



PV POWER

Newsletter of the IEA Photovoltaic Power Systems Programme



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Window of Opportunity; what will the future hold for PV and IEA-PVPS? The PVPS Conference in Osaka will help to define future industry and market development strategies (see page 2). [PHOTO: DE BOER & VAN TEYLINGEN]

PV SECTOR EVOLUTION DEMANDS NEW PVPS APPROACH

PV business is rapidly expanding worldwide; at the same time interest in, support for, as well as the urgent need for more sustainable and secure energy services present a 'window of opportunity' for PV to establish itself as a well-recognised and widely accepted energy technology. PVPS has a critical enabling role in this process.

Since the inception of the PVPS Implementing Agreement in 1993, photovoltaic technology and the markets for PV have changed enormously. Awareness of PV's role in delivering sustainable energy services, and knowledge of the factors that govern its successful application have also evolved over the last decade, strongly assisted by the IEA's collaborative PVPS initiative. However, PVPS's job is far from complete.

It is fair to say that PV is technically mature today for use in decentralised energy systems and small scale energy production. While industry continues to pursue technological development – to improve system efficiency and product durability, streamline manufacturing and develop new products and devices – PV is still very much in its infancy in terms, for instance, of the extent of manufacture, supply, distribution and support chains, the number of customers reached, the amount of energy services de-

livered or the overall contribution to global energy supply. More widespread implementation across the various application areas, such as building integrated systems on an urban scale, medium and large size grid-connected systems, support of weak grids and the delivery of energy services in developing countries, present many technical and non-technical issues that still need to be addressed.

This also demands the involvement of a far wider range of stakeholders than in the past, as well as requiring better interaction with other energy and building related technologies and increasingly with customers. This in turn presents a whole new raft of stakeholder needs for information, tools and resources as well as further technological and product development (see box).

PVPS's future role will therefore focus on addressing these needs to promote and facilitate this cross-sectoral awareness and engage a broader participation in PV market development. International co-operation within the IEA-PVPS framework can contribute to resolving some of these aspects by collectively defining and addressing the key issues and undertaking collaborative collection of information, research, analysis, establishing recommended practice and disseminating well targeted information.

Panta Rhei houses in Nieuwland, Amersfoort, the Netherlands by architect Van Straalen. [PHOTO: ECOFYS]

The PVPS Osaka Conference provides an excellent opportunity for the various stakeholder groups to discuss and refine the PVPS future strategy and to resolve how the Programme can contribute most effectively towards large-scale implementation and the transition to self-sustaining markets.

PVPS - MEETING THE NEEDS OF A BROAD RANGE OF STAKEHOLDERS

- Continued objective and independent information collection and analysis of the main technological trends, new products and applications, market development, implementation activities, standards, training, education, as well as policy development;
- Collection and analysis of experience gained in technical and non-technical areas and formulation of lessons learned;
- Contribution to cost reductions by evaluation of PV systems to help establish meaningful guidelines for system design with respect to the actual needs of the system owner;
- Optimisation of system oriented approaches, with a stronger focus on the related framework (e.g. the building, the energy management system, etc.);
- Reliability and durability of photovoltaic power systems;
- Technical issues of grid-connected photovoltaic power systems in weak grids;
- Innovative and adapted financing and marketing initiatives;
- Quality assurance and standards, training and education, certification;
- Support and monitoring in all aspects of large scale demonstration activities;
- Supporting the development of PV towards competitiveness with other sources of electricity supply;
- Facilitation of the development and deployment of policies and programmes to accomplish the transition to unsubsidised markets and the aggregation of fragmented developing country markets.





JAPAN SEES FIERCE COMPETITION AHEAD

When it comes to forward thinking on PV, it seems that Japan has been leading the way for much of the last decade. Within Japan, industry insiders – in common with PVPS – see activation and stimulation of a broad demand for PV as a key focus for the industry over the next few years. Several years of fierce industry competition are also predicted.

