



# PV POWER

Newsletter of the IEA Photovoltaic Power Systems Programme

DECEMBER  
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*Size matters. Inside we report on the biggest PV conference held to date, and the largest centralised system to be installed in the urban environment.*



## BIGGEST EVER CONFERENCE DEMONSTRATES INDUSTRY CONFIDENCE

**Vienna, Austria played host to the 2nd World Conference and Exhibition on PV Solar Energy Conversion in July. With nearly 2 500 delegates and over 1 100 papers, the event – which was again perfectly organised by WIP – was by far the biggest PV meeting ever.**

The clear consensus of opinion among the participants was that PV is booming. This was reflected in strongly encouraging speeches from keynote speakers including Kunisuke Konno of NEDO, Japan, James Rannels from the US DOE and Wolfgang Palz of the European Commission. Japan's commitment to PV technology and the promising progress being made under the national policy on New Energy Introduction was made clear when Konno reported the upward revision of the country's year 2010 installed capacity target from 4 600 MWp (the target set in 1994) to 5 000 MWp. Subsidies for PV installed on public sector and residential buildings have driven up installed generating capacity by an average of 45 % each year since 1991 to 90 MWp at the end of 1997. R&D efforts are



*VIPs from the European Commission and the Austrian government join key members of the organising committee at the EC's exhibition stand (Photo: Courtesy WIP).*

now concentrating on improving thin-film module efficiencies and cutting inverter unit costs to help realise the government's goal of economically viable PV technology for the Japanese market within the next decade.

Rannels' state-of-the-industry presentation pointed to the massive demand from Japan as the dominant force behind the recent rapid expansion in sales. But he also highlighted the continued growth in professionalism within the industry as a whole – giving customers more of the products they want

### **DR. ALLEN BARNETT, PRESIDENT & CEO ASTROPOWER INC.**

I was impressed by the vitality of the industry evidenced by the continual flow of people through the exhibition and the strength and professionalism shown in the technical papers. Oral papers were an interesting mix of state-of-the-art research plus the required politically selected papers, while the posters provided a very high density of strong technical content.

The commercial exhibits were widely distributed over the separated space but were very successful. There was important contact between customers and vendors and also between technologists and the commercial people. Several of my colleagues and I observed that there was

too much to do and there was not enough time to interact with many of the excellent posters. Too much to do seems like a great problem.

The award of the Becquerel Prize to Walter Sandtner for the creation of the ground breaking 1 000 solar roofs programme in Germany was an inspired gesture. It was great to meet and hear from the person who began this important world wide initiative.

Vienna set a very high standard for the next international meetings in Sapporo, Anchorage and Glasgow. The industry and technology appear to be in excellent health. I look forward to a bright future as solar electric power delivers on its potential.

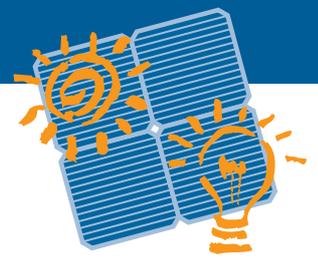
### **DR. HARVEY FOREST, PRESIDENT AND CEO, SOLAREX**

From a Solarex perspective, Vienna highlighted a number of interesting and important new developments. Significant progress continues to be made in improving cell and module performances, including new conversion efficiency records for a mono-crystalline silicon PV module (22,7 %), a multicrystalline silicon cell (19,8 %) and triple-junction amorphous silicon cells (initial efficiency 15,2 %).

In addition, companies such as BP Solar, Siemens Solar and Solarex are aggressively moving ahead with commercialisation of thin film products. BP Solar is starting production of CdTe PV modules in California while Siemens has already started limited production of CIS modules. Solarex exhibited 0,75 m<sup>2</sup> tandem amorphous silicon modules that are now being produced commercially in our new plant in Virginia. There also appears to be a growing interest in the possibility of using thin film photovoltaics in space due to excellent radiation tolerance and high power to weight ratios. The development of thin crystalline silicon solar cells is another area that is receiving considerable attention.

Many papers dealt with the manufacturability of high efficiency processes and the development of high throughput equipment. Considerable progress was also evident in the development of PV systems for building-integrated applications and for grid-connected systems in general, and also in setting up a global system for rating PV modules and systems.

Vienna witnessed the largest PV meeting ever. The number of attendees and exhibitors bodes well for the future. We should try to open these events even more to the general public now, perhaps set up an evening panel session, where important issues relevant to the development of photovoltaics could be aired.



