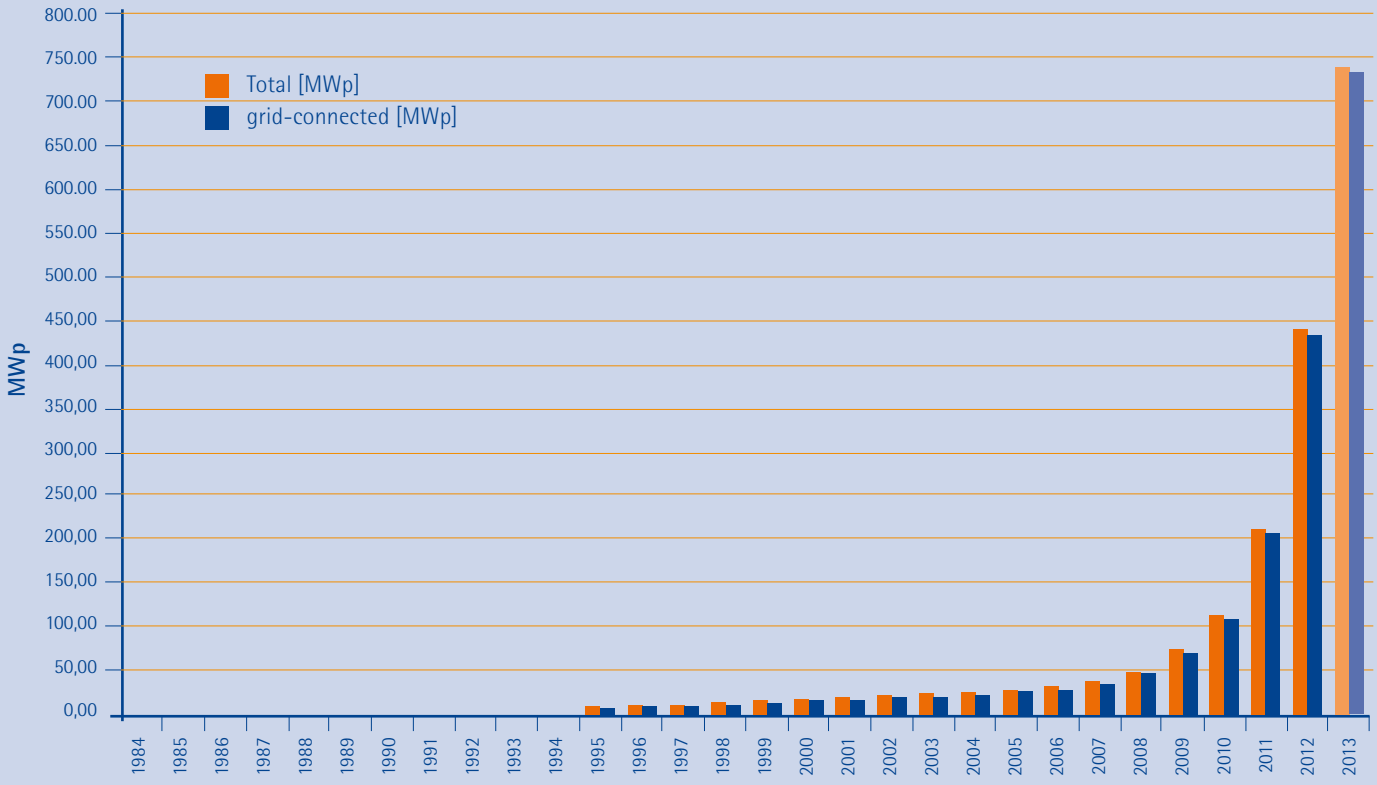

Fig. 7 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2013 (total and grid-connected, estimated values for 2013).

Materials Testing and Research EMPA. Further companies are active in the manufacturing of coloured PV modules (swissinso) and dye-sensitized solar cells (glass to energy, Solaronix).

In the past, inverters have proved to be an export success. Due to the recent slower market development in Europe, this segment has also suffered. Sputnik Engineering produces grid-connected inverters with a capacity of up to 700 MW per year. Studer Innotec has had comparable success with their stand-alone inverters. ABB has entered the inverter market and closed its deal of acquiring the US manufacturer Power One during 2013, thereby becoming a leading inverter supplier.

With an increasing PV capacity being installed in Switzerland, a clear growth of the number of companies as well as that of existing businesses involved in planning and installing PV systems can be observed. 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. System sizes have increased over the past years with up to 5 MW systems being installed on building complexes. 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 in recent years. 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. Due to the limited financial volume available within the feed-in tariff for PV systems up to now, many systems could not benefit from the feed-in tariff and are on a waiting list (see also introduction). This has lead to a variety of intermediate support schemes by regional governments and utilities, thereby diversifying the possible market support.

The combination of the various support schemes and the increased cost-competitiveness of PV systems have lead to an annual market volume for grid-connected systems greater than 300 MWp, thus representing a roughly 40 % market growth compared to 2012. The total installed capacity has thus risen to about 740 MW (Figure 7) corresponding close to 100 W/capita. With this installed capacity, roughly 1 % of the annual national electricity consumption can now be covered by photovoltaics in Switzerland.

