International Energy Agency

CO-OPERATIVE PROGRAMME ON PHOTOVOLTAIC POWER SYSTEMS

Task 1

EXCHANGE AND DISSEMINATION OF INFORMATION ON PV POWER SYSTEMS

National Survey Report of PV Power Applications in the United Kingdom 2003

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R&D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. Eight Tasks have been established, and currently five are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning urban-scale deployment of PV systems is being developed.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

This report has been prepared under the auspices of IEA-PVPS Task 1. An important deliverable of Task 1 is the annual International Survey Report (ISR) *'Trends in Photovoltaic Applications'*. The ISR presents summary information on trends in PV power applications in the twenty member countries, based on the information provided in the National Survey Reports (NSR) of each participating country.

This National Survey Report of PV Power Applications in the UK has been produced following discussions with, and input from, organisations and individuals involved in the development and implementation of PV Technology in the UK. It represents an overview of the key developments and achievements in the UK PV sector during the year 2003.

UK National Survey Reports covering the past four years (2000, 2001 2002 and 2003), together with other information about the UK's participation in IEA-PVPS, is available from the UK-PVPS website: www.iea-pvpsuk.org.uk.

iii Definitions, symbols and abbreviations

For the purposes of this report, the following definitions apply:

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

DNO: Distribution Network Operator.

DFT: Domestic Field Trial - Demonstration programme of PV for use in residential applications, supported by the DTI.

DTI: (UK Government) Department for Trade and Industry.

EPSRC: The Engineering and Physical Sciences Research Council. EPSRC funds research and postgraduate training in universities and other organisations throughout the UK.

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Grid-connected centralised PV power system: Power production system performing the function of a centralised power station.

Grid-connected distributed PV power system: A PV system installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected residential PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers, etc. These may be used for support of the utility distribution grid.

Installed PV power: Power delivered by a PV module or a PV array under STC – (also see 'Peak power').

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, utilities etc.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

NC: National Currency (GBP - Pound Sterling)

Off-grid domestic PV power system: System installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Peak power: Amount of power produced by a PV module or array under STC, written as W.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

Rated power: Amount of power produced by a PV module or array under STC, written as W.

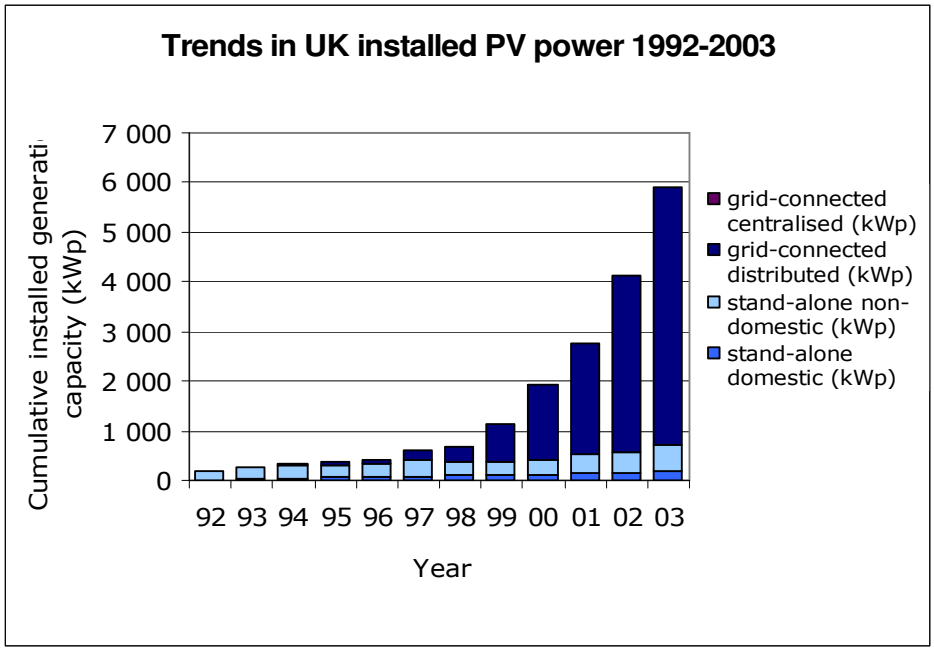
STC: Standard Test Conditions – irradiance of 1 000 W/m^2, cell junction temperature of 25°C, AM 1.5 solar spectrum

Turn-key price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid system, the prices associated with battery maintenance/replacement are excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication systems in a remote area are excluded).

1 EXECUTIVE SUMMARY

1.1 Installed PV power

There was a significant increase in the annual installed PV generation capacity in 2003 of 27 % compared to 2002. A total of 1 767 kW was installed in the UK in 2003. The cumulative installed PV generation capacity increased by 43 % during 2003 reaching a total of 5.9 MW. Much of this increase is due to the rapid expansion of the grid-connected market, accounting for 92 % of the 2003 installations. Government support of the Major Demonstration Programme launched in 2002 as well as Field Trials accounted for approximately 66 % of the total new capacity.



1.2 Costs & prices

Average PV module retail prices are slightly lower than in 2002, typically in the range 2.5 to 3. GBP/W for reasonable volume orders. For small orders (few modules) retail prices range from approximately 2.7 GBP/W up to 5 GBP/W. Lower minimum prices have also been achieved. The lowest price achieved during 2003 was for multicrystalline modules and was 2.2 GBP/W.

Overall system prices range considerably because they take into account the significant differences in the projects, the level of integration and technology used. On-grid prices ranged from 4.04 GBP/W to 14.8 GBP/W. However the average turnkey price for a standard 1-3 kW system was 6.7 GBP/W; similar to prices in 2001 and 2002.

1.3 PV production

The UK's only major indigenous cell manufacturer, ICP Global Technologies, increased its production from 2.3 MW to 2.5 MW in 2003. Production capacity increased by 17% in 2003 (compared to 2002) to 3.5 MW.

Crystalox, producers of multi-crystalline silicon blocks, increased production by 60 % in 2003 (compared to 2002). Total production in 2003 was sufficient for 120 MW of cells. The company, the UK's largest employer in the PV sector, increased production capacity from 90 MW in 2002 to 130 MW in 2003.

In October 2003 Sharp announced plans for a new PV module manufacturing facility in the UK, to be officially opened in July 2004.

BP Solar is working with two companies, Romag and Marley Roofing to manufacture and supply building integrated PV products in the UK using BP Solar PV cells. Romag, a specialist glass manufacturer will start producing semi transparent crystalline PV laminates in early 2004 at its new 6 MW lamination facility in Consett, County Durham. Marley Roofing have developed a solar roof tile designed to integrate with its Modern interlocking roof tiles. The PV tiles are likely to be assembled in Romag's factory in Consett.

1.4 Budgets for PV

Budgets for Pre-competitive R&D and Demonstration / Field Trials (supported by the Department for Trade & Industry and The Engineering and Physical Science Research Council) totalled 8.74 million GBP in 2003, this compares to 8.01 million GBP in 2002. A large proportion of this funding has been for the three separate demonstration and field trial programmes, provided by the DTI.