The exhibition was well supported by industry (Photo: Courtesy WIP).



**ROBERT DE FRANCLIEU, COMMERCIAL DIRECTOR, PHOTOWATT**

Vienna was an excellent opportunity for us to present the new Photowatt company (now a subsidiary of Matrix), and to generally increase our level of communication with the market. From a marketing viewpoint we see a lot of optimism. The huge growth in 1997 still has a strong effect on the business, and the high level of interest in the exhibition was a direct reflection of this growth. All of the major manufacturers were present, along with new actors in module assembly and PV system components. We can also see the industry maturing in the growing involvement of financial experts in the development of the markets. The work being done on new financial tools and new independent participants is confirmation of the potential for this industry.

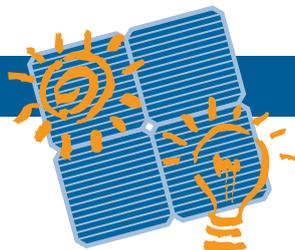
at the right quality. These are the essential foundations for major industry expansion that will drive the cost reductions that have been promised for so long.

Palz highlighted major new plant construction across Europe as further evidence of the 'PV industry explosion' since 1997. Such expansion will be much needed to support the growing number of large integrated energy projects materialising across Europe, particularly in Germany and the Netherlands and the ongoing programmes in Japan and USA. Gernot Oswald, MD of Sie-

mens Solar, struck a cautionary note, pointing out that previous predictions of the rate of PV market take-off were invariably over-optimistic. Siemens are "planning for 15 % (growth) and dreaming of 25 %". Even this would only equate to 1 % of the world's electricity coming from PV by 2025-2040. The PV industry can not afford to relax – problems such as the solar grade silicon shortage still need to be properly resolved, and subsidies will still be a very real part of the development of the industry for some time. Nevertheless Vienna demonstrated that the commitment to succeed is very much here.

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TOOLS OF THE TRADE



**A group of researchers from the UK with financial support from the UK Government's Department of Trade and Industry, recently completed a survey of the first generation of tools to offer design capabilities for Building Integrated Photovoltaics (BIPV).**

Six different PC-based PV design tools, four operating under DOS, the other two within the Windows environment, and all readily available to building professionals in North America and Europe, were shortlisted for evaluation against a broad range of qualitative criteria.

The technical evaluation criteria addressed the scope of each tool including: the provision for analysing building loads; sizing sys-

tems and determining power output; and the databases supplied to assist component and weather data selection. The overall 'user-friendliness' of each system was also assessed based on aspects such as ease of inputting or modifying site specific meteorological data and components lists, presentation of the output data (both graphical and tabular), level of guidance (manuals and help functions) and how intuitive the programs are to use.

As yet, none of the tools allow detailed technical design, but several of the packages do support outline technical design, to forecast system performance based on site-specific weather data and a detailed definition of the components that will be used (modules, inverters etc.). Basic economic

analysis capabilities are also supported in several of the tools.

Overall, the study demonstrates that there are still relatively few tools to assist would-be BIPV designers, and those that do exist must necessarily make a trade-off between ease of use and comprehensiveness of the tool.

Nevertheless, the fact that such products are becoming more widely available is encouraging for the future of BIPV.

The conclusions of this research have been published in a report entitled Photovoltaics in Buildings: A survey of design tools, which is feeding into Task VII of the IEA PV Power Systems Programme.

Contact Paul Ruyssevelt at HGA  
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## PHOTOVOLTAICS FOR THE NORTH

***Large seasonal variations in solar radiation and other adverse climatic factors have made the implementation of PV technologies challenging in Canada, especially in the North.***

PV modules and components operating at high latitudes require special consideration to ensure continued operation under extremes of cold, snow and ice. The PV for the North programme, initiated in 1993 by the CANMET Energy Diversification Research Laboratory, and the Research Institutes of Aurora and Nunavut, is Canada's response to the need for PV systems better adapted to harsh Arctic conditions.

Studies undertaken early in the programme clearly showed that the largest market in Canada's Northwest Territories (17 MWp) is to displace running costs of community diesel grids. Diesel engines currently account for 60 % of electricity generation. Tapping this market remains an objective for the future, as estimates suggest that installed costs need to drop to below 4,25 CAD/Wp

(about 2,75 USD/Wp) before PV is cost-competitive with current supply options.

