



PV POWER

Newsletter of the IEA Photovoltaic Power Systems Programme



**AUGUST
2008**

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More than mere kWh: Toronto artist, Sarah Hall, has created a stunning and inspiring installation, 'Lux Nova', for the University of British Columbia's Regent College. The feature challenges viewers to explore the connection between the beauty of art and the preservation of our planet and its resources. The stained-glass tower incorporates an array of solar cells, collecting energy during the day to illuminate the park at night. The luminous column flows like a waterfall in silvery blues, violet and white, acting as a warm, glowing beacon for the community.

[CREDIT: SARAH HALL / JEFFREY KRAEGL]

MORE THAN JUST KILOWATT HOURS

It is not always obvious why governments and policy makers should set strong market incentives to promote PV or why different customer groups and electricity utilities should invest in PV systems or PV electricity. The added values of PV – those assets other than the simple generation of electricity, including positive impacts on the electricity network, building function and aesthetics, environmental benefits, employment creation and energy self-sufficiency – have been discussed for a number of years. Over that period, policy makers, lobbyists and others have been unified in their call for one key element: quantification of these values. A new report from IEA PVPS Task 10 bravely answers this call.

Currently, grid-connected PV appears to be an expensive option for producing electricity compared to other energy sources and depends upon financial support in a range of guises to achieve accelerated market deployment. Consequently policy makers and governments strongly influence the market penetration of PV technology with their decisions. Value analysis can provide guidance to the policy makers and governments involved in setting financial incentives and market deployment strategies for PV.

At the customer level, two issues are of key importance in achieving increased demand for PV: on the one hand, increasing the customer's voluntary willingness to pay

(WTP) and, on the other, reducing costs for customers. As WTP is directly related to the particular added values that are significant for each individual, an understanding of how to influence demand requires a good understanding of the added values as perceived by different groups of customers.

Task 10 set itself the goal of identifying, quantifying and evaluating the values and benefits of urban scale PV. The findings, including some 30 figures and a dozen tables of data, are presented in the report 'Analysis of PV systems' values beyond energy, by country and stakeholder'.

The value analysis involved the derivation of a general methodology that is applicable for all countries analyzed. The countries involved in this study include Austria, Canada, Denmark, France, Germany, Japan, the Netherlands, Spain, Sweden, Switzerland, the United Kingdom and the United States. Quantifiable examples are used to demonstrate country specific differences and perceptions.

The main stakeholders influencing the demand for grid-connected PV are customers, utilities, policy makers and governments, each having their own concerns and preferences when it comes to PV's added values. PV customers can broadly be defined as the group of people who purchase a PV system and/or purchase PV electricity. Consequently two markets are evident – one for PV systems and another for PV electricity. At the same time, the stakeholders groups may be considering PV from multiple perspectives: an electricity utility, for example,

can purchase a PV system or promote the purchase of PV electricity. A householder can be a PV system owner or a purchaser of PV electricity.

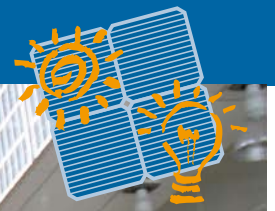
CUSTOMER BENEFITS

For residential customers the most important values are environmental aspects, image and prestige, reliability of PV systems, system modularity, independence with regard to their power supply and the corresponding price benefits. Commercial customers are interested in not only making money with PV but also additional benefits such as prestige, image or supply security. Architects identify PV mainly as a building element with multifunctional characteristics such as shading, roofing or material saving. The innovative design features, for example colour, shape or transparency, or the thermal performance characteristics of PV such as heating, ventilation or insulation, may also inspire this group to make use of PV systems.