TURKEY

PV TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK

Turkey has a reliable growth potential for the massive expansion of the photovoltaic installation and production activities. The advantages of Turkey are summarized below:

- Steady growth of the Turkish economy over the last ten years [1].
  - 16th largest economy in the world and 6th largest economy compared with the EU in 2012 (GDP at PPP, IMF WEO).
  - The economy grew with an average annual real GDP growth rate of 5 percent over the past decade between 2002 and 2012.
  - According to the OECD, Turkey is expected to be the fastest growing economy of the OECD members during 2012-2017, with an annual average growth rate of 5,2 %.
  - A dynamic and mature private sector with 153 BUSD worth of exports and an increase of 325 % between 2002 and 2012 (TurkStat).
- High growth potential of the Turkish energy sector.
  - With a population reaching 76,7 million [2], Turkey's electricity production and consumption based on primary energy resources are continuing to increase. Gross electric energy consumption of Turkey was 245,5 TWh in 2013 [3].
  - The Turkish Electricity Transmission Company (TEİAŞ) warned that "unless the necessary steps are taken, the electricity supply will not meet the demand in 2016" [4].
  - The total amount of investments to be made to meet the energy demand in Turkey until 2023 is estimated around 130 BUSD [1].
- Advantage of Turkey operating as an energy hub between Europe and the Middle East.
  - In order to establish a common energy market with the EU, Turkey plans to interconnect its energy system with UCTE (Union for the Coordination of Transmission of Electricity) grid [1].
- Increase in the share of the private sector through the privatization of state-owned generation assets.
- Privatization of regional distribution companies (finalized at the end of 2013) will allow for an independent merchants' market.
- High potential supply of solar energy technologies.
  - Solar energy is the most important alternative clean energy resource in Turkey. The yearly average solar radiation is 1 311 kWh/m^2 per year and 3,6 kWh/m^2 per day. The total yearly insulation period is approximately 2 460 hours per year and 7,2 hours per day. The energy yield potential for a PV plant is 1 300 -1 600 kWh/kWp.

NATIONAL PROGRAM

Turkey is still dependent on imported natural gas. The total installed capacity of electricity was 64 044 MW at the end of 2013 and can be broken down by the following resources as 34,8 % hydro, 4,3 % wind, 0,5% geothermal and 60,4 % thermic (natural gas, coals, liquid fuels etc.) [3]. In the face of increasing oil prices and the need for national energy security, it is widely recognized that it is imperative for Turkey to increase the contribution of renewable energy resources rapidly. This recognition obliged Turkey to have targets for the next years. As a tangible target, the Energy and Natural Resources Ministry Strategic Plan aims to reach a 30 % share of renewables (incl. hydro) in electric energy production by 2023 in Turkey. Within this target, Turkey aims to use 20 000 MW wind and 600 MW geothermal energy by 2023. Although there is not a certain target for solar electricity generation by 2023, Turkey is willing to use its high potential. The Law 6094 entitled: "Utilization of Renewable Energy Resources for Electrical Energy Production" and related regulations prescribe the technical and financial procedures and principles for supplying energy to the grid. According to the Law 6094, 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 USDcents/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 USDcents/kWh)

IMPLEMENTATION

In 2013, the most positive prospects were found in the small-scale PV market, since projects under 1 MW are not required to obtain a production license. 199 PV power projects covering about 62 MW in total were applied to the Turkish Distribution Corporation (TEDAŞ) and 6 MW of them received the preliminary acceptance at the end of 2013 [see Table 1]. It proves there has been an acceleration since

TABLE 1 - THE STATUS OF THE PROJECT APPLICATIONS TO TEDAŞ AS THE UNLICENSED PROJECTS [5]

	The Application for Approval of the Project				Preliminary Acceptance Facility	
	Total Number of Applications for Projects		Completed Applications for Approval Projects		Total Applications	
	Number of Projects	Installed Capacity (kW)	Number of Projects	Installed Capacity (kW)	Number of Projects	Installed Capacity (kW)
Wind	36	12 283				
Solar	199	62 074	103	29 002	34	6 076
Hydro						
Geothermal						
Biogas	3	2 200	2	1 700	2	1 700
Biomass						
Sub-total	**238**	**76 557**	**105**	**30 702**	**36**	**7 776**
Cogeneration	8	26 097				
General Total	**246**	**102 654**	**105**	**30 702**	**36**	**7 776**

Fig.1 - 1,8 MW grid-connected PV system in Polatlı, Ankara.

the cumulative grid-connected installed PV power was about 2,5 MW at the end of 2012. The annual PV installation in 2013 tripled the cumulative capacity of the previous years. As seen in Table 1, over 62 MW of new photovoltaic capacity was projected to be installed in Turkey in 2014 via such unlicensed projects.

Some investors preferred to setup MW scaled PV plants in total by covering a few unlicensed plants (see Figure 1).

Additionally, in the first license application round, a total of 600 MW PV projects larger than 1 MW have been completed, thus exceeding the proposed capacity by 15 times with 496 applications made to the Energy Market Regulatory Authority (EPDK) reaching 8,9 GW in total. The tender and license procedures will be concluded in 2014. These MW-scaled plants are expected to be put in operation until 2015. The Ministry of Council will determine the new capacity after 2015.