However, near term markets for radio- or telecommunication sites, remote parks and fire towers totalling some 690 kWp are already within reach. For instance, a techno-economic study for NorthwTel demonstrated that the conversion of small VHF telecommunication sites, from disposable potash batteries to photovoltaic power, had a payback of a little over 1 year and would lead to savings of over 500 000 CAD over 20 years. This quickly encouraged the company to convert 9 out of 11 VHF telecommunication sites to PV systems in 1995-1996.

Modelling studies and field testing, undertaken as part of the programme, have demonstrated that the absorption of solar radiation reflected on the back of the module and the insulating air space at the back of the panel are central for helping keep modules free from snow and ice. This has helped in the development of kits to modify commercial PV modules for use in the North. Similarly, maintaining moderate battery

temperatures through the year makes the storage sizing of remote PV systems simpler. Battery capacity decreases substantially when operating temperatures drop below 0 °C, so efforts were made to improve insulated battery enclosures. This has led to an advanced housing incorporating phase change material; under field tests in Canada, this has been shown to prevent the battery temperature falling below -5 °C despite the outside temperature reaching -37 °C, and also ensured that battery temperatures did not exceed 22 °C in the summer. PV for the North, with international collaboration from the IEA PVPS member countries, is responsible for a comprehensive new book *Photovoltaics in Cold Climates* (see Page 7 for details).

For further information contact Raye Thomas at Newsun Technologies.

Fax: +1 613 723 5980

*The success of the PV-wind-diesel hybrid system powering the Tanquary Fiord parks facility has led to the conversion of seven other park facilities in the last 3 years.*



## MAKING A BIG IMPRESSION

**A German utility and one of the world's leading PV module manufacturers have combined forces to prove that large-scale PV can work in the urban environment.**



The Munich Trade Fair Centre incorporates 7 812 of Siemens Solar's newly developed frameless SM130-L (130 Wp) modules across the roofs of six of its twelve halls. This gives a total array power of 1 016 kWp – by far the biggest large-scale urban PV plant in the world today. Bayernwerk AG, Bavaria's largest power utility, was overall manager of the 14 million DEM (8,4 million USD) project. Siemens Solar as general contractor commenced installation of the plant in August 1997 and officially commissioned the turnkey system in November that year. The system is innovative in many ways: the large area modules are designed to be manipulated by one person for easy installation; electrical and mechanical connections were designed for on-site simplicity to mini-

mise installation time and cost; and shock-proof connections ensured the safety of field staff during cabling. Perhaps the most significant innovation is that the entire array, consisting of 12 equal sub-arrays, feeds into a central bus system and a single central inverter unit (CIU). Megawatt plants to date have consisted of sub-systems of around 300 kWp feeding into separate inverters connected in parallel on the AC side. But the extremely high resistance of the new modules allows the full array to feed into one central unit. The CIU actually consists of 3 x 330 kVA standard series inverters, but these operate in a master/slave/slave configuration, such that slave units are only called into operation when the total array power requires this. Because inverters

*The 1 MWp PV plant harmonises with the high-tech atmosphere of the New Munich Trade Fair Centre.*

are less efficient when operating at low power inputs, this CIU arrangement with additional slave switching on demand gives a much better efficiency at lower insolation levels than AC side parallel inverter connection. The plant is expected to generate around 1 GWh of electricity annually for direct use within the Centre. This will satisfy around 4 % of the annual on-site power demand and offset 1 000 tonnes of CO<sub>2</sub> emissions each year.

Contact: Siemens Solar GmbH  
Fax: +49 89 636 59173

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## ITALY'S PV PROGRAMME HITS THE ROOF

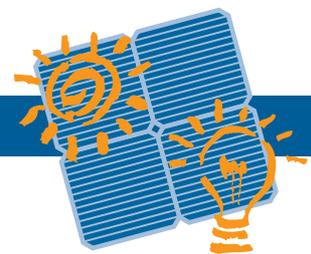
**ENEA (the Italian National Agency for New Technology, Energy and the Environment), with support from both the Italian Industry and Environment Ministries, has announced an ambitious national programme aimed at installing 50 MWp of grid-connected PV on 10 000 rooftops over the next five years.**

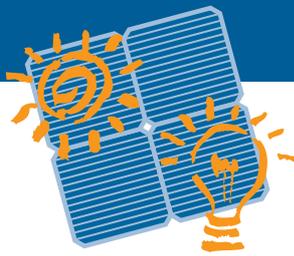
The programme, which is expected to start in 1999, will be part-financed by the Italian Government in the framework of the post-Kyoto initiatives. Italy is intent on reducing greenhouse gas emissions by 7 % from