Some attributes of photovoltaics could become more important for electricity suppliers or distributors in the future, for example PV as an opportunity for new markets and business, or to improve the image and prestige of the utility. An increasing number of utilities are offering green power products as a distinguishing element in liberalized and competitive markets. The potential for PV to contribute to peak electricity demand reduction is also an important value from the electricity utility point of view. Whereas the benefits of PV for each interest group

IEA PVPS-PROGRAMME EXTENDED

In December 2007 the Committee on Energy Research and Technology (CERT) of the International Energy Agency (IEA) agreed to extend the term of the Implementing Agreement for a Co-operative Programme on Photovoltaic Power Systems until November 2012. Given the current impressive growth rates of the international market for PV systems, the increased awareness of global climate change issues and the dire need for energy remaining in so many parts of the world, the Programme's attention over the next term will require a balancing act – accelerating market introduction of PV on the one hand and staying in the region of pre-competitive research on the other. This is embodied in the mission of the Programme: To enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option.



PV makes an architectural statement at the Matsumoto Station, Matsumoto City, Nagano Prefecture, Japan. [PHOTO: RTS CORPORATION]

outlined above are in fact a part of the whole sum of societal benefits, policy makers and governments mainly focus on the issue of avoiding fossil fuels in order to contribute to supply security and to secure the environmental benefits, in addition to the promotion of industry development and creation of new job opportunities.

QUANTIFYING THE BENEFITS

Of the countries involved in the study, the highest greenhouse gas emission reduction factors occur for the United Kingdom where

1 kWh of PV electricity contributes to the avoidance of 1 048 g of CO₂ from coal-fired power plants, while Spain shows the highest reduction with respect to the air pollutant NO_x (1 kWh of PV electricity contributes to the avoidance of 6,89 g of NO_x). The total reduction of the external costs of fossil power generation – referring to CO₂, NO_x and SO₂ emissions – by PV electricity was calculated, with Spain recording a high monetary value of 0,0995 EUR/kWh, while in the Netherlands with its gas-based electricity supply system the corresponding

value is 0,0286 EUR/kWh. To round off this quick snapshot, it is estimated that by 2020 in Germany alone PV market turnover will reach 15,2 billion EUR. At present, an estimate of 30 000 German jobs can be apportioned to the PV sector.

Analysis of PV Systems' Values Beyond Energy, by Country and Stakeholder has been prepared by the Energy Economics Group of Austria as a collaborative activity for IEA PVPS Task 10 and the European research project PV UP-SCALE. Copies of the report can be downloaded from www.iea-pvps.org.

PV ADDED VALUES IN A NUTSHELL

Why should policy makers and governments set financial incentives and market development strategies for PV systems?

PV systems have a wide range of important added values which move societal welfare towards sustainability, notably:

- using a globally abundant and locally available fuel source (the sun).
- contributing to supply security through avoidance of (imported) fossil fuels and hence reducing fuel price risks.
- reduced greenhouse gas emissions and air pollutants.
- the opportunity to develop a new industry, creating export possibilities and local jobs.

Why should residential and commercial customers be willing to pay more for this technology?

- PV systems are noiseless, relatively maintenance free, reliable and easy to install.
- customers can demonstrate their environmental awareness by using a visible environmental technology as part of their building.
- building material costs can be saved while at the same time PV generation can provide the whole or part of the electricity needs.
- PV systems can provide individual energy independence.

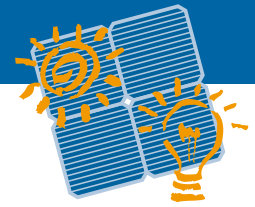
Why should utilities invest in PV systems or PV electricity and/or support their customers' use of PV?

- PV can contribute to reduction of peak electricity demand.
- PV electricity is available at times when electricity prices tend to be high in the spot market.
- PV electricity can reduce the environmental cost burden associated with CO₂ certificates and the like.
- PV creates a green image and offers new business opportunities.

Why might architects and building developers consider PV systems in their building designs and urban planning?

Because PV systems:

- are an innovative design feature of a building.
- offer multifunctional design features such as weather protection, shading or sound proofing in addition to electricity generation.
- contribute to improving the thermal performance of a building, for example by preventing overheating or increasing daylight.
- offer a wide range of colours, shapes and transparency possibilities.
- increase the prestige of a design or development.