1.5 Business Value

The value of PV business in the UK for 2003 is estimated at 59 million GBP, 79 % of which comes from the export of PV modules and multi-crystalline silicon ingots.

2 THE IMPLEMENTATION OF PV SYSTEMS

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

For the purposes of this report PV installations are included in the 2003 statistics if the PV modules were installed between 1 January and 31 December 2003 although commissioning may have taken place at a later date.

2.1 Applications for photovoltaics

UK installed photovoltaic generation plant contributed an estimated 445 GWh to the UK's total energy supply in 2002. . This remains very small (less than 0.15%) compared to a total electricity consumption of approximately 338 TWh[1]. Nevertheless, PV provides an invaluable cost-effective service in an increasing variety of niche applications, particularly where power requirement is relatively small and/or accessibility is poor. There is also sustained expansion in the distributed grid-connected sector.

2.1.1 Stand-alone applications

Until the mid-1990s, the use of renewable energy for professional applications in the UK was limited to mountain-top telecoms equipment and light-house or harbour beacons. Since then, the number of applications using solar generators has advanced significantly and solar street lighting, solar lit road signs and bus stops are becoming increasing common. A total of 146.6 kW was installed off-grid in 2003. Of this 7 % was installed on residential properties with the remaining installations for a range of applications including street lighting and furniture.

In November 2002 London's Bus Services (LBS) announced a field test of bus shelters with roof-integrated panels to provide electricity for lighting. Solar Century, Sepco Holdings Plc and Canadian Carmanah Technologies Inc. are supplying the products. Three pilot shelters were installed during 2003 and the scheme is now being expanded with several hundred to be installed during 2004. The company is also considering PV for lighting of bus timetables at bus stops. Plymouth City Council installed over 100 solar bus shelters during 2003 with 330 shelters completed by early 2004. The Plymouth bus shelters were designed by Solar Century and JCDecaux and each use a 64 W Unisolar thin film PV module. A similar scheme has been implemented in Leicester. The first solar powered grid tied lighting scheme on UK mainland was also introduced in 2003, with the installation of 10 solar powered street lamps in Newport. Total installed capacity on bus shelters during 2003 was estimated as 60 kW.

Table 1 presents an overview of stand-alone applications for photovoltaics in the UK, categorised by end-users. Many of the applications have an installed capacity of less than 40 W.

[1] Digest of UK Energy Statistics 2003. Trends from 2003.

Table 1: Overview of stand-alone applications for photovoltaics in the UK

END-USERS	TYPICAL APPLICATIONS
INSTITUTIONAL	
Environment Agency, British Waterways	• Lock and sluice operation • Water pumping • Water quality monitoring
Local Councils	• Parking meters and "pay & display" machines • Car park security lighting • Street/path lighting • Bus stop lighting
Highways Authorities	• Emergency phones • Road-side information and hazard warning signs • Mobile units for temporary warning signs • Speed cameras • Remote junction/crossroads lighting • Powered 'cats-eyes' • Vehicle weigh-in-motion measurement • Traffic and pollution monitoring
Rail network	• Remote rail stations – lighting • Point greasers • Signalling and warning signs
Harbour Authorities / Trinity House	• Lighthouses • Offshore (buoy-mounted) navigation beacons • Harbour navigation beacons and warning signs
Met Office	• Weather stations - wind speed, temperature, etc. • Air quality monitoring
National Trust, Youth Hostel Association, etc.	• Remote visitor centres / hostels • Wardens' huts and workshops
Universities, Research Laboratories	• Remote monitoring of equipment
UTILITY	
Gas suppliers	• Unmanned oil/gas platforms • Remote meter reading • Gas pressure and flow measurement • Valve operation
Electricity suppliers	• Remote meter reading • Monitoring of HV cable insulation
Water companies	• Remote meter reading • Valve operation • Anti-freeze heating ("trace" heating) • Water level measurement • Water pumping, treatment and purification • Energy recovery in water supply lines
Telecoms companies	• Mobile phone local transmitters • Telecoms repeater stations
COMPANY	

END-USERS	TYPICAL APPLICATIONS
Farming and agriculture	• Electric fencing • Pest control - flashing lights, bird-scarers • Waterpumping for livestock drinking water • Lighting for stables and out-houses • Fish farm pond aeration • Fish farm feeding systems • Greenhouse lighting & heating
General	• Alarms for remote buildings • Area lighting • CCTV • Advertising
INDIVIDUAL	
Leisure boats	• Electric boat battery-charging
Camping & remote homes	• Battery charging (lighting/TV)

2.1.2 Grid-connected applications

The grid-connected PV market, with 2003 installed capacity of 1 621 kW, now accounts for over 92 % of the annual total. This was an increase of over 20 % over that installed in 2002. This is largely due to the completion of a number of projects under the DTI's grant supported programmes and in particular the Major Demonstration Programme which was introduced in 2002. During 2003 172 projects were completed under Stream 1 of the DTI's Major Demonstration Programme (< 5 kW systems) and 16 projects were completed under Stream 2 (> 5 kW systems) (see section 2.3). Also during 2003, PV was installed at 6 separate clusters of houses under the DTI's Domestic Field Trial (DFT) totalling 140 kW and six large scale projects were completed under the DTI's Large Scale BIPV programme, with a combined capacity of 193 kW.

Therefore about 447 kW of grid connected PV was fully paid for by the customer or received funding from sources other than the DTI. These projects included 89 kW installed by Woking Borough Council on two different buildings, 25 kW at Chumleigh School in Devon, 51 kW installed on BP Solar's offices in Sunbury and a 43 kW installation at Whitecross Estate for the Peabody Trust, which received European Commission funding.

2.2 Total photovoltaic power installed

The year-on-year total cumulative installed PV power for the UK sub-markets (stand-alone residential, stand-alone non-residential, and grid-connected distributed) from 1992 onwards are presented in Table 2.

BP Solar and Solar Century remain the UK's largest PV installation companies. Together they installed 1207 kW in 2003, compared to 723 kW in 2002. The remaining 560 kW was installed by over 20 PV installation companies.

Note, there are no centralised grid-connected PV power generation systems in the UK.

Table 2: The cumulative installed PV power in 4 sub-markets.

Sub-market/application	31 Dec. 1992	31 Dec. 1993	31 Dec. 1994	31 Dec. 1995	31 Dec. 1996	31 Dec. 1997	31 Dec. 1998	31 Dec. 1999	31 Dec. 2000	31 Dec. 2001	31 Dec. 2002	31 Dec. 2003
Stand-alone residential (kW)	7	47	52	57	69	83	108	119	121	135	162	172
Stand-alone non-residential (kW)	166	213	232	252	279	316	254	276	302	385	406	542
Grid-connected distributed (kW)	0	6	54	59	75	190	328	736	1 506	2 226	3 568	5 189
Grid-connected centralised (kW)	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (kW)	173	266	338	368	423	589	690	1 131	1 929	2 746	4 136	5 903

A total of 1 767 kW was installed in the UK in 2003. This represents an increase of 27 % compared to annual figures for 2002. The cumulative installed PV generation capacity increased by over 43 % during 2003 reaching a total of 5.9 MW. The growth rate over the last three years has averaged 45 %.