INDUSTRY STATUS

Regarding PV manufacturing activities, currently there are not any feedstock, ingots and wafers manufacturers in Turkey. China Sunergy Co. Ltd. (CSUN) which is a specialized solar cell and module manufacturer, announced that the company has set up a new manufacturing facility in İstanbul, Turkey, with a local partner, Seul Energy Investment Corp. (SEUL Energy). The new plant covering more than 22 000 square meters has been set up in facilities in the Trade Free Zone in Istanbul, Turkey. CSUN announced its 300 MW/y capacities for both of the cell and module production lines. The company aims to reach 600 MW/y production capacities and 1 200 employees in 2015. The currently operating PV module manufacturing plants in Turkey are listed by GÜNDER (ISES-TR) [see Table 2].

There are also a few PV module constituents (glass, frame etc.) manufacturers in Turkey. For instance, the Trakya Cam Co. is a leading flat glass supplier in the region and one of the largest glass producers in Europe that is increasing sales for solar glass. It's mother company, the 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. (www.trakyacam.com.tr).

MARKET DEVELOPMENT

Europe has dominated the global PV market for years but the rest of the world clearly has the biggest potential for growth. This was highlighted by market developments that saw Europe's share of the global market being reduced from 74 % in 2011 to 55 % in 2012. Driven by local and global energy demand, the fastest PV growth is expected to continue in China and India, followed by Southeast Asia, Latin America and the Middle East and North Africa (MENA) countries. The PV potential of the Sunbelt countries – where PV can already compete with diesel generators for peak power generation without financial support – could range from 60 to 250 GW by 2020, and from 260 to 1 100 GW in 2030. Additionally, with the faster than expected price decrease that the industry experienced in 2011 and 2012, even more countries will see PV becoming competitive before the end of this decade [6]. Within this expectation, solar energy demand in the MENA region is attracting the attention of the global solar market, as the industry begins to diversify existing demand from feed-in tariff markets with demand from markets that offer fundamental solar drivers such as insolation, grid prices and electricity needs. On the back of these fundamental drivers, GTM Research, in collaboration with the Emirates

TABLE 2 – THE OPERATING MODULE MANUFACTURERS IN TURKEY LISTED BY GÜNDER

COMPANY	ANNUAL PRODUCTION CAPACITY (MW)
Alfa Solar A.Ş.	30
Antak Enerji A.Ş.	2
Gazioğlu Solar A.Ş.	30
GEST Enerji	30
SEİSO A.Ş.	2
SOLARTÜRK A.Ş.	60
SUNLEGO (PLURAWATT)	30
ZAHİT ALÜMİNYUM	30
ÖDÜL SOLAR	30
BEREKET ENERJİ	30
ANEL	9

Fig. 2 - "PV Investor's Day in Turkey," December 18th, 2013, İstanbul.

Solar Industry Association (ESIA), forecasts the annual solar market in MENA countries to reach nearly 3,5 GW by 2015 and comprise close to 8 % of the total demand globally in 2015, as well. The clear majority of demand in the MENA region will originate in Saudi Arabia and Turkey, according to GTM's report, "Middle East and North Africa Solar Market Outlook, 2013-2017." Saudi Arabia promises to be the region's first gigawatt-scale market by 2015. The report forecasts Turkey to be the second strongest market in the region in 2015 and beyond, as favorable renewables policies and previous wind installation experience is expected to translate into greater solar demand [7].

The Turkish Solar Energy Associations (such as GÜNDER, GENSED, UFTP) continued their endeavors to facilitate information flow for a healthy market development. One of the events organized by GÜNDER and UFTP entitled "PV Investor's Day in Turkey" was concluded in Istanbul on December 18th, 2013. The main goal of this summit was to bring together Turkey's related stakeholders with the experienced institutions and discuss collaboration strategies to achieve bankability for solar PV projects and standardize best practices (see Figure 2).

FUTURE OUTLOOK

Within the context summarized in this report, a rapidly growing market in Turkey and its neighboring countries will not be surprising. In this phase it is essential to ensure prosperous, but at the same time, sustainable market growth guaranteeing a long-term high quality of solar energy generation. To achieve this goal, adequate policy measures and quality infrastructure have to be in place. Turkey has the opportunity to consider the existing international experience in order to find an efficient approach to tackle the potential pit falls.
New control, protection and management strategy requirements (Collection and monitoring of system performances, load management etc.) for the successful grid operation with unconventional generation systems should be reviewed and reported.

The share of the grid-connected PV power systems shall grow year by year in the next decade.

REFERENCES

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[2] Turkish Statistical Institute (TUIK), http://www.turkstat.gov.tr
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[4] IEA-PVPS, 2012, Dr. Mete Çubukçu, "IEA-PVPS Annual Report 2012," Imprimerie St-Paul, Fribourg, Switzerland, ISBN: 978-3-906042-11-4, pp. 92-94.
[5] Turkish Distribution Corporation (TEDAŞ).
[6] "Global Market Outlook for Photovoltaics 2013-2017," EPIA, 2013.
[7] http://www.greentechmedia.com/articles/read/new-report-mena-solar-markets-to-exceed-3-gigawatts-annually-by-2015 .

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UNITED KINGDOM

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK, IMPLEMENTATION & NATIONAL PROGRAMME

From the release of the recent document: UK Solar PV Strategy Part 1: Roadmap to a Brighter Future, in October 2013, it is clear that the UK Government believes that solar PV has the potential to form a significant part of our renewable energy generation mix.

Currently the UK has over 3 GW of installed solar PV capacity in operation and analysis indicates that the market should achieve a cumulative total of 10-20 GW of solar PV by 2020 (equivalent 9-18 TWh generated energy). Whilst smaller scale (less than 50 kW) solar PV installations, supported through the UK's Feed-in-Tariff (FiT) scheme, were the main driver for the growth in solar PV capacity up until the first FiT reductions in 2012, 2013 was a relatively quiet year for this sector with larger systems beginning to take over. The now predictable FiT degression policy has helped to stabilise the market and the PV sector as a whole performed well.