PV IN NEW RESIDENTIAL CONSTRUCTION

The new residential construction sector has an important role to play in supporting more widespread deployment of building integrated photovoltaic (BIPV) technology. To date the PV industry has had limited awareness of how best to encourage this sector's acceptance of BIPV. Task 10 is working to address this shortcoming via a newly-published report, Urban BIPV in the New Residential Construction Industry.

Task 10's remit is to enhance the opportunities for wide-scale, solution-oriented applications of PV in the urban environment as part of an integrated approach that maximizes building energy efficiency alongside solar thermal and PV usage. The long-term goal is to see PV accepted as a desirable and commonplace feature of the urban environment in IEA PVPS member countries.

Aimed primarily at representatives of the PV industry, the construction industry and policy makers, the new report covers a range of pertinent topics, from innovation in the context of the residential construction industry and BIPV considerations for residential building typologies, to proposed PV industry and policy based solutions to encourage BIPV. It also provides an analysis of new residential BIPV potential in the participating countries.

RESIDENTIAL CONSTRUCTION IN FOCUS

While certain companies and some parts of the construction sector are very progressive, the industry as a whole can be considered a laggard when it comes to sector-wide innovation where multiple firms are required to change their processes and perspectives. The adoption and diffusion of BIPV technology to date reflects localized innovation and as such a focus on 'early adopter' residential building companies rather than a generalized approach to the broad building industry can, particularly in young markets, result in greater deployment of BIPV.

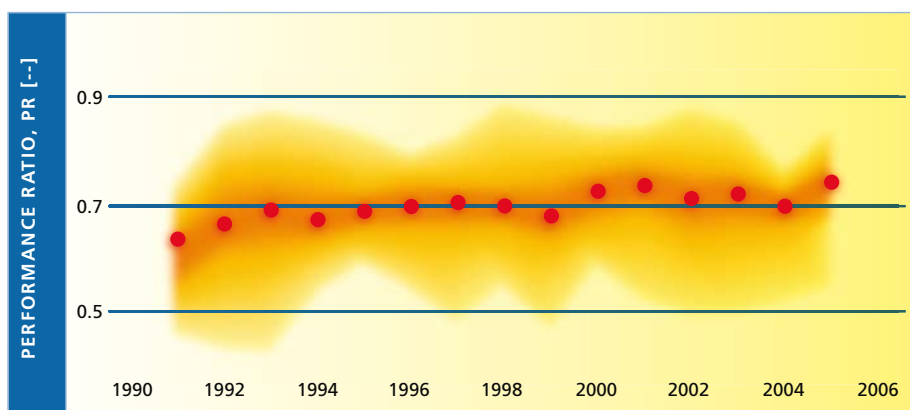
Different building types with their various dimensions and geometries, construction models and ownership structures require different approaches to BIPV. The three main types of building discussed are single family detached, single family attached and

multi-unit housing. Each presents its own challenges for the development of creative technical, policy and marketing solutions to encourage increased BIPV uptake.

THE BIG PICTURE

On the macro scale, data were also analyzed with respect to the number of dwellings in the residential building stock, the annual dwellings constructed and PV market growth rates in the respective countries. A wide range of market potential exists for the new residential construction sector when compared to the existing annual distributed grid-connected PV market. Canada, Norway, Portugal and Sweden each have high potentials, due to the combination of a small existing grid-connected PV market and a strong construction market. Japan and Germany have the two smallest relative potentials, due primarily to their very large current annual PV markets in comparison to their new annual residential construction. Japan warrants further study because of the historical success of its support mechanisms focusing specifically on the residential market. More broadly, case studies of large scale

CRUNCHING THE NUMBERS



The performance ratio of 461 monitored systems shows an upward trend from 0,64 in 1991 to 0,74 in 2005.

Task 2, which undertakes analysis of cost and performance trends in grid-connected PV systems, has recently compiled the findings of its Economic Survey of installed systems. As one would hope, the data covering the past fifteen years shows a trend towards lower system costs, plus indications of increased performance.