2.3 Major projects, demonstration and field test programmes

The three UK funding programmes which accounted for approximately 66 % of the total installations (in kW) during the year are described in the following sections.

2.3.1 Major Demonstration Programme

The PV Major Demonstration Programme (MDP) was officially launched on 26th March 2002. 20 million GBP was made available for the three-year programme from the Department of Trade and Industry. A further 5 million GBP additional funding for Stream Two was announced in February 2004. It was expected that the first phase of the MDP would result in at least 3 000 homes and 140 larger non-residential buildings receiving solar PV systems, but these targets have since been revised downwards. Its long-term aim is to assist in making PV technology an attractive investment for residential, public organisations and corporate customers. The UK government hopes that long-term sustained investment will result in a ten-fold increase in PV installations by 2005.

The scheme, administered by the Energy Savings Trust, comprises two application streams:

- Stream One – individual or small-scale applications (systems from 500 W to 5 kW) are dealt with on a rolling basis.
- Stream Two – medium or large-scale company or group applications of between 5 kW and 100 kW are dealt with quarterly by a competitive call process.

The maximum eligible subsidies were initially as follows:

- Public Sector buildings – 65 % of the nominal cost.
- Large profit making organisations – 40 %.

- All others, including SMEs and homes (Stream 1), - 50 %.

The subsidy level will diminish over time. From June 2003 maximum grant levels for Stream One were capped as follows:

- Bolt-on systems are eligible for a capped grant of the lesser of 3 000 GBP/kW or 50 %.
- Integrated systems are eligible for a capped grant of the lesser of 4 250 GBP/kW or 50%.

For Stream Two applications Public Sector grant applications were capped to a maximum of 60% funding.

Grants are available for both on and off-grid applications (since June 2003) and are eligible for modules, inverters and installation but not batteries or complex charge controllers. Only building related off-grid applications are eligible for funding. All grant applications require the use of approved products and accredited installers and designers.

In Stream One, 261 applications were approved in 2003 and 1 917 661 GBP was allocated for the installation of 574 kW. 172 systems were installed during the year (approximately 337 kW). The vast majority of the approvals (72%) are for 'bolt-on' systems and 68 % of the systems use crystalline technology. Projects have been approved all over the country but approximately 50 % of the approvals are situated in the south of England (South-West, South-East and London regions).

In Stream Two, 67 applications totalling 2 216 kW were approved during 2003 and 7 232 194 GBP allocated. 16 systems (503 kW) were installed under Stream Two in 2003. These included two installations in Woking which together totalled over 156 kW; the Devonshire Building at the University of Newcastle upon Tyne where a 24.9 kWp system using monocrystalline PV modules was fitted to the building's curved metal roof; and a 115 kW installation at the Centre for Engineering and Manufacturing Excellence (CEME) in Dagenham, Essex. The installation at CEME is now the UK's largest non-residential solar installation. It comprises 102 kW of BIPV on the two-storey building's standard Kalzip roof and a further 13 kW of glass- glass PV modules as part of a glazed entrance canopy.

2.3.2 Domestic PV Field Trials

The Department of Trade and Industry's Domestic Field Trial (DFT) aims to use the design, construction and monitoring of a wide range of residential types of installation as a learning opportunity for key players in the process of PV installation. In total, 28 sites, constituting over 480 dwellings and over 750 kW generation capacity will benefit from the 4.7 million GBP funding provided under DFT. The funding was allocated in two rounds. 6 of the 28 projects were installed during 2003 equalling 140 kW installed. This brings the total installed capacity under this programme, at the end of 2003, to 660 kW. Two thirds of the projects are in social housing or mixed developments and the systems are fitted in conjunction with exemplar energy efficiency technology. The projects investigate some novel integration approaches for the UK, including various solar roof tile systems.

The performance of the installed systems is being monitored for a period of two years after installation. This data is being used to establish typical efficiencies and outputs for UK sites, look for variations in performance due to system design and to look for variations in performance of similar systems due to operational effects such as shading. Data is already being collected on at least nine installations.

As well as the collection of data on the performance of the systems during the monitoring stages, also of importance are the key lessons learned during design and construction of the systems. The issues arising include[2]:

- Regional variations in building regulations (for example, Scottish regulations require that tiles are nailed to roof battens).
- Ensuring that PV products comply with British Standards. One PV tile product failed British Standards on fire testing and had to be modified.
- Having efficient and effective contractual arrangements, including involvement of all parties to the planned use of PV at the earliest stage of any development.
- Consideration of responsibilities at the early stage of the contract to avoid problems or delays related to items such as insurance and damage due to vandalism.
- Well planned logistics to minimise additional costs and ensure good working relationships are maintained.
- Good co-ordination between PV system installers and other building tradesmen, particularly roofers and electricians, to ensure adherence to quality and to the building schedule.
- Continuity of contract workers and ensuring training on handover when there are changes.
- Consulting with tenants to secure positive support for the installations.
- Having flexibility in the mounting systems, particularly for refurbishment projects, to allow for alignment with irregular or non-square roof members on site.
- Positioning of the array on the roof to take account of loading, particularly for older, refurbished properties.
- Some pre-payment electricity meters do not allow export of electricity and can be damaged by attempted export, or assume tampering and cut off supply.
- Labelling is a key issue for DNOs and attention to detail is required when finalising to ensure that the installation is acceptable to them.
- Ensuring that good practice is maintained with respect to wiring, i.e. clipping of cables to rafters or similar without long lengths of spare cable.
- Health and safety issues must be continually re-iterated because access to roofs is sometimes required in addition to standard roof installation, i.e. checking connections if problems are found on commissioning.
- Mitigation against vandalism, although this is not usually a problem once ownership of the systems is recognised i.e. when tenants have moved in, some sites, near waste grounds or similar areas attractive to local youths have experienced problems.
- Ensuring adequate and effective liaison with the DNO and electricity supplier. The supply of appropriate import-export meters has been problematic. The need to ensure electricity supply companies are involved and kept in touch with the project has been highlighted, especially since misunderstanding of the new meters has caused errors in customers' billing.

[2] Taken from Photovoltaics in Buildings Domestic Field Trial Newsletters No.4 May 2003 and No.5 November 2003

2.3.3 Large-Scale BIPV Field Trial

In November 2001 3 million GBP was allocated for 12-15 large building integrated PV projects (i.e. >20 kW), with the objectives of raising awareness and of creating confidence in the application of PV, increasing UK capabilities in the application of the technology, providing opportunities for UK industry and assessing the potential for BIPV in the near term and its role in future energy policies and strategies.

In March 2002 UK Energy Minister, Brian Wilson, announced 4.2 million GBP funding for 18 projects totalling almost 1.15 MW on public buildings across the UK. The extra funding was made available due to the large number (63) of quality schemes proposed.

All the designs are for true building integrated systems, and modules and inverters are required to conform to appropriate certification standards.

6 of the 18 projects were completed during 2003 and are described below.