1990 levels by 2010 and is aiming to double renewable energy contribution to national energy demand to 12 % in the same timeframe. Although the contribution of PV to these targets will be relatively small, the technology is viewed as strategically important in the long-term. The new programme will help to expand the market for PV technology in Italy, which will not only contribute to longer-term CO<sub>2</sub> emissions reduction, but is also expected to lead to technology cost reductions, energy saving and job creation. The exact programme cost will depend on future technology cost developments, but present assumptions indicate an

installation budget of 225 million ECU (265 million USD), of which approximately 75 % will be publicly funded. There will be two categories of plants eligible for support: systems in the 1 kWp to 5 kWp range, which will probably be taken up by private individuals, will be eligible for 80 % of the maximum investment costs while a second band of 5 kWp to 50 kWp plants, which is aimed at private companies and public institutions, will be eligible for 75 % support. The maximum supported investment will be reduced over the course of the programme to reflect technology cost reductions.

Contact: Anna de Lillo at ENEA  
Fax: +39 05 3048 4643





## IN BRIEF

### SILICON-FILM ON A ROLL

*US PV Manufacturer Astropower announced the first commercial shipments of its new APex cells and modules in July*

The material used for the cells is polycrystalline silicon, but it is formed using the company's innovative silicon-film continuous sheet process (similar to the methods used for manufacturing plate glass or sheet steel), which was developed with partial support from USDOE under the cost-shared Photovoltaic Manufacturing Technology Programme (PVMaT).

The new process reportedly offers substantial savings in manufacturing cost and production time over the batch methods used to make the majority of crystalline silicon cells currently sold on the world market, and also allows greater flexibility over cell size. The manufacturing costs savings are enabling Astropower to undercut the price of conventional silicon technology by around 10 % initially, with the prospect of further reductions in future, depending on market performance. The new product range consists of 45 Wp and 90 Wp power modules and was launched at the Soltech Conference in Orlando in April. The modules are being manufactured at a dedicated new 9 MWp capacity plant in Newark, Delaware. Contact Trish Carrico at Astropower Fax: +1 302 368 6474



*Silicon film rolling of the new production line.*

### PVMTI ISSUES SOLICITATION FOR PROPOSALS

*Loans and investments totalling 25 million USD will be deployed by the World Bank's International Finance Corporation (IFC) on behalf of GEF to support private sector PV commercialisation in India, Kenya and Morocco.*

Proposals from equipment suppliers, systems integrators, distributors, installation companies, power generation companies and financial intermediaries are now being sought under the terms of the IFC's Photovoltaic Market Transformation Initiative (PVMTI).

Investment proposals should be near commercial and sustainable. Key characteristics may include, but are not limited to, accelerated replication of proven business models, exploitation of new market niches with significant long-term potential, development of innovative financing mechanisms and demonstration of long-term business partnerships. IFC has contracted a UK based External Management Team (Impax/IT Power) to manage investments.

Contact: Anthony Derrick at IT Power, Fax: +44 118 973 0820

### PV BOOMING IN NSW

*With major new manufacturing plant under construction, utility green pricing schemes enjoying consumer support and state sponsored rebates for PV now in place, New South Wales is emerging as Australia's 'Sunshine State'.*

In August, BP Solar announced plans to construct a major new manufacturing facility just outside Sydney. The 20 MWp plant, which is due for completion in October 1999, is expected to generate around 190 jobs and will strengthen the state government's ambitions to turn NSW into a significant international player in solar.

There is strong grass-roots support for PV and other renewable technologies in the region as evidenced by the 20 000 or so subscribers to green power schemes. Energy-Australia, the country's largest energy retailer, has over 7 500 partners in its 'Pure Energy' programme under which customers can opt to pay between 25 % and 100 % of their electricity bill at a premium rate to support renewable energy.

Green pricing led to more than 12 million AUD (7.1 million USD) investment in solar power projects statewide during the 18 months up to August, including EnergyAustralia's 2.5 ha, 400 kWp, Solar Farm at Singleton. The plant was constructed in two phases of 200 kWp, the first using Solarex multicrystalline silicon modules, and the second using Canon amorphous silicon modules. Simplified clip-in modules and plug connections, together with fewer but larger inverters contributed to reducing the construction cost between the first and second phases by 16 %. Further PV installations are likely to be seen across the state on private homes and public buildings under the Sustainable Energy Development Authority (SEDA) 2 million AUD programme for rebates of between 20 % and 40 % on systems purchases. The aim is to install 2 000 building-integrated solar power systems by the end of 2000.