527 datasets provided useful economic information for the period from 1992 to 2006. Over that time the average system cost was halved from 16 USD per watt to 8 USD per



Pal Town Jyosai-no-Mori in Ota City, Gunma Prefecture is a prime example of an intensive PV integration into newbuild housing. The development totals over 2,1 MW across 553 houses.

[PHOTO: OTA CITY LAND DEVELOPMENT CORPORATION]

deployments of PV in a variety of new residential building markets will promote better understanding of aspects of relevance to the building industry.

THE WAY FORWARD

Key issues and solutions to encourage the adoption and diffusion of BIPV by the new home building industry, some best described as PV industry-based approaches and others as policy-based solutions, have been identified.

The PV industry-based solutions include:

- providing PV customers to the building industry by promoting end-user support strategies.
- identifying and targeting early adopter builders to provide focus in the development of both policies and market structure.
- creating product solutions that meet the needs of the building industry, such as meeting regular building standards at the very least.

- approaching the residential building industry directly to provide appropriate support.
- engaging the construction industry in the design and planning stages of the residential building or development.

On the policy side, solutions broadly include:

- developing policies that provide incentives directly to the residential building industry in order to encourage them to offer PV to their customers.
- developing a planned approach to the demonstration of BIPV in the new home building sector.
- developing specific policy measures for the promotion of BIPV.

Urban BIPV in the new residential construction industry has been prepared by David Elzinga of Natural Resources Canada under the supervision of IEA PVPS Task 10 and in co-operation with the Task 10 national experts. The report can be downloaded from www.iea-pvps.org.



watt. The location, size, type of project, use and mounting arrangements varied greatly across these systems and subsequently there was a wide range of values for each year. The annual mean values do not follow a linear trend – in fact for the earlier years there is no discernible trend, while from 1999 to 2002 there was very little change. However, from 2002 to 2005 a steady decrease in costs is evident. All components of a grid-connected system – modules, inverter and other balance of system components – were shown to have contributed to the reduction of system costs over time.

An analysis of 461 grid-connected PV systems built between 1991 and 2005 shows a trend towards both higher inverter efficiency and a higher performance ratio over time. With a total of 1 544 operational years, most of these systems are domestic PV plants smaller than 10 kW and most are located in Germany, Japan and Switzerland. Contributing factors to the improved performance ratio are the increasing inverter efficiency over time and also less frequent downtime of the systems. The report summarising these findings also contains national case studies on topics such

as system costs, annual yield trends, performance trends and maintenance statistics. A unique contribution from Japan describes the low failure occurrence in residential PV systems with only 12 % of systems reporting any failure occurrence and half of these being reported in the first year of operation – some 84 % of problems being associated with the inverter. More information on this activity and other work of Task 2, can be found on www.iea-pvps.org.

IN BRIEF

DENMARK

Recently finalized political negotiations on energy have resulted in a decision to allocate 100 million DKK over four years to photovoltaics, wave power and other emerging renewable energy technologies. The majority of this support is expected to go to PV with the first call for proposals to occur during this year. This is the first new support mechanism for PV in Denmark since 2001.

GERMANY

As reported in PV Power #27, the German feed-in tariff system is undergoing an overhaul. A further innovation is the definition of a 'growth corridor' for the next few years, coupled to variable degression rates. This provides some flexibility for self-correction of the feed-in tariff. In a nutshell, if the market grows more quickly than expected (i.e. new installed capacity exceeds the upper limit of the growth corridor), the feed-in tariff available for systems installed the following year will be less than if the market grows as anticipated. On the other hand, if the German PV market cools in a given year and growth is below the lower limit of the corridor, the tariff reduction for the following year will be lessened.

Other modifications to the FIT design include the cancellation of the bonus for facade-integrated systems, and a requirement for the location and capacity of all systems to be registered before they can be connected to the grid.