2.3.3.1 The Insolvency Service, Bloomsbury - HQ Office

215 m^2 of PV laminate glazing were installed on the atrium roof of the headquarters of the Insolvency Service in central London. The original refurbishment in 1988 included an extensive atrium, where glazing was fitted with a screen to reduce glare. The PV laminates were designed to directly replace the existing atrium glazing, with the existing support system being retained. Glass-glass PV laminates were specially manufactured and were integrated into double-glazed units. The string arrangement was designed to minimise the effects of shading on system output. The PV array has a rated output of 25.4 kW.

2.3.3.2 University of East Anglia, Norwich - Research Facility

A 32.8 kW installation of double-glazed laminates containing multicrystalline and monocrystalline PV cells/modules was installed on the atria and façade of the Zuckerman Institute for Connective Environmental Research (ZICER) building at the University of East Anglia's School of Environmental Sciences.

2.3.3.3 Gloucester University Sports Science Centre

A 64.4 kW system was installed on the waveform roof of the sports science centre which features north lights and south facing PV cladding. The PV system comprises 23 rows of 16 175 W Photowatt PW1650 modules mounted on a Unirac rail system. Each array has a SMA SWR2500 inverter. The total system yield is predicted to be 51.7 MWh/year.

2.3.3.4 St Mary's Osterley - Community Church Hall

The south-facing roof of the new community hall includes a 29.5 kW monocrystalline PV array to provide rainscreen protection, solar control in summer and additional insulation in winter. The PV array also provides some additional sound control for a building situated under the London Heathrow flight path.

2.3.3.5 West Oxfordshire District Council - Council Offices

An existing office building was refurbished and linked to a new two-storey building through a Visitor Centre. The complex provides demonstrations examples of solar roof tiles, glass laminates and solar metal roofing with a total installed capacity of 23 kW. The new buildings are super-insulated with advanced BEMS control of heating and lighting. The building also incorporates rainwater collection and use, solar water heating and underfloor heating run from condensing boilers.

2.3.3.6 The Columba Centre, Islay

The Columba Centre is an education centre for the Gaelic language and culture incorporating community facilities for the island. The new building incorporates high levels of insulation (beyond the latest revisions to the Building Standards (Scotland) Regulations) and also includes natural ventilation and heat recovery. The 20 kW system made up of 1674 Unisolar polycrystalline sunslates provides power for the building including supply to the underfloor and radiant electric heating.

2.3.4 Woking Borough Council

The largest PV installation programme outside the government supported programmes is run by Woking Borough Council. Woking Borough Council provides services for over 93 000 residents and businesses in Woking. Through its Energy Efficiency Policy and Climate Change Strategy, the Council has reduced CO_2 emissions in its own buildings by 75% and in the Borough as a whole by 14.5% since 1990, through its own actions alone. In 2003 Woking Borough Council installed PV on four separate sites in the borough, the majority of which was on sheltered housing. Two of these installations (89 kW) were funded entirely by Woking Borough Council Over 256 kW was installed during 2003 bringing the total installed capacity in the borough to over 400 kW.

Since 1992 Woking has implemented a series of private wire district energy systems, extracting the true economic value of green energy by supplying customers directly on its networks rather than the national grid and so avoiding transmission and distribution losses and use of system charges. Woking adopts a mixed technology approach which not only affords local security of supply (as their systems can operate in island generation mode) but also enables expensive green technologies to be funded through a 'dilution economics' approach. This approach has seen the first fuel cell CHP system in the UK and has been responsible for Woking achieving the largest concentration of PV in the UK.[3].

Seven of the PV systems are on buildings which also incorporate CHP. All sites trade electricity with each other and other CHP systems in Woking via an enabling agreement for exempt supplier operation, enabling Woking to supply its own standby and top up, collectively, rather than from the grid.

During 2003 Woking Borough Council provided funding of 938 605 GBP for its PV projects. Woking's near term plans will see the PV capacity installed in Woking increase to over 1 MW.

[3] Minister for Energy, 10 February 2004

Table 3: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2002/problems and lessons learned	Funding	Project management	Remarks
Domestic Field Trial 2000-2002	1,4m GBP was originally assigned for 9 cluster projects – total >220 kW for >160 residences. (One of the nine projects was since cancelled)	To use the design, construction and monitoring of the installations as a learning opportunity for utilities, building developers and other key players. Geographical spread and technologically varied systems will maximise lessons learned. Monitoring of the systems will be carried out to assess performance over the two years following commissioning.	Eight developments totalling 170 kW have been completed.	Up to 100% DTI (some projects secured complementary EC funding)	BRE (leader), EMC Ltd., IT Power, NPAC	The installation process in each case has run smoothly. Any delays experienced have been due to the main building programme or to the complexities of monitoring. The results from the monitoring are now being analysed.
Domestic Field Trial – Phase II 2001-2003	4m GBP was originally assigned for 23 developments – total >600 kW for 379 dwellings. (Three projects have since withdrawn).	As above, with increased regional distribution allowing introduction of new players, including new DNOs	6 developments totalling almost 140kW were installed during 2003, bringing the total installed capacity under this programme to just under 490 kW. Monitoring of 9 of the installations is taking place and various issues arising from the installations have been recorded.		BRE (leader), NPAC, EMC, EA Technology	
Large Scale Building Integrated PV Trial (LSBIPV)	18 projects totalling almost 1.15 MW on public buildings across the UK. (Six projects have since withdrawn.)	The objectives of LSBIPV are to: -raise awareness and create confidence in the application of PV; -increase UK capabilities in the application of the technology; -provide opportunities for UK industry; and assess the potential for BIPV in the near term and its role in future energy policies and	6 projects (193 kW) completed in 2003 and 8 projects (358 kW) completed to date.	4.2 million GBP funding has been allocated for projects totalling almost 1.15 MW.	Halcrow Group Ltd.	

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2002/problems and lessons learned	Funding	Project management	Remarks
		strategies				
Major Demonstration Programme 2002-2005	20 million GBP was originally made available for the three-year programme from the DTI. It was expected that the first phase of the MDP would result in at least 3 000 homes and 140 larger non-residential buildings receiving PV systems, but this has since been revised downwards. A further 5M GBP was announced in March 2004.	Its long-term aim is to assist in making PV technology an attractive investment for both residential and corporate customers.	Small scale (< 5 kW) 172 systems totalling 337 kW installed, 261 applications approved and 1 917 661 GBP allocated during 2003. Large scale (> 5 kW) 16 systems totalling 503 kW installed, 67 applications approved and 7 232 194 GBP allocated. Total installed capacity to date: 906 kW	25 million GBP is available for the three-year programme. Project funding levels caps were introduced during 2003.	EST	

2.3.5 Highlights of R&D

Academic research in the UK is largely funded by the Engineering and Physical Sciences Research Council (EPSRC). In addition to companies' internal research activities, some pre-competitive industrial Research and Development projects are supported by the DTI mainly under the renewable energy programme.