Following the global trend, the solar PV sector saw dramatic cost reductions between summer 2011 and mid 2013, with installed costs estimated to have fallen by up to 60 %. The ability to deliver further reductions in the installed costs of solar PV will determine the level of sector growth and the ability for the levelised cost of solar PV to continue to gain ground against other low-carbon electricity sources. The UK Government has introduced a cost-control mechanism for the FiT scheme to promote a predictable and stable environment conducive to sustainable cost reduction.

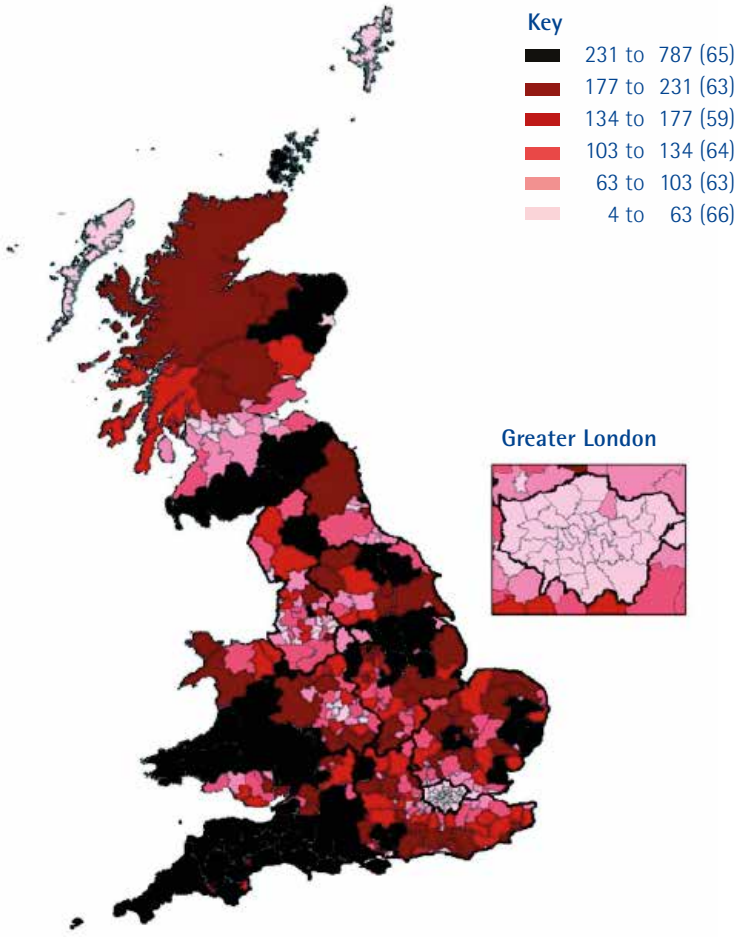
Solar PV benefits from being easy to install on domestic and many commercial buildings, as well as on the ground. With 85 % public support, it has a role in connecting individuals, communities and businesses with future deployment of renewable energy and the transition to the low-carbon economy. Further growth of solar PV generation will present new challenges to grid balancing but this will be aided by generation used onsite, along with potential improvements in storage technology and active network management.

UK Deployment

Although the UK has less sunshine (and therefore lower load factors) than some countries, our climate is similar to that in Germany, where deployment of solar PV is considerably higher. Figure 1 shows the UK map of FiTs solar PV deployment: The number of domestic photovoltaic installations per 10 000 households by Local Authority. As at June 2013, the regional data shows the majority of installations are focused in South West England.

Wales, the East Midlands and the Scottish Borders also show significant deployment. Deployment in the UK has grown rapidly since the FiT scheme was established in April 2010 to 3 GW of operational installed capacity by the end of the 3rd quarter of 2013, with the majority of current PV deployment at smaller scale installations less than 50 kW. This situation started to change rapidly in 2013, with evidence of substantial activity now underway, including both large commercial rooftops and ground mounted schemes. For example, a large scale UK developer and installer commissioned a 5,2 MW system (over 20 000 modules) on the Bentley car factory roof, creating the UK's largest solar rooftop array (see case study below). Global analysis showed the UK to rank 6th for deployment in the first 6 months of 2013.

Feed In Tariffs in the UK



Notes:

1. There are 8,374 domestic photovoltaic installations that have not been allocated to Local Authorities.
2. For Scotland, areas are represented as Council Areas.

Fig. 1 – Feed-in Tariffs in the UK – Number of domestic PV installations per 10,000 households by Local Authority, as at end of June 2013.
Source: ONS, Crown copyright 2004. Crown copyright material is reproduced with the permission of the controller of HMSO. Contains data from OfGem

Case Study – The Bentley Factory, Crewe

The Bentley Factory in Crewe built in the 1940s is ideally situated to generate solar power as the "saw tooth" factory roofs are south facing at an angle of 20 degrees. It is the UK's largest rooftop solar PV array, owned and operated by solar power generator, Lightsource Renewable Energy and installed by main contractor Solarcentury.