Despite the relatively poor health of the Japanese economy at the present time and a comparatively austere FY2003 budget for PV development and promotion (down 30 % from FY2002), Japan's PV industry has good reason to be cheerful. The main programme of support for residential PV system dissemination, which was scheduled to end in April, will now continue until the end of FY2005 and seems likely to be supplemented by additional local government funds. This should be sufficient to sustain the current residential demand, while other

aspects of the government's PV plan continue to assist cost reduction and general raising of awareness of PV's role in Japan's future energy supply.

But Japanese industry, like the rest of the world, cannot afford to relax. The residential programme extension and other support initiatives should be viewed purely as 'breathing space' for industry to position itself for independence from government subsidies. There is a weight of expectation on PV, and the industry has a short timeframe to show that it can deliver. This will be achieved through two routes; continued cost reduction and broad cultivation of demand for PV in a variety of existing and new markets.

Significant module cost reductions do seem to be close at hand. The cell production capacities of the main manufacturers (mainly but not only in Japan) are now approaching volumes that will bring clear economies of scale. Indeed we are perhaps witnessing the start of a new era of fierce

competition; in Europe, for instance, at the current time it is possible to buy Japanese modules – even in relatively small volumes – for less than 2,5 EUR/W (compare this to typically 4 EUR/W two years ago.)

Nevertheless, it is not necessarily only the biggest that will survive, nor will module price reductions alone see PV delivering on its promise. Identification and delivery of marketable products for the new users (construction and other industries, transport sector, consumer applications, energy service companies, for instance) together with price reductions in balance of systems components, installation, operation and maintenance is where innovation and new strategic alliances will bring rewards.

The next three years may well mark a watershed for the PV industry worldwide. Japan is readying itself; the rest of the world would be wise to pay attention.

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IEA

WHO BUYS SOLAR?

Since 1998, SEDA – the Sustainable Energy Development Authority of New South Wales (NSW), Australia – has surveyed over 800 owners of residential solar power systems who have applied for a rebate under the state government's Solar Power Rebate Programme. The survey data have been collated and analysed and are now available as a summary report and supplementary CD-ROM.

The dominant indicator shows that the vast majority of PV users are located in non-metropolitan (i.e. mainly off-grid) areas. The study might therefore be (mis)interpreted

as being peculiar to Australia; but IEA-PVPS data attests that 10 other PVPS countries, including the USA, have a higher percentage of off-grid domestic PV than Australia, so read on...

Other indices show that the majority (57 %) of owners are male, with only 16 % female (the remainder describing themselves as part of a couple), and a much higher than expected proportion are in the 40-60 age-group (63 %) when compared to census indicators. Purchasers (over 50 %) tend to be from professional backgrounds, with less than a quarter describing themselves as from blue-collar backgrounds. Households are generally 1-2 persons, and perhaps most surprisingly, those with a combined

annual income of less than AUD 30 000 (USD 18 000).

The main motivation for investing in PV was necessity, but environmental concerns were an important driver, particularly among younger white-collar workers in metropolitan areas, and particularly since October 2000.

From the promotion perspective, the most effective publicity tool was word of mouth, with magazines and suppliers also stimulating interest.

Copies of the summary report together with the detailed data tables on CD can be purchased from SEDA for AUD 55.

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PUBLIC POLICY & PV PROMOTION

With the number and variety of policy approaches for promoting grid-connected PV ever increasing, one of the important roles for IEA-PVPS is to provide policy decision makers with resources to assess the positive and negative aspects of the options as well as information about the added-values of PV which might underpin such policy decisions.

This has been documented in several IEA-PVPS reports, notably 'Market deployment strategies for PV systems in the built environment'; 'Photovoltaics in Competitive Electricity Markets'; 'Added Values of Photovoltaic Power Systems' and the series of international survey reports 'Trends in Photovoltaic Applications' (see page 8 for details). Nevertheless, policy makers have largely been slow to incorporate added values in emerging renewable energy policies and programmes. There are many questions still to be answered, and demonstrations of 'best practice' approaches will be helpful.