Research funded by the EPSRC may be dedicated specifically to photovoltaic research, or may support more general research which may result in advances in photovoltaics as well as in other adjacent areas. The area of research is changing, research effort is moving slowly away from traditional silicon based materials toward new organic polymers based systems, and micro/nano structured devices, as well as exotic new materials such as semiconductor quantum dots and copper indium selenide. EPSRC supports a major strategic initiative in photovoltaics, namely Supergen – PV Materials for the 21st Century, and another consortium on next generation cell technologies to be launched in 2004.

The Department for Trade and Industry (DTI) R&D programme is concentrating mainly on cost reduction. The programme's main emphasis is on new, leading edge cell technology and manufacturing and also on improving the cost-effectiveness of balance of systems components. A project led by Johnson Matthey has just been completed that builds on their previous experience in the area to undertake basic research into low cost dye-sensitised solid state plastic encapsulated solar cells. The results at this early stage exceeded expectations, with efficiencies in excess of 5% already being measured.

Plasma Quest Ltd.'s three year DTI sponsored project 'Low Cost Thin Film Polysilicon Solar Cells' continued during 2003 and is scheduled to achieve stable thin film PV cells of at least 10% efficiency by the end of 2004. The company uses a Plasma Enhanced Chemical Vapour Deposition (PECVD) process, enhanced by the use of the high density plasma generated using Plasma Quest's patented generation system.

2.3.6 Public budgets for market stimulation, demonstration/field test programmes and R&D

Table 4a: Public budgets (in GBP million) for R&D, demonstration/field test programmes and market incentives.

		R&D	Demo / Field Test	Market
National	DTI	0.8	5.76	
	EPSRC	2.18	-	-
Regional				
Total (GBP)		**8.74**		

Budgets for Pre-competitive R&D and Demonstration / Field Trials (supported by the Department for Trade & Industry) totalled 8.74 million GBP in 2003, this compares to 8.01 million GBP in 2002.

Table 5: DTI funding (in GBP million) for field trials and demonstration programmes.

Programme	Amount, GBP million
Major Demonstration Programme (MDP)	2.9
Large scale BIPV and Residential field trials	2.86
TOTAL	**5.76**

The EPSRC currently supports research grants worth 10.7 million GBP in the area of photovoltaic research. Responsive mode research accounts for 7.6 million GBP of funding, with 3.1 million GBP strategic funding allocated through the Supergen scheme. These research grants may be dedicated specifically to photovoltaic research, or may support more general research which may result in advances in photovoltaics as well as in other adjacent areas. The research grants may last anywhere between 1 and 5 years, with profiled payments throughout the duration of the grant. In the calendar year 2003, the total funds paid out for photovoltaic research was 2.18 million GBP. This 2003 funding was distributed to over 20 different universities with the largest recipients being: the University of Cambridge, Imperial College London and De Montfort University.

The Low Carbon Innovation Programme, from the Carbon Trust, funds research and development, demonstration and market diffusion projects in low carbon technologies, with the aim of reducing carbon dioxide emissions. Whilst it is a potential source of funding for PV, in practice other technologies which produce the same carbon reductions more cheaply are usually favoured. The Carbon Trust is part funding the Photovoltaic Installer Training described in Section 3.6.1.5 during 2003 it provided 34 800 GBP.

Information on Local Authority funding programmes has not been accessible.

3 INDUSTRY AND GROWTH

3.1 Production of feedstocks and wafers

Table 6: Production and production capacity information for the year for feedstock producers and wafer manufacturers

Manufacturer	Process & technology	Total Production (MW)	Maximum production capacity (MW/yr)	Product destination
Crystalox	Crystalox PVPS System -Directional solidification of multicrystalline silicon	120	130	Solar cell producers in Europe and Japan

Crystalox, based in Wantage near Oxford, pioneered the development of multi-crystalline silicon directional solidification as a production process for the PV industry and delivers automated equipment to many of the world's leading PV companies.

The company also produces multi-crystalline silicon ingots, and following its production increase in 2002 by 250 %, it further increased production in 2003 by 44 % (compared to 2002). Its total production in 2003 was sufficient for 120 MW of cells. These are exported mainly to Japan and also to Germany, where they are wafered by PV Silicon, a sister company. The company employs 90 staff and is the UK's largest employer in the PV sector. The firm increased its total annual production capacity from 90 MW in 2002 to 130 MW in 2003. It has ISO 9001 accreditation.

3.2 Production of photovoltaic cells and modules

Table 7: Production and production capacity information for the year for each feedstock manufacturer

Manufacturer	Technology	Total Production (MW)		Maximum production capacity (MW/yr)	
		Cell	Module	Cell	Module
ICP Solar Technologies UK Ltd.	Amorphous silicon	2.5	2.5	3.5	3.5

ICP Solar Technologies UK Ltd (ICP UK) manufactures thin-film amorphous silicon cells and modules at its factory in Bridgend, South Wales (previously owned by Intersolar). The company operates to ISO 9001-2000. ICP UK is part of the ICP Group of Companies, which has its head Office in Canada. It employs 40 staff at the Bridgend factory.

ICP UK Develops and manufacture advanced Thin Film Solar Cells (ATF) based on a-Si thin film Technology. Recent investment includes a new in-house glass cutting line and 2 new multi-head solid state YAG and Double Yag laser systems mounted on granite beds using air-bearing slides for accurate laser scribing alignment.

This investment as well as fundamental process development has seen the performance of ICP UK modules increase from an average of 14W to over 18W.

In 2004 ICP UK plans to introduce Dual Junction Technology as part of its product range, with the benefit of improved stability. The existing plant at its factory will be upgraded in the second half of the year to accept the new technology, developed on its own development plant located at Plasma Quest Limited.

ICP UK increased production at the Bridgend factory from 2.3 MW in 2002 to 2.5 MW in 2003. 95% of the company's production is exported, 65 % of which to North America, 25 % to Europe and 10 % to Africa: The production figure also includes cells produced for a variety of consumer products manufactured in-house. Annual production capacity increased from 3.0 MW in 2002 to 3.5 MW in 2003.

Typical module prices are given in the Table 8 below:

Table 8: ICP Solar Technologies Wholesale module prices

Size of order	Modules prices, GBP per W
Orders <1kW	2.00
Orders 1-10kW	1.50
Orders>10kW	1.40

The Company has programmes part funded by the DTI:

Electra Slate. ICP UK have developed a new roof top power product, which is similar in appearance to and mounted using the same method as a standard roof slate. This product is based on the Electra Slate product developed by Intersolar, the previous owners of the factory. However the product now produces nearly 4W of stable power at 36V and has a unique connection system to minimise the number of connections required. It is suitable for new build and retro fit applications. The development programme is due to be completed in August 2004. The product will be certified to IEC 61646 and production is expected to start in the 2nd quarter of 2005.

Electra Clad. This is the development of a reverse junction solar cell deposited onto painted steel monolithically interconnected. This is a first stage development programme, to be completed by June 2005

Ten Seven: This project is the development of a new large area (1250 mm x 660 mm) process and equipment set for a new 10 MW process plant. The process will be dual junction ATF technology and will be produced on an inline batch based equipment set. The new factory is planned for 2006 and depending on support will be located in South Wales.