Over 20 000 solar PV panels have been installed generating enough electricity adequate to power over 1 200 households covering 3,45 hectares of roof space which would otherwise be un-utilised. Lightsource Renewable Energy entered into a power purchase agreement with Bentley Motors, making it possible for the electricity generated during working hours to be used directly by the factory and for the electricity generated at weekends and times of low demand, to be fed back into the National Grid. At peak generation times, the system will produce up to 40 % of Bentley's energy requirements.

The installation on Bentley's factory demonstrates the potential for solar energy to be generated on commercial roof-tops in the UK and is a clear example of how businesses can gain greater pricing certainty for the future whilst reducing their carbon footprint. With the build only taking 16 weeks, it shows the speed at which installations of this size can be completed even when constructed in tandem with existing business activity.

SOLAR STRATEGY

The UK's Department of Energy and Climate Change (DECC) wants to set out a clear vision for solar through to 2020, and do so in a way which gives industry confidence to invest. In October 2013, DECC produced the first part of its solar PV strategy, "The Roadmap", in which the Government's strategic approach to solar PV was outlined. The detailed strategy is expected to be released in Spring 2014. The approach reflects both Government and industry perspectives as to the main challenges facing the deployment of solar PV. It will consider the scope for small-scale, community-owned, commercial and utility scale deployment in the UK and identifies the barriers to growth that need to be addressed in each case. The Roadmap sets out four guiding principles, which form the basis of Government's strategy for solar PV.

These principles are:

I. Support for solar PV should allow cost-effective projects to proceed and to make a cost-effective contribution to UK carbon emission objectives in the context of overall energy goals – ensuring that solar PV has a role alongside other energy generation technologies in delivering carbon reductions, energy security and affordability for consumers.
II. Support for solar PV should deliver genuine carbon reductions that help meet the UK's target of 15 % renewable energy from final consumption by 2020 and in supporting the decarbonisation of our economy in the longer term – ensuring that all the carbon impacts of solar PV deployment are fully understood.
III. Support for solar PV should ensure proposals are appropriately sited, give proper weight to environmental considerations such as landscape and visual impact, heritage and local amenity, and provide opportunities for local communities to influence decisions that affect them.
IV. Support for solar PV should assess and respond to the impacts of deployment on: grid systems balancing; grid connectivity; and financial incentives – ensuring that the challenges of deploying high volumes of solar PV are addressed.

RESEARCH, DEVELOPMENT & DEMONSTRATION

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

Developing cost-effective storage solutions could also make a step-change in affordability and long-term potential for solar PV in the UK. A National Solar Centre has been established in Cornwall and is already becoming known as a centre of excellence for the development of solar technology.

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

SUPERSOLAR intends to set up a national solar cell efficiency measurement facility for the benefit of the solar PV community in the UK. EPSRC is also funding research improvements in solar cell efficiency, overall system performance, and analysis of whole life system costs via the SUPERGEN programme.

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

SOURCES OF FURTHER INFORMATION

DECC Renewables Statistics

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

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

Feed-in Tariff Statistics

Quarterly and Monthly data on capacity and installations

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

THE UNITED STATES OF AMERICA

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS

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GENERAL FRAMEWORK AND IMPLEMENTATION

The United States (U.S.) photovoltaic (PV) market development is supported by both national and state level financial incentives, yet state and local policies in support of increased solar deployment are more varied than national policies. Over the course of 2013, members of the national government outlined the potential for a national level clean energy standard that would mandate a certain percentage of the nation's energy portfolio be derived from "clean" sources. To date a national level mandate has not been implemented, however there have been individual state mandates successfully executed. Despite the lack of a unified national framework, existing policy at the national and state level has enabled PV to continue growing rapidly in the U.S. as a result of local and state initiatives, with the U.S. adding approximately 4,8 GW_{DC} of PV capacity in 2013. At the end of 2012, cumulative installed PV capacity in the U.S. totaled approximately 7,3 GW, bringing the U.S. cumulative installed total to approximately 12,1 GW [1].

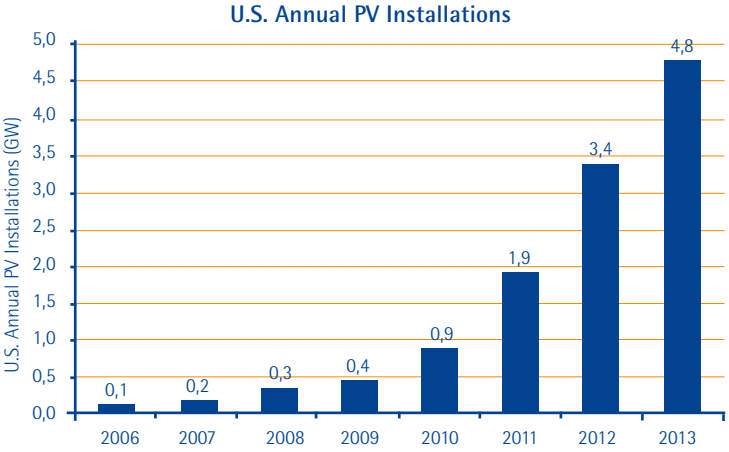

Fig. 1 – U.S. Annual PV Installations. Sources: 2006-2009: IREC, U.S. Solar Market Trends. 2010-2013: GTM Research/ SEIA, Q4 2013: U.S. Solar Market Insight. March 2014.

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. Third-party ownership has also gained significant popularity for financing the installation of PV systems, particularly in the residential sector, where in some markets it has achieved 70-80 % market penetration. In 2013 several third-party PV ownership companies issued innovative financing mechanisms to raise cheaper sources of capital through the public markets.