RENEWABLE PORTFOLIO STANDARDS

Governments are now increasingly relying on the 'renewable portfolio standard' (RPS) approach to increase renewable energy deployment in their countries – often, but not solely, as a mandated mechanism for pursuing greenhouse gas emission reductions. However, in the absence of a national strat-

egy for PV or at least some concrete targets for installed capacity of PV, the RPS is unlikely to have a positive impact on PV deployment and may even have unforeseen negative implications. This arises because the RPS generally encourages the lowest direct cost renewable energy options – a criterion which grid-connected PV is unlikely to fulfil in the near term. This helps minimise electricity retail price rises, important politically where governments have tried hard to sell the economic benefits of electricity market reform.

However, this near-term approach does not take account of the potential longer-term competitiveness of technologies like PV, which may only be realised by specific support in the near-term.

REBATES

At the same time, governments are also realising that simple grid-connected PV rebate schemes, implemented without a broader PV policy framework or complementary industry support measures, may do little to decrease prices, promote innovation or develop sustained market demand – probably because these schemes alone do not send the right signals about value to the stakeholders (PV industry, electricity businesses and investors / end-users). PVPS Programme activities have documented and

Country Energy's Queanbeyan solar farm feeds PV electricity for its green power customers in Australia.

continue to investigate approaches that can be simple, and easy to implement and administer, while not distorting market development.

GREEN POWER

Meanwhile we are seeing a proliferation of 'green power' schemes offered by electricity businesses. In principle, these rely on part of the customer base giving some environmental or other value to renewable energy – and paying a premium for the privilege. These also rely on the customer base having trust in the supply of their green electricity. Electricity businesses also have an opportunity to maximise network benefits and promote other benefits when they support or invest in green power projects. PV fits well with this because customers often seek 'solar energy' (compared with electricity from biomass or hydro plants, for example) while in the built environment the promotion of some of PV's added values can smooth the pathway to deployment. However green power schemes (especially in their infancy) are often characterised by the same broad, least-cost approach as per the RPS, and it is uncommon to see PV specifically promoted. Governments do have a vital role to play in establishing a realistic and supportive policy framework, and accelerating the development of PV-specific green power schemes, even though this may be regarded as a commercial matter. Issues such as the financial regulation of electricity businesses with respect to their green power activities, refinement of accreditation processes and interaction of green power with other policy measures are being discussed in various countries.

The PVPS Programme, through ongoing and new activities (such as Task 10 on Urban-Scale PV), will continue to investigate the many questions still to be answered, identify 'best practice' approaches and address the broader public policy issues to support efforts to stimulate appropriate deployment of grid-connected PV systems. Watch this space!



GETTING THE BEST FROM STAND-ALONE SYSTEMS



IEA-PVPS Task 3 has published three new reports aimed at improving the operational performance selection and use of Stand Alone PV (SAPV) systems. The reports address testing of batteries, appliance selection and load matching, and guidelines for selecting an appropriate system for a given application.

TESTING OF BATTERIES

The battery bank is often the weakest component of an SAPV system and a major contributor to the system's overall life-cycle cost. Insight into the likely field performance of different batteries is therefore of major concern to system designers, suppliers and managers of technology dissemination projects. A variety of accelerated battery cycling procedures simulating field operating conditions are used to evaluate battery lifetime. These invariably aim to induce ageing of the battery including sulphation, corrosion, stratification and softening of the battery grid and the active mass.

The new report, IEA-PVPS T3-11:2002, assesses seven cycling test procedures and the performance of more than 40 different batteries. One of the key findings of the study is that none of the test procedures alone actually induce a significantly high level of degradation. This implies that choosers of batteries should apply several of the proce-

dures to ascertain which of the degradation patterns is most likely to match their application before deciding on the correct battery. This is particularly true for flat plate solar batteries where lifetime is very dependent upon the test procedure adopted. In terms of battery technology, the results show a wide variation in efficiency and life between batteries of the same technology. This is due to differences in the type of grid alloy, the active mass composition, the manufacturing process or the cell geometry. One clear conclusion from the analysis is that it confirms the longer and better service of tubular batteries.