3.2.1.1 Planned new manufacturing plant

In October 2003, Sharp announced plans for a new 20 MW capacity PV module manufacturing facility in Wrexham. It will be Sharp's first European module assembly plant and will produce 160 W and 165 W PV modules. 60 staff were employed at the the PV manufacturing facility in early 2004 and the plant is due to be officially opened in July 2004. In the first instance most of the modules will be exported to Germany but it is hoped that in the future a proportion will be sold to the UK market.

BP Solar is working with two companies, Romag and Marley Roofing to manufacture and supply building integrated PV products in the UK using BP Solar PV cells.

Romag, a specialist glass manufacturer will start producing semi transparent crystalline PV laminates in early 2004 at its new 6 MW lamination facility in Consett, County Durham. Marley Roofing have developed a solar roof tile designed to integrate with its Modern interlocking roof tiles. The PV tiles are likely to be assembled in Romag's factory in Consett.

3.3 Module prices in the UK

Average module prices are slightly lower than in 2002, typically in the range 2.5 to 3.7 GBP/W for reasonable volume orders. For small orders (few modules) retail prices range from approximately 2.7 GBP/W up to 5 GBP/W. Lower minimum prices have also been achieved. The lowest price achieved during 2003 was for multicrystalline modules and was 2.2 GBP/W.

Table 9: Average retail module prices for small orders

Year	2001	2002	2003
Average retail module prices for small orders, GBP (current)/W	4	4	3.8

3.4 Manufacturers and suppliers of other components

Approximate price ranges for a range of inverter sizes are presented in Table 10.

Table 10: Price (in GBP) of inverters for grid-connected PV applications

Size of inverter	<1kVA	1-10 kVA	10-100 kVA	>100kVA
Average price of inverter per kVA (GBP)	280-1000	370-700	~ 300	~ 3 000

Manufacturers and suppliers of components in the UK include the following organisations. This list does not include all installers and suppliers of PV systems, but those supplying balance of system components and non-standard items:

BecoSolar of Dartmouth manufacture a range of controllers, batteries and building customised systems for industrial, commercial, leisure and residential uses, particularly for the off-grid sector, often for harsh environments.

Dabbrook Power Systems, based in Yarmouth are BP Solar product distributors and design and supply packages for off-grid applications.

Dulas Engineering of Machynlleth is a worker-owned company specialising in renewable energy system design and supply. The company designs and manufactures a range of robust electronic control equipment in-house. Dulas is also UK agent for Fronius inverters.

Invertec Ltd, traditionally a low-voltage lighting manufacturer, supplies a range of inverters for stand-alone PV applications.

Futronics Power Designs Ltd, based in Hertfordshire, designs and manufactures the 'Sustain' range of inverters for stand-alone applications.

I-Power of Gateshead produces a range of Stand-Alone and Grid Linked Inverters for (PV) Applications.

Labcraft of Romford is a specialist manufacturer of low voltage fluorescent lighting and inverters for PV and other alternative energy applications.

Mastervolt UK is the UK sales and distribution arm of Mastervolt, headquartered in Amsterdam. The company designs and manufactures inverters, battery chargers and related components, and distributes batteries and modules. In 2003 Mastervolt's Sunmaster QS range of grid connected inverters were approved for use under the UK electricity regulation G83 and are now available in the UK. The company also introduced a new datalogger for use with up to 20 of their Sunmaster inverters.

Solar Century of London is the main UK agent for a number of innovative roofing products including Pfleiderer's roof-tile integrated 'Terra Piatta' system, SES-Atlantis's Sunslates and Powerlight's insulated 'Powerguard' system for flat roofs. Following an agreement with Corus they also offer ''Kalzip AluPlusSolar, which uses Uni-solar 64 W thin film silicon and is suitable for metal roofing applications. It has also developed its own "C21" solar roof tile.

SolarGB of Leeds produces a wide variety of products using LED technology powered by small PV modules including amber flasher units, bollards, traffic lights, street lights and road studs (powered cats-eyes). They also offer a PV powered twin LED amber flasher unit for use on school safety zones and crossings or other warning zone applications such as cattle crossings.

Solagen Solutions produce a rage of solar powered lighting products for public lighting and information and warning signs.

Sollatek of Slough manufactures low-voltage DC lights and battery charge controllers for stand-alone applications, predominately for the export market. Their latest product is the solar powered Glowstar lantern.

SunDog Energy of Penrith is sole UK stockist of the Redland Integrated PV Roofing System. The 35 W panels come with a unique mounting system that integrates directly into a tiled roof, using standard battening and requiring no visible brackets or supporting structure. A basic system consists of 20 panels. The company is currently trialling a brand new roof tile.

Wind & Sun of Leominster is the main agent and authorised service centre for Xantrex-Trace inverters in the UK. The company also supplies SMA and Studer inverters for grid-connect applications.

DIY systems are available for stand-alone marine and leisure applications and also for educational purposes, as listed in section 2.1.1, but no DIY systems are available for grid-connected applications.

3.5 System prices

Table 11: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Price per W in GBP
OFF-GRID Up to 1 kW	Modules for leisure market (holiday homes, boats, caravans)	5.4 – 10.0
OFF-GRID >1 kW	Remote homes with battery storage or backup generator; Pumping Systems	5.2 – 9.0
ON-GRID Specific case	1-3 kW residential roof mounted	4.3 – 12.8 (average 6.7)
ON-GRID Specific case	1-3 kW residential roof integrated (e.g. slates or tiles)	5.0 - 12
ON-GRID up to 10 kW	Roof or ground-mounted systems (e.g for commercial building retrofits)	4.4 – 6.6
ON-GRID >10 kW	e.g. 20 kW roof mounted system (on filling stations, commercial / industrial buildings)	~ 5
	One-off true building-integrated designs will be more expensive	7.0 – 13.1

Table 12: National trends in system prices (current GBP) for 1-3 kW residential roof mounted system

Year	2000	2001	2002	2002
System price, GBP (Current) per W	5.0 – 7.0	5.5 – 8.5	4.3 – 12.8	4.3 -12.8

The range of prices takes into account the significant differences in the projects: the type of technology, the level of standardisation, level of integration etc. This is clearly illustrated by the approved prices for the Major Demonstration Programme (MDP) in 2003. Under Stream 1 (< 5kW) the average turnkey price for bolt on systems was 6.7 GBP/W. However the prices ranged from 4.8 GBP/W up to 12.8 GBP/W. Similarly for integrated PV systems under 5 kW the prices ranged from 5 GBP/W up to 14.8 GBP/W. The average price for approved integrated systems was GBP 8.9 GBP/W.

The prices for the projects approved in Stream 2 of the MDP (> 5kW) in 2003 were a similar price to the small-scale projects. The costs ranged from GBP 4.4 GBP/W up to 12.7 GBP/W with an average of 6.6 GBP/W. The lowest reported turnkey system price in 2003 was 4.04 GBP/W for a 100 kW system.

3.5.1 Labour places

An estimate of (full-time equivalent) labour places related to the photovoltaics sector in the UK is presented as Table 13.