ISRAEL

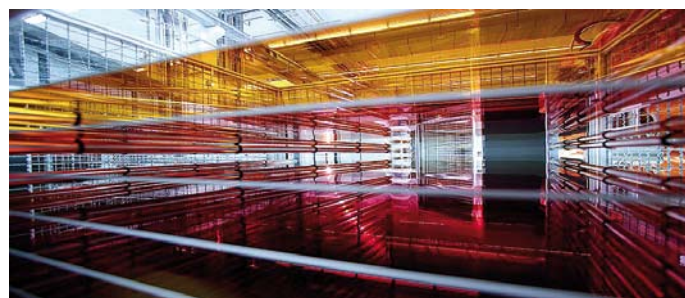
In March the Government announced an initiative to accelerate the deployment of solar technologies in the country. Entities and consortia from Israel and abroad have been invited to participate in the pre-qualification stage of tenders for solar thermal plants in Ashalim in the Negev region.

Two solar thermal power plants, with an aggregate capacity up to 250 MW, have been requested. The project also mentions a more modest PV component that could see an installed PV capacity of 15 MW with an option to increase this by an additional 15 MW. It is anticipated that a license will be granted under Israel's Electricity Sector Law for the finance, design, construction, operation, maintenance and transfer to the State of Israel after a period of no more than 25 years.

MALAYSIA

So far, 2008 has been an active year for PV in Malaysia. On the industry side, the Government has approved a plan for a new 300 MW plant by a major German cell manufacturer. Meanwhile a US-based thin film manufacturer has started construction work on a 620 million USD plants in Kedah. Pusat Tenaga Malaysia (PTM) has been recognized as the first organization in the ASEAN countries to achieve Institute for Sustainable Power (ISP) accreditation for training related to design and construction of grid-connected PV, with the first courses held in February and May 2008. Mirroring all this activity, the first PV Finance and Investment Forum was held in Kuala Lumpur in March this year as part of the MBIPV Project and attracted over 200 participants for the one day event.

Industrial equipment for amorphous and micromorphous thin film silicon cell production. [PHOTO: OERLIKON SOLAR]

**SWITZERLAND**

From May 2008 Swiss producers of renewable electricity from photovoltaics, hydro power (up to 10 MW), wind power, geothermal power and biomass energy can register their facilities for financial remuneration via feed-in tariffs. The Federal Office of Energy has now defined the details of the registration process and the annual quota for photovoltaic energy has been set. From 2009 feed-in remuneration will be granted for electricity which is produced from renewable energies and fed into the Swiss electricity grid. The revised Energy Act contains a package of measures aimed at promoting renewable energies and energy efficiency, the mainstay of which is the compensatory feed-in remuneration scheme for electricity generated from renewable energies. The feed-in tariffs will be funded by a surcharge of up to 0,006 CHF/kWh levied on high-voltage grid transmission costs from 1 January 2009. It is expected that this will generate funds of the order of 320 million CHF per year.

SWEDEN

By the end of 2007, and with one year remaining for the support scheme for PV in public buildings to run, the cap of 150 million SEK was nearly reached. The interest in PV has increased dramatically due to this support measure but with a high level of uncertainty regarding its continuation the market is running the risk of collapse in 2009. The PV in-



Some 80 kWp is installed at the Båstad Tennis arena, home of the Swedish Open tournament. [PHOTO: GLACELL/SHARP]

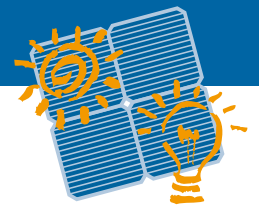
stallers that have entered the market are looking elsewhere for business as they cannot rely solely on the Swedish PV market unless a longer-term support scheme is put in place.

UNITED KINGDOM

The Government announced its intent in 2007 that all new homes in the UK be 'zero carbon' by 2016. A key measure underpinning the drive for a step-change in sustainable home building practice is the 'Code for Sustainable Homes'.