USE OF APPLIANCES

While batteries are the most common failure point, inappropriate loads are very often the origin of PV system malfunction or failure. Start-up power peaks, or reactive power and harmonic distortion can cause system signal instability with the result that protective devices will close the system down.

A well-matched load together with a carefully selected choice of appliances can lead to significant savings in terms of reduced PV and electricity storage capacity. Conversely, inefficient appliances and processes, standby loads and inappropriate loads will increase the requirement for expensive PV and storage capacity.

This new report, IEA-PVPS T3-09:2002, presents a survey of real cases from around the world with load related problems for a range of applications and the effects on quality and cost of the service. The study goes on to present the solutions that were adopted together with suggested alternative solutions.

One of the main conclusions of the work is the importance of integrating the choice of appliance into the total SAPV system design.

GUIDELINES FOR SELECTING SAPV SYSTEMS

With such a variety of system architectures, components of varying performance and a barrage of claims to compare, choosing a system to service a specific stand-alone power need within realistic budget constraints can be a daunting task. The new guidelines from Task 3, Report IEA-PVPS T3-12:2002, are not intended to replace competent professional design, but were developed to help those seeking to invest in a PV power supply to identify features of an appropriate system and also to appreciate the role of the different components in that system.

The guidelines aim to simplify the range of system design options into a manageable number of categories within three main groups: systems with or without batteries and inverter; PV hybrids; and conventional generation technologies including the diesel generator set against which PV might be competing. A 'Key' is also used to filter the user of the guidelines through four simple options – is technical support for the application difficult to access; does the application require AC or DC power; is intermittent supply acceptable; and what is the daily demand on site in kilowatt-hours.

Armed with this tool, the user is helped to identify component requirements from which they can make an informed decision of SAPV investment options.

All reports are available for download from the PVPS website www.iea-pvps.org.



PVPS NEWS

GRID-INTERCONNECTION REPORTS PUBLISHED

A wealth of information relating to the implications for electricity networks of grid-interconnection of PV systems has recently been made public by IEA-PVPS.

The documents are the accumulated knowledge of Task 5's studies into issues such as islanding (where a grid-connected PV system continues to operate despite a network-failure); the impact of large numbers of distributed PV systems on the distribution network (penetration); certification guidelines; and power and capacity values of PV.

Three of the reports address the islanding phenomenon which is a potential safety concern for network engineers. These deal respectively with the probability of islanding occurring, an analysis of the (electric shock) risk and an evaluation of islanding detection methods. The latter reviews the theory, strengths, weaknesses and non-detection zones of a variety of common islanding detection methods, while the other two studies suggest that the likelihood of an islanding event occurring and associated risk for network engineers is extremely small. High penetrations of distributed generators, particularly in residential ar-



Grid-connected modules on Cascade houses in Nieuwland, Amersfoort, the Netherlands. [PHOTO: ECOFYS]

reas can pose potential problems for conventional networks as this could conceivably give rise to reverse flows from the low voltage (LV) to medium voltage grid during periods of high PV power output. The report 'Impacts of Power Penetration from PV in the Distribution Network' attempts to answer the questions of what are the upper limits to the amount of PV that can be fed into a power system without causing problems, what sets the limits and how can these be overcome. The paper also analyses the financial aspects of high concentrations of PV in a power system, concluding that the benefits such as peak-shaving are likely to far outweigh any inconvenience to the utility.

This last issue is addressed in more detail in the report 'Power Value and Capacity Value of PV systems'. The power value of PV varies from one instant to the next depending on the

eco-efficiency, innovation and corporate social responsibility.