NATIONAL PROGRAM

The U.S. supports the domestic installation and manufacturing of PV generating assets for domestic consumption. Financial incentives for U.S. solar projects are provided by the national government, state and local governments, and some local utilities. Historically, national incentives have been provided primarily through the U.S. tax code, in the form of a 30 % Investment Tax Credit (ITC) (which applies to residential, commercial, and utility-scale installations) and accelerated 5-year tax depreciation (which applies to all commercial and utility-scale installations and to third-party owned residential, government, or non-profit installations.

In 2011, two additional national programs supporting PV expired. They included the grant in lieu of tax credit through Section 1603 of the American Recovery and Reinvestment Act of 2009 (ARRA), as well as the temporary loan guarantee program through the Department of Energy (DOE), which provides loan guarantees for renewable energy installations and manufacturing facilities for renewable energy components. Because the Section 1603 grants allow businesses to receive a grant for projects which began construction in 2011 but are completed before the end of 2016, this program continued to fund the deployment of solar assets in 2013. In addition, many of the manufacturing and solar installations which received loan guarantees in 2011 or earlier, continued construction or operation of those assets in 2013. Through this program the two largest PV installations in the U.S., as of January 2014, were completed; the 250 MWAC Agua Caliente Project in 2012, and the 250 MWAC California Valley Solar Ranch in 2013.

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. In 2013 Minnesota amended their RPS to include a mandatory amount of solar energy. As of January 2014 seventeen states and Washington D.C. had RPS policies with specific solar provisions.

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

RESEARCH, DEVELOPMENT & DEMONSTRATION

The DOE is one of the primary bodies that support research, development, and demonstration (RD&D) of solar energy technologies. In February 2011, the Secretary of Energy launched the SunShot Initiative, a program focused on driving innovation to make solar energy systems cost-competitive with other forms of energy. To accomplish this, the DOE is supporting efforts by private companies, academia, and national laboratories to drive down the cost of utility-scale solar electricity to about USD 0,06 per kilowatt-hour, and distributed solar electricity to at or below retail rates. This in turn could enable solar-generated power to account for 15–18 % of America's electricity generation by 2030 (assuming other systemic issues are addressed as well) [2]. 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.

[1] GTM Research/ SEIA. Q4 2013: U.S. Solar Market Insight. March 2014.

[2] U.S. Department of Energy (DOE). (2012). SunShot Vision Study. DOE/GO-102012-3037. Washington, DC: U.S. Department of Energy. Accessed 2013: http://www1.eere.energy.gov/solar/pdfs/47927.pdf

Fig. 3 - 67 kW (STC rating) photovoltaic array at the Mesa Verde Visitor and Research Center in Montezuma County, Colorado. The array consists of 286 Schott Poly 235 watt solar modules (13,8 % efficiency) wired in 22 series strings of 13 modules per string. Coupled with a micro-hydro system and solar water heating, the on-site renewable energy systems are capable of providing 95 % of the building energy requirements (Photo: Dennis Schroeder / NREL).

To achieve these goals the SunShot Initiative focuses on removing the critical barriers for the system as a whole, including technical and non-technical barriers to installing and integrating solar energy into the electricity grid. In addition to investing in improvements in solar technologies and manufacturing, the department focuses on integrating solar generated energy systems into the electricity grid and reducing installation and permitting costs. The DOE focuses on innovative technology and manufacturing process concepts as applied to PV. It also supports PV systems integration, by developing radically new approaches to reduce the cost and improve the reliability and functionality of power electronics; by supporting industry development through test and evaluation standards; and by developing tools for understanding grid integration issues. Emphasis is also placed on market transformation areas to quantitatively address non-hardware related balance-of-system costs including streamlined permitting, inspection, and interconnection as well as performing key analyses of policy options and their impact on the rapid deployment of solar technologies.

Examples of SunShot Initiative funded research and development activities in 2013 include:

- Working with small businesses to eliminating market barriers and reduce non-hardware costs and to encourage technology innovation to support SunShot goals.
- Working with industry, national laboratories and university researchers to advance the state of the art for solar forecasting, speed solar energy innovation, and lower costs and improve grid inter-connection.
- Working with utilities to develop adaptable and replicable practices, long-term strategic plans, and technical solutions to sustain reliable operations with large proportions of solar power on the grid.

RESEARCH	MUSD	92
DEVELOPMENT	MUSD	103
DEMONSTRATION	MUSD	28
DEPLOYMENT	MUSD	46
TOTAL	**MUSD**	**269**

Fig. 2 - Breakdown of Solar Energy Technologies Program FY 13 R&D Activities.

INDUSTRY AND MARKET DEVELOPMENT

From 2010-2013, the U.S market increased its annual installation by approximately 1 GW more than the previous year; growing in annual installations from 0,9 MW in 2010 to 4,8 MW in 2013 [3]. Much of the growth came from utility-scale installations. PV capacity continues to be concentrated in a small number of states, such as California, Arizona and New Jersey, each with more than 1 GW of cumulative installed PV. However, this trend is changing slowly as 15 states currently have 100 MW or more of PV capacity and 11 states each installed more than 50 MW in 2013 alone [4]. With more than 3,6 GW of PV projects under construction as of February 2014, that have individual capacities above 1 MW in size, total installations in 2014 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. Finally, state RPS targets require a larger amount of renewable energy additions in 2014 than in previous years, encouraging more growth within the market.