A 1 to 6 star rating system will indicate the overall sustainability performance of a new home. As of May 2008 it is mandatory for all new-build houses to have a rating against the Code, although at this stage that does not make it mandatory for builders to go beyond the current building regulations; they may instead opt to accept a 'nil-rating'. Evidently at this stage it is expected that the market for sustainable homes will derive from better informed buyers purchasing homes that have been (voluntarily) built to higher environmental performance standards. At the same time, it is expected that there will be progressive tightening of standards for energy efficiency of buildings. Although the definition of zero carbon remains a topic of discussion it is likely that in the future new buildings may need to meet 100% of their energy needs from on site renewable energy generation. Since PV is ideally suited for building integrated applications it is likely that this will increase demand for PV and support industry growth. A recent independent report estimated that the zero carbon homes requirement could increase the number of PV systems from around 2300 in 2007 to over 1 million in 2020.

For further information contact the relevant national newsletter representative (see list on P7).



PVPS NEWS

IEA PVPS @ EUPVSEC IN VALENCIA

The IEA PVPS Programme is planning to have a strong presence at this year's EUPVSEC to be held in Valencia in September. Presentations and posters will highlight work underway in many of the Programme's tasks. Publications and other material will be freely available from the IEA PVPS stand at the exhibition – please visit us!

Special interest workshops are also being developed:

■ 'The status and development of software tools for PV hybrid and mini-grid systems' is being developed by IEA PVPS Task 11 and is aimed mainly at developers of software design and simulation tools for PV



5,6 kW PV array of a PV-Wind-Diesel hybrid system installed at the Biodiversity Reserve on Contoy Island, near Cancun. [PHOTO: CONERGY MEXICO]

systems, renewable energy systems and electrical distribution systems, and the expert users of these tools from industry, research institutes and academia.

■ 'Grid parity and beyond' is a joint effort of Tasks 1, 8 and 10 and will look at the issues remaining for sustainable market deployment of PV as it moves towards parity with retail electricity prices and onwards towards competitiveness with centralized power generation.

Advance information on these events will be made available via the website www.iea-pvps.org

NETWORK VISUALIZATION TOOL

Too busy to re-read that electrical engineering text book? Struggling to explain electricity network concepts to the uninitiated? Need a refresher on overvoltage and undervoltage, harmonics, unintended islanding, peak power and distributed generation? Task 10 has produced an animated power point presentation that is refreshingly simple yet clearly highlights the effects and impacts of PV grid interconnection, aimed at any stakeholder not familiar with power electronics and transmission / distribution theory. The visualization tool has been developed by Japan's Mizuho Information and Research Institute on behalf of Task 10.

Further information is available from www.iea-pvps.org.

NEW ON OUR WEBSITE

The IEA-PVPS website holds numerous PV-related statistics, reports, news and other features to view or download. The site is regularly updated.

The site has recently been given an overhaul. We have largely retained the familiar look and feel, but have simplified the navigation, improved the internal search capabilities and introduced some new features to make it easier for visitors to find the essential new content.

Recent additions include:

- > The Annual Report for 2007
- > Three New Reports:
 - Performance Prediction of Grid-Connected PV Systems Using Remote Sensing*
 - Urban BIPV in the New Residential Construction Industry*
 - Analysis of PV Systems Values beyond Energy*

Visit www.iea-pvps.org

DIARY DATES...

23rd European PVSEC
Valencia, Spain

1-5 September 2008

☛ WIP-Renewable Energies

Tel: +49 (0)89 7201 2735

www.photovoltic-conference.com

ISES 3rd Asia Pacific Congress
Sydney, Australia

26-28 November 2008

☛ ISES

Tel: +49 (0)761 459 060

www.ises.org

10th China Solar PV Conference & Exhibition

Changzhou, China

27-30 September 2008

☛ Trina Solar Energy Co. Ltd.

Tel: +86 (0)519 8517 6050

www.trinasolar.com

18th International PV Science & Engineering Conference

Kolkata, India

19-23 January 2009

☛ Indian Association for the Cultivation of Science

Tel: +91 33 2473 6612

www.pvsec18.in

Solar Power 2008

San Diego, USA

13-16 October 2008

☛ Solar Electric Power Assoc.