Membership of WBCSD is by invitation only, but the website provides a variety of useful resources to assist businesses to understand key environment and development issues such as the Kyoto Protocol, and the Clean Development Mechanism as well as the role and opportunities for businesses to assist capacity building and sustainable livelihood creation in less developed countries. www.wbcd.ch

level of power production and on the surrounding load conditions. This study therefore undertakes an appraisal of PV value through a comparison of the photovoltaic production and local consumption for three different types of users connected to the LV network. It is clear that for urban areas with peak daytime demands (driven by office use for instance) there is a definite advantage in terms of load curve flattening and reduced energy losses to having some local PV capacity. For purely residential areas there seems to be little such benefit.

Titles of all recent PVPS reports are presented on page 8.

IMPLEMENTATION MODELS FOR SOLAR HOME SYSTEMS

A new two-part guide to assist policy makers in identifying critical factors in the successful implementation of small domestic PV systems (Solar Home Systems or SHS) in developing countries has been produced by IEA-PVPS Task 9.

PV has considerable potential to contribute to the energy needs of rural and remote communities in developing countries. However, as is often reported, the comparatively high capital cost of PV SHS means that they are often not affordable for many would-be users. New and innovative implementation models are essential for more widespread use of the technology.

The guide to implementation models, Report IEA-PVPS T9-02:2003, summarises three different approaches; direct sales, credit sales (both from the dealer and end-user perspective, as well as hire purchase arrangements) and fee-for-service models. The first part of the guide presents the typical characteristics of the models, including the mechanisms, advantages, disadvantages, and associated risks of each, while



Market shop in Tibet.

part 2 provides practical experience of the alternative models through eight case-studies of such initiatives from around the world.

As the practicalities of implementing a SHS financing model are heavily dependent upon the local market conditions, the guide also presents an overview of the key factors that decision makers must consider when assessing implementation model suitability for a particular environment.

The report is available for download from www.iea-pvps.org.

CAPACITY BUILDING FOR PV RURAL ELECTRIFICATION

Many previous PV rural electrification projects and programmes have failed due to a poor enabling environment in terms of policy and legal frameworks, institutional or human resources and weak managerial systems.

This lack of local capacity can be relatively easily resolved if identified and addressed at an early stage in the project life-cycle.

Report IEA-PVPS T9-03:2003 provides an introduction to capacity building activities that may be required by utilities, the service delivery chain, the finance sector and NGOs as well as end-users. It gives special attention to government departments, which often fail to appreciate the cross-sectoral value of PV electrification services (e.g. for health, education and water delivery). The report is available for download from www.iea-pvps.org.

INTERNET RESOURCES

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT

The WBCSD is a coalition of 165 international companies and 43 national and regional business councils and partner organisations located in 39 countries.

The Council aims to provide business leadership as a catalyst for change toward sustainable development, and to promote the role of

IN BRIEF

CAP LIMITS PROSPECTS FOR AUSTRIAN PV BOOM

With its new Green Electricity Act the Austrian government has created one of the most attractive environments in the world for renewable energy and CHP projects. For PV though, the excitement looks to be short-lived due to the low capacity threshold.

Until now, the Austrian framework for renewable energy project implementation was rather muddled, with geography being the overriding factor for planning and investment regulations, value and duration of buy-back incentives, and even levy arrangements which varied significantly from state to state. Such discrepancies have been removed now with the implementation of the nationwide act which harmonises the green electricity investment incentives and establishes a long-term guaranteed tariff for each technology irrespective of project location. It also provides an equitable distribution of costs across the country.

For grid-connected PV systems installed from January 2003 the feed-in tariff is set at 60 Eurocents per kWh for systems up to 20 kW, while larger systems attract a healthy 0,47 EUR/kWh. Both are guaranteed for 13 years. However, there is a flaw; crucially the PV tariff availability is capped to a national capacity of 15 MW, and the 9 MW already installed by the end of 2002 counts towards this cap. With a further 6,5 MW requested between the programme launch and the first of February 2003, the budget appears to have been spent before the programme really had a chance to take-off. Concerted lobbying by the PV industry is going to be needed to ensure that this shadow does not obscure the sunshine.