Table 13: Estimated PV-related labour places in the UK

Research and development (not including companies)	66
Manufacturing of PV system components, including company R&D	171
All other, including within electricity companies, installation companies etc.	166

Of the 'All other' category, approximately 124 labour places are in the system supply and installation and/or distribution sectors.

The total number of labour places in 2003 is estimated at 403, which represents an increase of just under 2%. Most of this increase occurred in the installation companies.

These figures were produced as a result of email questionnaires and personal discussions with most of the UK PV industry players.

3.5.2 Business Value

The value of PV business in the UK for 2003 is estimated at 59 million GBP. This figure is based on the sum of total end financial value of the PV Systems installed during the year and the components -PV modules and multi-crystalline silicon ingots, exported during the year. 79% of the total business value comes from the export of PV modules and multi-crystalline silicon ingots.

3.6 Framework for deployment (Non-technical factors)

3.6.1 New initiatives

3.6.1.1 Promotional initiatives

Marketing of the Major Demonstration Programme is being carried out by The Energy Saving Trust (EST), as part of their contract with the DTI to manage the overall scheme, in partnership with Halcrow (technical and monitoring partner). EST is responsible for strategically developing the programme and dealing with installer accreditation, reporting, marketing, analysis and managing the application process. Marketing of the scheme is done via a website and by presentations at suitable energy efficiency, renewable energy and housing fora.

A number of activities to promote PV in Social housing took place during 2003, as part of European Commission funded projects:

- The PV in Social Housing (PViSH) project developed guidelines for social housing providers planning to implement a PV project. Recommendations were also made for a strategy for a successful promotion and implementation campaign "PV in Social Housing". The project was completed in early 2004.
- PV-DOMSYS was designed to stimulate the take-up of photovoltaic (PV) systems on homes. The UK partners, Guildford Borough Council and The National Energy Foundation (NEF), worked with seven other partners in Germany, France, Spain, and Belgium. The two-year project was completed in December 2003 and in the UK was supported by many local authorities, the Government Office for the South East, South East England Development Agency, the British Photovoltaic Association, Thames Valley Energy Agency and a housing developer, Laing Homes. During 2003 various promotional activities took place to promote PV to the general public. These included poster and leaflet campaigns, and a PV roadshow. As part of the project Guildford Borough Council made available 'Solar Technology Loans' where homeowners can borrow up to 1 500 GBP at 0 % interest for five years to assist them in buying a PV system. There has been no take up of the loans so far but it is hoped that a new project called Solar Living will encourage homeowners to take advantage of the scheme. Monitoring of existing PV installations to assess changes in energy use since their installation and to identify possible barriers affecting the development of PV was also carried out.
- The Resurgence (Renewable Energy Systems for Urban Regeneration in Cities of Europe) project is a European Commission funded initiative to integrate photovoltaics into the social housing sector as part of urban renewal programmes of European cities. At the heart of the project is the commitment to install 1.3 MW of photovoltaics in social housing or community buildings across 5 participating countries - the UK, Germany, Netherlands, Denmark and Switzerland. Within the UK up to 350 kW will be installed on the properties of the Peabody Trust Housing association by 2005. This will be completed as part of the organisation's re-roofing programme. During 2003 a 43 kW PV system was installed on the Whitecross P&Q Housing Block.

A number of electricity utilities offer to pay for exported electricity from a PV system. These include:

- EDF Energy (previously London, SWEB and Seeboard) If no export meter is fitted, EDF will pay 10 GBP per year per kW installed. If an export meter is fitted, EDF will pay 0.0764 GBP per kWh for exported electricity
- Powergen (previously TXU) will either estimate the exported electricity, or supply and install an export meter for free under the *solarnet* scheme. 0.0619 GBP/kWh paid for export.
- npower, under an Interim Solar Scheme (*Solar Moneyback*), npower will pay 0.05 GBP/kWh for generation (not export), as read from the kWh meter for the PV system. No export meter required. Customers must sign up to npower's green electricity tariff, Juice. New arrangements will be set up some time during 2004.
- Scottish & Southern will only buy back electricity from systems within their region. An export meter must be installed.

The 'Going Solar' scheme was launched in June 2003 by the Royal Society for the Protection of Birds (RSPB) to encourage people to use PV (and also solar water heating). The scheme offers 'solar loans' from the Co-operative bank together with a fixed price installation. System owners are also able to sell the electricity generated to RSPB Energy. The scheme is open to the general public but is being specifically targeted at the RSPB's one million members and supporters.

VAT on professional installations of PV systems has been set at the reduced rate of 5 % since April 2000.

The regional governments are setting regional targets for energy generation from each renewable technology including PV.

3.6.1.2 Utility perception of PV

Most of the 14 regional Distribution Network Operators now have direct experience of grid-connected PV systems. A number of interesting lessons for the DNOs and PV installers have been learnt during the Domestic Field Trial, as outlined in section 2.3.2.

Naturally, given the current low-level of PV penetration in the UK, the DNOs do not see solar electricity as a business priority at this time. Nevertheless, there is a general interest in PV issues and all DNOs are keeping a watching brief to see how the sector develops.

3.6.1.3 Public perceptions

A number of important policy announcements, including speeches by the Energy and Environment Ministers and the Mayor of London, have helped to raise the public profile of PV and other renewable energy technologies. Likewise the continuing promotional efforts of the government supported programmes and the installation companies appear to be having a positive impact on public opinion. The increase in use of PV powered street furniture and lighting has also helped to raise awareness of the technology.

Installers have noted a continuing increase in the number of residential enquiries they receive.

3.6.1.4 Major new projects / initiatives

As detailed in section 2.3 the Major Demonstration programme (MDP) was launched in 2002. Many installations under these programmes were completed during 2003 but

many more are scheduled for 2004 and beyond. Of the approvals from this and the LSBIPV made up to 31 December 2003, almost 3.5 MW is still to be installed.

A Distributed Generation Co-ordinating Group (DGCG) has been set up as an expert group and is chaired jointly by the DTI and Ofgem (Office of the Gas and Electricity Markets). It advises Ofgem, the DTI and other governmental departments on the removal of unjustifiable barriers to the development of distributed generation.

3.6.1.5 Other new issues

Training and Accreditation

Under the MDP grants, installers are required to be accredited. In order to gain accreditation applicants must demonstrate appropriate technical knowledge and capability in relation to PV and also meet certain criteria relating to insurance, finance and warranties. Technical knowledge and ability can be demonstrated either through previous experience in PV, or via completion of a recognised PV training programme –see below. Actual PV installation experience can be proven through the submission of case studies which are assessed by the scheme's technical advisors, Halcrow. The first installations of each newly accredited installer are site-inspected to ensure workmanship to an agreed standard.

The first nationally recognised course to train practising electricians to install PV is being developed by IT Power, in association with CREST (University of Loughborough), TNEI and ISPQ Europe. Course 2372 'Certificate in Installation and Testing of Domestic Photovoltaic Systems' gained City & Guilds accreditation in February 2004. The project began with the support of the EC Altener programme which set up a Europe wide Accreditation Scheme for courses in the installation of photovoltaic systems, and developed a peer-reviewed syllabus.