*Australia's largest solar farm (400 kW) is installed in Singleton NSW.*



*Vertical bifacial modules on a motorway bridge near Zurich.*

### NOISE BARRIERS

*Following on from a competition held in 1996 to encourage Swiss-German innovation in PV noise barriers, TNC consulting AG is now field testing a 10 kWp system of novel bifacial PV modules.*

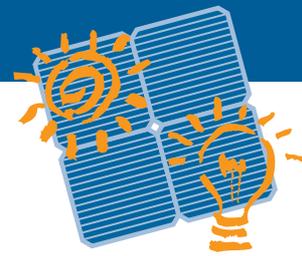
The system, which was commissioned in March 1998, spans 120 m of the Aubrugg bridge on the A1 motorway outside Zurich.

The modules, which provide dual functions of electricity generation and protection from traffic noise, were constructed by German manufacturers ASE. They are installed vertically rather than tilted towards the sun, and are oriented in an east-west direction, as opposed to conventional modules which would normally be south-facing in the northern hemisphere to maximise solar energy capture.

The ongoing two-year monitoring campaign hopes to demonstrate that the bifacial design can produce almost as much electricity (800 kWh/kWp is anticipated) as an optimally orientated conventional module – and with a more even power generation distribution over the course of the day.

Combining the 'power without noise' functions is helping to bring down the cost of PV generated electricity, primarily through avoided land costs. The bifacial design if successful will overcome the restriction to orient modules to the south, so opening up far greater stretches of motorway noise-barrier for PV power generation plant.

Contact Thomas Nordmann at TNC Fax: +41 1 921 13 77



## PVPS NEWS

### NEW CHAIRMAN FOR PVPS

*Following Roberto Vigotti's completion of his five-year tenure as Chairman of the Executive Committee, PVPS has a new charismatic director.*

Erik Lysen has over 20 years experience of renewable energy technologies, and is internationally recognised for his strategic work on PV applications in developing countries. Prior to taking on the role of ExCo Chairman he was the Dutch ExCo representative and a key player in the Developing Countries' Team, which has helped PVPS to foster closer links with international agencies such as the World Bank.

Formerly of NOVEM, the Netherlands' Agency for Energy & Environment, Dr. Lysen now heads the Centre for Energy Research at the University of Utrecht.

The role of ExCo Secretary, which has been admirably fulfilled by Eva-Elena Bruno since 1993, is handed over to Irene de Jong of OKE in the Netherlands.



*Erik & Irene at the PVPS display stand at a conference of the Netherlands' Solar Power Programme.*

### PV IN COMPETITIVE ELECTRICITY MARKETS

*Competition has already been established in bulk electricity markets in a number of countries and is now being extended into retail markets.*

PVPS Task I (Information exchange and dissemination) following an initiative from the PV Special Research Centre at the University of New South Wales, Australia, has completed a survey of 18 countries to

identify the emerging trends and associated support strategies that are being implemented around the world to promote PV use. The key purpose of the research is to identify successful mechanisms from those countries where energy market deregulation is more advanced for possible adoption or adaptation by those countries still preparing for the onset of competition.

The survey has served to identify a range of mechanisms such as utility support strategies (e.g. green pricing, rate-based incentives and net-metering) which allow or encourage increased PV use. It also highlights the need for strong government support, including legislative measures for PV promotion mechanisms to be successful.

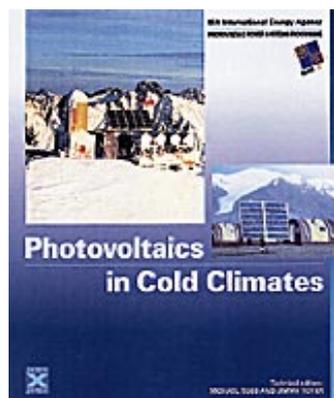
The results of the survey have been summarised in a report 'PV in Competitive Electricity Markets'. Copies can be ordered through the Australian PVPS Consortium Secretariat. Fax: +61 2 9969 1364

### NEW PUBLICATIONS

*Two new books have recently been published under PVPS.*

Stand-alone Photovoltaics Applications: Lessons Learned, represents the collaborative experience of the 15 member countries participating in Task III of the IEA PVPS Programme. The book is the summation of the many valuable and practical lessons that have been learned during the past decade or so in respect of the economic, institutional, social and technical aspects of installing and using stand-alone PV systems. These are explained in a clear and succinct manner, with examples from actual projects helping to illustrate the key points.