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INDIAN SOLAR LOAN PROGRAMME

UNEP has launched a four-year 7,6 million USD effort to help accelerate the market for financing solar home systems in southern India. The project involves two of India's major banking groups – Canara Bank and Syndicate Bank. Initially the effort targets the electrification of twenty thousand homes and small businesses.

The initiative provides interest rate buy-down to allow the partner banks to offer loans to customers at concessional rates of interest. Initially this will be 7% below the prime lending rate, which is currently around 12%. The loans are accessible to customers of established solar rural electrification companies. Four solar vendors have now completed the UNEP qualification process. Some seven in ten rural households in India are still without access to electricity. They continue to rely on less efficient and polluting energy sources, typically kerosene. Even where grid electricity is available, problems of capacity shortages and inconsistent quality plague the power supply.

This has led households to look to alternative power supply systems such as solar PV. However lacking access to credit, most potential users cannot afford to pay up-front for a PV system.

One of the most attractive features of an interest rate subsidy is that it doesn't distort the market, either in terms of the capital cost that the customer associates with a solar PV system, or the risk that a banker associates with a solar loan. The intent is that this will serve as a stimulus for the banking sector to include PV in their lending portfolio.

www.unep.org/energy/act/fin/india/index.htm

DIARY DATES...

Osaka, Japan
19-20 May 2003
☛ Bernard McNelis, IT Power
Fax +44 (0)1256 392701
www.iea-pvps.org/conference

Renewable Energy for the Developing World
Carbondale, USA
16-20 June 2003
☛ Solar Energy International
Fax +1 970-963-8866
www.solarenergy.org/redw.html

Solar 2003
Austin, Texas
21-26 June 2003
☛ American Solar Energy Society
Fax +1 303 443 3212
www.ases.org

Intersolar 2003
Freiburg, Germany
27-29 June 2003
☛ Solar Promotion GmbH
Fax +49 (0) 7231 351381
www.intersolar.de

EURO-PV
Granada, Spain
7-12 November 2003
☛ PV-NET
Fax +39 0332 789268
www.pv-net.net/europv2003.htm

14th International PV Science and Engineering Conference
Bangkok, Thailand
26-30 January 2004
☛ Dusit Kruangam, Chulalongkorn University
Fax +66 2 2 518991
www.chula.ac.th/pvsec-14

IEA-PVPS NEWSLETTER

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PV POWER

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PVPS REPORTS & BOOKS

PVPS ANNUAL REPORTS AND EXECUTIVE CONFERENCES

- ✧ Implementing Agreement on Photovoltaic Power Systems Annual Reports 1998-2001 (4 editions)
- ✧ Il valore del sole (The value of the sun), Summary of Third International Executive Conference on Photovoltaic Power Systems, 3-5 November 1999, Venice, Italy, 2001

MARKET AND TECHNOLOGY SURVEY REPORTS

- ✧ Trends in Photovoltaic Applications in selected IEA Countries. Seven editions up to 2002

OPERATIONAL PERFORMANCE, MAINTENANCE AND SIZING

- ✧ Operational Performance, Reliability and Promotion of Photovoltaic Systems, May 2002
- ✧ Analysis of Photovoltaic Systems, April 2000

PV FOR STAND-ALONE AND ISLAND APPLICATIONS

- ✧ Testing of batteries used in stand-alone PV power supply systems: Test procedures and examples of test results, October 2002
- ✧ Use of appliances in stand-alone PV power supply systems: Problems and solutions, September 2002
- ✧ PV Horizon – Workshop on photovoltaic hybrid systems. Proceedings, summary and conclusions of the workshop, November 2001
- ✧ Survey of national and international standards, guidelines & QA procedures for stand-alone PV systems, October 2000
- ✧ Lead-acid battery guide for stand-alone photovoltaic systems, December 1999
- ✧ Stand-alone PV Systems in developing countries, August 1999
- ✧ Stand-alone photovoltaic applications: lessons learned, February 1999
- ✧ Recommended practices for charge controllers, August 1998