Tel: +1 202 857 0898

www.solarpowerconference.com

7th Solar Silicon Conference & PV Technology Show 2009

Munich Germany

3-6 March 2009

☛ Solar Verlag GmbH

Tel: +49 (0)241 4003 146

www.photon-expo.com

IEA-PVPS NEWSLETTER

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If you have any comments or require further information about any articles appearing in PV Power, or if you have suggestions for new features, please contact your national representative. Full contact details are provided on the PVPS website.

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ITALY Salvatore Guastella

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KOREA Kyung-Hoon Yoon

MALAYSIA Wei-nee Chen

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PV POWER

PV Power is the newsletter of the IEA PVPS Programme. It is prepared by IT Power under supervision of PVPS Task I.

This newsletter is intended to provide information on the activities of IEA PVPS. It does not necessarily reflect the viewpoints or policies of the IEA, IEA PVPS Member Countries or the participating researchers. Articles may be reproduced without prior permission, provided that the correct reference is given.

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FITZGERALD MEMORIAL AWARD

Johnny Weiss from Solar Energy International (SEI) was announced the winner of the inaugural Mark C Fitzgerald Memorial Award at a special ceremony during the New Ideas in Education Conference held in New York in March.

The award is presented by the Institute for Sustainable Power (ISP) in recognition of an individual's dedication to promoting quality renewable energy training.

Johnny is co-founder and Executive Director of SEI, a non-profit organization established in 1991 to offer education and technical assistance to help people use renewable energy (RE) resources and natural building technologies. With over 20 years' experience teaching the practical applications of solar, wind and water power, he received the award for his long-standing commitment to excellence in RE training.

Mark Fitzgerald was the global champion of the development and application of professional standards to the training of renewable energy practitioners. Mark's goal was to contribute to a step-change in the

SEI uses a hands-on approach with commercial products and practical installations. Since 1991, over 5 000 people from all US states and close to 70 countries have attended SEI's Renewable Energy Education Program. SEI currently runs some 75 classes each year. The majority are hands on, but the organization now also offers various online courses. Some 2 000 participants now attend workshops and online courses each year. Approximately two-thirds of all the classes relate to photovoltaic technology. Contact sei@solarenergy.org



Johnny Weiss (right) accepts his award from ISP's Geoff Stapleton.

successful installation of RE systems. Having identified a serious and unaddressed gap in the quality of installations resulting from a lack of adequate training for system integrators and installers, he launched the not-for-profit ISP in 1995. Under Mark's leadership, ISP prepared an international standard and commenced an application and audit process to ensure continuity, consistency, and quality in the delivery of PV training, and subsequently expanded this to include other RE technologies. Mark was an active and long-term member of IEA PVPS, particularly in respect of Task 9's developing countries work, until his death in June 2005. Via ISP his work continues and this annual prize has been established by the world's renewable energy community in memory of him.

HELP FROM ABOVE

With the upsurge in large-scale PV power plants and a general increase in PV's market penetration, the PV industry today faces challenges to deliver secure and reliable power while managing uncertainties relating both to fluctuations of the solar energy source and also to the complete energy conversion process. Meeting the challenge requires accurate and timely information on the availability of the solar resource as well as data on other parameters affecting the energy yield, such as shading and equipment characteristics.

A new report from IEA PVPS Task 2, Performance Prediction of Grid-connected Photovoltaic Systems Using Remote Sensing, explores the possibility of using solar irradiation calculated from satellite images for performance predictions. Remote sensing from satellites offers an attractive and competitive approach for delivering data sets of global energy resources as large areas of the earth's surface can be monitored at high spatial (3x3 km²) and time resolutions (15 minutes) using uniform and consistent methodologies. In addition, different system performance evaluation models have been described and the results from a simple

parametric model are compared with measurements from selected systems found in the Task 2 Performance Database. The parametric model chosen to illustrate the confidence that can be given to a simple approach requires no additional input data other than the temperature and irradiation from the HelioClim-2 irradiation database. After choosing the appropriate period a simple polynomial model calibrated for the selected system and monthly input data from the irradiation database yields monthly PV production predictions within 15 % of the measured output. Copies of the report can be downloaded from www.iea-pvps.org.