The book, which has been edited by Ecofys in the Netherlands, will be of interest to all involved in the development, planning, commissioning



and installing of stand-alone energy systems.

Photovoltaics in Cold Climates, as the name suggests, illustrates the potential and techniques for using PV under extreme cold conditions. The book, which is edited by Michael Ross from CEDRL and Jimmy Royer of Solener who have gained considerable experience of such systems through Canada's PV for the North Programme (Page 3), includes key contributions from IEA PVPS participants through Task I.

The effect of cold on the PV array, electronics, batteries and energy management is covered in detail. Cold climate PV systems planning, design, installation and operation are all addressed, and supported with several case studies. Both Publications are available from James & James Science Publishers: Fax: +44 171 387 8998

### SURVEY REPORT

*The third International Survey Report (ISR) presenting the status and trends of PV technology production and use in the PVPS Participating Countries up to the end of 1997 will be published at the end of this year.*

As PVPS countries account for over 90 % of worldwide module production and sales, the ISR is probably the most authoritative document for defining the latest state of the global PV industry. For further information or to order your copy, contact your Task I national representative (see contacts on page 8).

### DIARY DATES...

*Building with Photovoltaics, Lausanne, Switzerland, 11-12 February 1999*

Organised under the auspices of Task VII of IEA PVPS, this workshop is focussed at manufacturers of PV modules and building products, building designers and building product installers

☛ Stephanie Sayer at HGa  
Fax: +44 1793 815020

*ISES 1999 Solar World Congress, Jerusalem, Israel, 4-9 July 1999*

Biennial Congress of the International Solar Energy Society

☛ Kenes Ltd.  
Fax: +972 3 514 0077

*PVSEC-11 Sapporo, Hokkaido, Japan 20-24 September 1999*

11th International Photovoltaic Science & Engineering Conference 'Photovoltaic Energy For the Coming Century'

☛ Prof. T. Sameshima  
Fax: +81 423 88 9055

*16th EPVSEC Glasgow, Scotland, UK 1-5 May 2000*

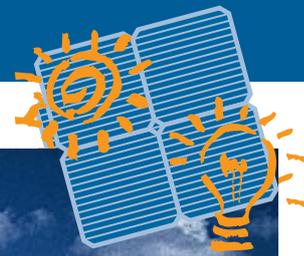
16th European PV Solar Energy Conference and Exhibition

☛ WIP  
Fax: +49 89 7201 291

*28th IEEE PVSC Anchorage, Alaska, USA 17-22 September 2000*

28th IEEE Specialists Conference and Exhibition

☛ Ajeet Rohatgi at Georgia Tech  
Fax: +1 404 894 5934



# THE SOLAR OFFICE

## CASE STUDY

### PROJECT SUMMARY

- Location: Doxford, NE England
- Installed March 1998
- 73 kWp fully integrated modules in 4 subarrays
- Grid-connected, AC system
- Novel double-glazed modules (U value = 1,2 W/m<sup>2</sup>K) reduce heat loss through facade
- 2 x 35 kWp + 2 x 0,85 kWp string inverters
- Annual electricity production 55 000 kWh (est.) expected to meet 25-33 % of total consumption

For further details contact David Lloyd-Jones at Studio E Architects  
Fax: +44 171 381 4995



***Doxford's 'Solar Office', designed by Studio E Architects is the first speculatively constructed building to integrate photovoltaic technology.***

The building has a very low annual energy consumption target of 85 kWh/m<sup>2</sup>, which is 60 % to 80 % lower than a normal air-conditioned office. Between 25 % and 33 % of the electrical power requirements will be provided by the 646 m<sup>2</sup>, 73,1 kWp PV array which is integrated into the building's angular, inclined south facade.

The PV system uses 352 Saint Gobain Solaglas modules in a variety of designs to

suit the size, shape and internal shading requirements of the building. The multicrystalline silicon modules, which use a glass/glass cell encapsulation to permit a degree of light infiltration back onto the double-glazed facade, are specially designed by Schüco. The whole facade forms a three-storey atrium enclosing a thermal buffer zone between the main entrance and the internal office spaces. System performance is being monitored continuously with data relayed to touch screen displays in the atrium. Initial data show the system will achieve the design annual production target of 55 000 kWh.

## IEA-PVPS

## PV POWER

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