U.S. PV manufacturing, which had grown in shipments 10x from 2003-2010, continued to have challenges in 2013. Due to overcapacity issues in global PV manufacturing, which caused a rapid decline in price, many U.S. companies have found it challenging to stay competitive. In 2013 U.S. PV cell production was 478 MW, on par with 2011 and 2012 but 22 % below the 2010 peak of 611 MW. In 2013 U.S. PV module production was 988 MW, on par with 2012 but 25 % below the 2011 peak of 1,323 MW [5].

However, U.S. manufacturing has a significant presence in other part of the PV value chain, including polysilicon, encapsulants, wiring, and fasteners. Since 2010, the number of U.S. solar manufacturing jobs has increased by 20 %, or approximately 5,000 employees [6]. Additionally, manufactured hardware is only a portion of the total solar value chain. Industry-wide, approximately 50,000 jobs relating to solar were added from 2010 to 2013, growing to 143,000 employees (48 % of which were added in 2013 alone). The growth rate from 2012 to 2013 is ten times faster than what the overall U.S. economy experienced during that same time period [7].

[3] *GTM Research/ SEIA, Q4 2013: U.S. Solar Market Insight. March 2014.*

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[6] *Solar Foundation. (2014). National Solar Jobs Census 2013. Washington, DC: The Solar Foundation.*

[7] *Ibid.*

COMPLETED TASKS
TASK 2 - PERFORMANCE, RELIABILITY AND ANALYSIS OF PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 2 was to provide technical information on PV operational performance, long-term reliability and costs of PV systems, which is very important for an emerging technology. This service was given to a diverse target audience including PV industry, research laboratories, utilities and manufacturers, system designers, installers, standardisation organisations and the educational sector. Task 2 aimed to provide performance data for both general assessments of PV system technologies and improvements of system design and operation.

MEANS

Task 2 work was structured into seven subtasks in order to achieve the objectives.
These were achieved through the development and continuous update of the PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV power systems and subsystems. Task 2 also analysed performance and reliability data for PV systems and components in their respective countries. Activities included the work on the availability of irradiation data, performance prediction for PV systems, shading effects and temperature effects as well as long-term performance and reliability analysis, monitoring techniques, normalised evaluation of PV systems, user's awareness and quality aspects of PV system performance.

Subtasks 1, 5, 6 and 7 were terminated at the end of 2007, while Subtask 3 was concluded in 1999 and Subtasks 2 and 4 were terminated in 2004. Task 2 was officially concluded in 2007.

SUBTASK 1: PV PERFORMANCE DATABASE

Participants worked on the development and update of a PV Performance Database, an international database containing information on the technical performance, reliability and costs of PV systems and subsystems located worldwide. The information was gathered and presented by means of standard data collection formats and definitions. The database allows the comparison of components' quality, long-term operational results, analysis of performance and yields, long-term operational results, analytical calculations, yield prediction and checking of design programmes. A collection of such a variety of high quality operational data presents a unique tool for PV system performance analysis. The performance data are available at the IEA PVPS website: www.iea-pvps.org. In addition, the complete database programme can be downloaded from the same website.

SUBTASK 2: ANALYSIS OF PV POWER SYSTEMS (FROM 1999 TO 2004)

Participants analysed performance and maintenance data for PV power systems and components in their respective countries, both in order to ensure the quality and comparability of data entered in the database under Subtask 1 and to develop analytical reports on key issues such as operational performance, reliability and sizing of PV systems. Participants also compared existing data on operational reliability and developed recommendations on maintenance aspects.

SUBTASK 3: MEASURING AND MONITORING APPROACHES (FROM 1995 TO 1999)

Participants worked on a handbook covering PV system monitoring techniques, normalised analysis of PV systems and national monitoring procedures in the IEA member countries. This document covered measuring and monitoring in the context of PV systems and expanded in breadth and details the issue of monitoring. It helped orientating and relating technical explanations and details of existing experiences and guidelines. Available documentation on measuring and monitoring approaches was brought together and assessed for their scope and contents.

SUBTASK 4: IMPROVING PV SYSTEMS PERFORMANCE (FROM 1999 TO 2004)

Participants worked on recommendations on sizing of PV power systems and suggested improvements for better PV system performance. Participants identified tools to process and analyse data for performance prediction and sizing purposes. Applied energy management schemes were analyzed from the energy and operating cost points of view. Participants took account of the work performed in other Subtasks and worked in collaboration with Task 3.

SUBTASK 5: TECHNICAL ASSESSMENTS AND TECHNOLOGY TRENDS OF PV SYSTEMS

Participants analysed and validated expertise and performance results from grid-connected (GCS), stand-alone (SAS) and PV-based hybrid systems. The aims of this subtask were to demonstrate up-to-date performance validation criteria for a qualitative ranking of PV grid-connected, stand-alone and PV-based hybrid systems. It also identified high performance products, technologies and design methodology in order to foster the development of maximum conversion efficiency and optimum integration of PV. Activities included evaluating PV performance over time and failure statistics, analysing the end-user's consciousness on PV system performance and the use of satellite images for PV performance prediction.

SUBTASK 6: PV SYSTEM COST OVER TIME

Task 2 identified and evaluated the important elements, which are responsible for the life cycle economic performance of PV systems by investigating economic data for all key components of PV systems and by gathering information about real life costs of maintenance of PV systems. Participants worked on national case studies on performance and costs in their countries to provide a good insight of performance and cost trends of PV systems for a 10-year-period.