In 2003 funding from the Carbon Trust and STREEM (Skills Training for Renewable Energy in the East Midlands) took this course forward to develop specifications and assessments for the City & Guilds course, train trainers in further education colleges, develop training material for trainers and students, provide technical assistance to colleges before and during course delivery, and to audit courses. 5 pilot courses are to be developed across the UK and run by the end of September 2004, with the first of these at the end of May 2004. These courses have the opportunity to play an important role in a new route to becoming an accredited installer under the Solar Grants Scheme.

3.6.2 Indirect policy issues

The Renewables Obligation (RO) was introduced in the UK on 1st April 2002. This aimed to see 5 % of UK electricity generated from renewable energy sources by 2003[4] and 10 % by 2010. All suppliers of electricity in the UK need to supply the set percentage of electricity from renewables, or pay a penalty. For each unit of 1 MWh (rounded to the nearest whole MWh) of electricity produced per month from accredited renewable energy schemes, the generator will be awarded a 'Renewables Obligation Certificate' (ROC) which can then be sold to an electricity supplier as evidence of a renewables purchase. Suppliers that fail to purchase sufficient ROCs must buy-out of their obligation. The penalty/buy-out price for 2002/3 was 0.03 GBP/kWh and has increased to 0.0305 GBP/kWh for 2003/4. The obligation

[4] By 2003 1,7% of the UK's electricity consumption came from renewables eligible under the RO, with the 2,9% from renewables including large hydro not included in the RO.

should encourage development of near cost-effective renewable energy schemes, but is unlikely to promote photovoltaic generation capacity in the near to medium term.

The UK's New Electricity Trading Arrangements (NETA), which were introduced at the end of March 2001, have led to a reduction in wholesale electricity prices for the consumer. However NETA penalises generators that fail to deliver to their contracted supply agreement and has therefore not been helpful for renewable electricity generators. The intermittent nature of most renewables makes forecasting very difficult and leaves generators open to under-supply penalties or diminished value for over-supply. Modifications of the trading arrangements to protect renewables and small generators are currently under discussion. The British Electricity Transmission and Trading Arrangements (BETTA), which is progressing towards implementation by April 2005, will bring into existence a single electricity market for Great Britain by introducing a single set of trading rules across Great Britain and will reduce barriers faced by independent generators. As the arrangements only apply to wholesale generation, PV is largely unaffected, except in as much as the reduction in retail electricity price implies a divergence from economic viability for PV power. Modification P81: Removal of the Requirement for Half Hourly Metering on Third Party Generation at Residential Premises was introduced in 2003. This allows small scale generation to be settled via non-half hourly meter advances so that electricity suppliers can now be credited for generation allowed to spill onto the network. This is limited to 16A per phase on the low voltage 230V single phase or multiphase 400V supply connected to the distribution network.

The 'Climate Change Levy' (CCL) on business use of energy was introduced on 1st April 2001. The levy on electricity is initially set at 0.0043 GBP/kWh, plus VAT and is set to rise year-on-year. Renewable energy, however, is exempt from the levy and businesses that sign up to a renewable energy tariff can avoid paying the CCL. To avoid being charged the levy, businesses need to sign a contract with a supplier containing a 'renewable source declaration'. This ensures that for every kWh that is used, a kWh of electricity is generated from renewable energy sources. However, the CCL itself is unlikely to stimulate significant growth in PV, as for the foreseeable future, PV generated electricity will remain significantly more expensive than conventional electricity (even with the levy imposed) and other renewable energy technologies such as wind and landfill gas that are closer to the bulk electricity price.

The UK Energy White Paper was published in March 2003. The White Paper restates the UK's goal of a 60 % reduction in CO_2 emissions by 2050 and calls for 10 % renewables generated electricity by 2010 with an ambition to extend the policy to 2020. Specifically for PV, the White Paper includes a chart showing the extension of the Major Demonstration Programme up until 2012, with funding allocated until 2005.

The Sustainable Energy Bill was introduced in December 2002. It calls for a sustainable energy policy to include specification of measures to move towards the achievement of the amount of electricity generated from renewable sources being increased to 25 % by the end of 2020.

3.6.3 Standards and codes

The first revision of G 83 '*Recommendations for the connection of small-scale embedded generators (up to 16A per phase) in parallel with public low voltage distribution networks*' was issued in September 2003. This supersedes Engineering Recommendation G77/1. It contains a generic first section addressing the network requirements of all distributed micro-generators (including PV and micro-CHP),

complemented by a series of annexes focusing on technology-specific issues, including annex C on photovoltaics. The main changes from the previous G77/1 are:

- Post Notification for single generators: This means that application to the DNO prior to installation is no longer required (as it was under G77/1). Under G83/1 the generator is required to inform the DNO on the day of connection and then provide full details within 30 days.
- New Overvoltage Setting: Overvoltage 'ceiling' is increased to 264V. This is from 253V in G77/1, which was previously causing some nuisance tripping in certain instances.

Grid-interconnection of PV systems rated above 5 kW is governed by Engineering Recommendation G.59/1, Amendment 1 (1992) and Amendment 2 (1995), *'Recommendations for the Connection of Embedded Generating Plant to the Public Electricity Suppliers' Distribution Systems'*.

The Government's national planning policy with regard to renewable energy is set out in Planning Policy Guidance note (PPG) 22: Renewable Energy which gives local planning authorities guidance on a range of issues that affect the siting of all renewable energy projects. Specific information pertaining to photovoltaic installations is contained with an annex published in 2002. Its aim is to provide planning control officers who consider planning applications for PV installations with clear guidelines on assessing such applications. In November 2003 the Office of the Deputy Prime Minister issued a consultation on the Draft New Planning Policy Statement 22 (PPS22): Renewable Energy. Many of the policies in draft PPS22 are based on policies in PPG22, updated as appropriate. However, there is a clearer focus on assisting the UK to meet national and international targets for the reduction of emissions of greenhouse gases. It proposes the use of regional and sub-regional targets for renewable energy and clear, criteria based policies for use in regional planning guidance and development plans.

3.7 Highlights and prospects

Further installations in the Major Demonstration Programme will facilitate a continued healthy rate of grid-connected PV installation until 2005. Of the projects approved so far, 3.5 MW is still to be installed.

The future development of the sector is heavily dependent upon the performance of existing manufacturers, installers and suppliers. The current programmes are addressing the need for well-qualified technicians and the participation of players from the building and planning sectors so it is important that the UK PV industry delivers quality products and services when required.

3.8 Annex A Method and accuracy of data

The information for this survey report has been drawn from many sources. The assistance and co-operation of all parties who provided information for the 2003 survey is gratefully acknowledged.

Data was gathered directly from most of the UK industry players via e-mail questionnaire and personal discussions. The Energy Savings Trust provided access to their information for comparisons. The various data was collated in a spreadsheet, sorted into the required categories and totalled.

The estimated accuracy of the year 2003 data is ± 10 %, except for data relating to the new installed generation capacity in the grid-connected distributed sector and UK production where the accuracy is estimated to be ± 5 % or better.