GRID INTERCONNECTION OF BUILDING INTEGRATED AND OTHER DISPERSED PHOTOVOLTAIC POWER SYSTEMS

- ✧ Probability of islanding in utility networks due to grid-connected photovoltaic power systems, September 2002
- ✧ Evaluation of islanding detection methods for photovoltaic utility-interactive power systems, March 2002
- ✧ Risk analysis of islanding of photovoltaic power systems within low voltage distribution networks, March 2002
- ✧ Grid-connected photovoltaic power systems: Power value and capacity value of PV systems, February 2002
- ✧ Impacts of power penetration from photovoltaic power systems in distribution networks, February 2002
- ✧ International guideline for the certification of photovoltaic system components and grid-connected systems, February 2002
- ✧ PV System Installation and Grid-Interconnection Guidelines in Selected IEA countries, November 2001
- ✧ Grid-connected photovoltaic power systems: Summary of IEA/PVPS Task 5 activities from 1993 to 1998, March 1999
- ✧ Demonstration test results for grid interconnected photovoltaic power systems, March 1999
- ✧ Utility aspects of grid-connected photovoltaic power systems, December 1998

The PVPS programme has produced a wealth of reliable market data and technical information to help decision makers evaluate the pros, cons and practicalities of PV project and programme implementation.

Further information about these and other titles is available from the PVPS website www.iea-pvps.org, with many of the reports available for download free-of-charge. Alternatively contact Mary Brunisholz, IEA-PVPS Executive Secretary for further details: tel. +41 26 494 00 30, fax +41 26 494 00 34.

PV POWER PLANTS FOR LARGE-SCALE POWER GENERATION

- ✧ A preliminary analysis of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems, May 1999

PHOTOVOLTAIC POWER SYSTEMS IN THE BUILT ENVIRONMENT

- ✧ Designing with solar power – A source book for building integrated photovoltaics (BIPV), 2002
- ✧ Building Integrated Photovoltaic Power Systems. Guidelines for Economic Evaluation, October 2002
- ✧ Market deployment strategies for PV systems in the built environment – An evaluation of Incentives, Support Programmes and Marketing Activities, September 2002
- ✧ Potential for building integrated photovoltaics, July 2002
- ✧ Reliability study of grid-connected PV systems: Field experience and recommended design practise, March 2002
- ✧ Innovative Electrical Concepts, 2001
- ✧ Building with PV – New product opportunities. Proceedings of the Workshop held at Amsterdam RAI, Wednesday 9 May 2001
- ✧ PV in non building structures - a design guide, April 2001
- ✧ Photovoltaics in the built environment. Proceedings of the 2nd World Solar Electric Buildings Conference, Sydney, Australia 8th-10th March 2000
- ✧ Literature survey and analysis of non-technical problems for the introduction of building integrated photovoltaic systems, March 1999
- ✧ Photovoltaic building integration concepts. Proceedings of the IEA PVPS Task 7 workshop 11-12 February 1999, EPFL, Lausanne, Switzerland featuring a review of PV products

CO-OPERATION WITH DEVELOPING COUNTRIES

- ✧ PV for Rural Electrification in Developing Countries – A Guide to Capacity Building Requirements, March 2003
- ✧ Summary of Models for the Implementation of Photovoltaic Solar Home Systems in Developing Countries, March 2003
- ✧ Financing mechanisms for solar home systems in developing countries. The role of financing in the dissemination process, September 2002

OTHER

- ✧ Added Values of Photovoltaic Power Systems, March 2001
- ✧ Photovoltaics in cold climates, November 1998
- ✧ Photovoltaics in Competitive Electricity Markets, May 1998

CD-ROMS

- ✧ Operational performance, maintenance and sizing of photovoltaic power systems and subsystems – Performance Database
- ✧ Education and training material for architects
- ✧ Task 7 project results and documents