SUBTASK 7: DISSEMINATION ACTIVITIES

Task 2 put enhanced efforts to disseminate Task 2 results & deliverables to target audiences on the national and international level using websites, workshops & symposia as well as presentations at conferences and seminars. Task 2 deliverables range from the PV Performance Database to technical reports and conference papers. The public PVPS and Task websites enabled downloads and technical information to be provided quickly and cost-effectively to the users. The Task 2 website is available in eight different languages spoken by the Task delegates. For gaining information on the user profile and

customers of Task 2 deliverables, monthly download statistics were prepared on a regular, biannual basis.

Activities included seminar presentations, training courses for system designers and installers (Italy), European master course and university seminars to advanced students (France, Germany), conference contributions for national and international audiences as well as presentations and distributions of the Performance Database programme and other Task 2 deliverables.

Task 2 developed a web based educational tool in close cooperation with Task 10. This tool represented 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

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

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

SCOPE FOR FUTURE ACTIVITIES

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

A proposal was introduced at the 23rd IEA PVPS Executive Committee Meeting in Espoo, Finland, in May 2004.

The newly proposed programme objective has lead to the initiation of the new Task 11, "PV Hybrid Systems within Mini-Grids;" which received approval for its Workplan at the 26th IEA PVPS ExCo Meeting, October 2005.

DELIVERABLES - WHERE TO GET THEM?

All Task 3 reports are available for download at the IEA PVPS website:
www.iea-pvps.org

PARTICIPANTS

Thirteen countries supported Task 3 activities:
Australia, Canada, France, Germany, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the Netherlands, United Kingdom.

The Netherlands and Spain, due to national decisions during this period, halted their participation; respectively in 2001 and 2002.

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COMPLETED TASKS
TASK 5 - GRID INTERCONNECTION OF BUILDING INTEGRATED AND OTHER DISPERSED PHOTOVOLTAIC SYSTEMS

OVERALL OBJECTIVE

The objective of Task 5 was to develop and verify technical requirements, which served as the technical guidelines for grid interconnection with building-integrated and other dispersed PV systems. The development of these technical requirements included safety and reliable linkage to the electric grid at the lowest possible cost. The systems to be considered were those connected with a low-voltage grid, which was typically of a size between one and fifty 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

PARTICIPANTS

In total, 14 countries participated in Task 7, with representatives from all targeted groups: architects, building and PV industry, PV and building specialists and utilities.

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Task 7 deliverables: www.iea-pvps.org
Task 7 demosite: www.demosite.ch

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

Databases
Educational Tool of BIPV Applications from Idea to Operation.
Database of community and BIPV applications.

PowerPoint

Network Issues and Benefits Visual Tool

Workshops

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

DELIVERABLES - WHERE TO GET THEM?

All reports are available for download at the IEA PVPS website: http://www.iea-pvps.org and the Task 10 website: http://www.iea-pvps-task10.org

PARTICIPANTS

Fifteen PVPS members supported Task 10 activities: Australia, Austria, Canada, Denmark, France, Italy, Japan, Korea, Malaysia, European Union, Norway, Portugal, Sweden, Switzerland and the USA. Moreover, through PV-UP-Scale, Germany, The Netherlands, Spain and the United Kingdom made contributions to Task 10 work.

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COMPLETED TASKS
TASK 11 – HYBRID SYSTEMS WITHIN MINI-GRIDS

INTRODUCTION

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

TASK 11 STRATEGY AND ORGANIZATION

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

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

SUBTASK 10: Design Issues

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

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

SUBTASK 20: Control Issues

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

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

SUBTASK 30: PV Penetration in Mini-Grids

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

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

SUBTASK 40: Sustainability Conditions

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

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

TASK 11 KEY DELIVERABLES

Task 11 completed the majority of its Workplan. The following deliverable reports were published:

1 Worldwide Overview of Design and Simulation Tools for PV Hybrid Systems - T11-01:2011
2 The Role of Energy Storage for Mini-Grid Stabilization - T11-02:2011
3 Sustainability Conditions for PV Hybrid Systems: Environmental Considerations - T11-03:2011
4 COMMUNICATION BETWEEN COMPONENTS IN MINI-GRIDS: Recommendations for communication system needs for PV hybrid mini-grid systems - T11-04:2011
5 Social, Economic and Organizational Framework for Sustainable Operation of PV Hybrid Systems within Mini-Grids - T11-05:2011
6 Design and operational recommendations on grid connection of PV hybrid mini-grids - T11-06:2011
7 PV Hybrid Mini-Grids: Applicable Control Methods for Various Situations - T11-07:2012
8 Overview of Supervisory Control Strategies Including a MATLAB® Simulink® Simulation - T11-08:2012

DELIVERABLES – WHERE TO GET THEM?

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

PARTICIPANTS

In the final year of the Work Plan, eleven IEA PVPS countries participated in Task 1I: Australia, Austria, Canada, China, France, Germany, Italy, Japan, Malaysia, Spain, and the USA. The management of the Task - the Operating Agent - was executed by Canada.

SUBSEQUENT ACTIVITY

PVPS Task 9 has taken on the dissemination and further development of several of the Task 11 results and activities.

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TASK 14 – HIGH-PENETRATION OF PV SYSTEMS IN ELECTRICITY GRIDS

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