# **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 2004

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#### 1 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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), 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. Nine tasks have been established, and currently five are active. Information about these tasks can be found on the public website <a href="https://www.iea-pvps.org">www.iea-pvps.org</a>. A new task concerning PV hybrid systems is now 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.

#### 2 DEFINITIONS

For the purposes of the National Survey Report, the following definitions apply:

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

<u>Installed PV power</u>: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m<sup>2</sup>, cell junction temperature of 25°C, AM 1,5 solar spectrum – (also see 'Rated power').

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

<u>PV system</u>: 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.

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

Off-grid domestic PV power system: System installed to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural 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'.

Grid-connected distributed PV power system: System installed to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

<u>Grid-connected centralized PV power system</u>: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

<u>Turnkey price</u>: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be 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).

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

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

<u>Market deployment initiative</u>: 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.

#### £: Pounds Stirling (National Currency)

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

<u>Performance ratio:</u> 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.

#### 1 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 Trends Report 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 2004.

UK National Survey Reports covering the past four years (2001 2002 2003 and 2004), together with other information about the UK's participation in IEA-PVPS, are available from the UK-PVPS website: <a href="https://www.iea-pvpsuk.org.uk">www.iea-pvpsuk.org.uk</a>.

#### 2 EXECUTIVE SUMMARY

#### 2.1 Installed PV power

There was a significant increase in the annual installed PV generation capacity in 2004 of 28 % compared to 2003 following similar growth in 2003. A total of 2 261 kW was installed in the UK in 2004. The cumulative installed PV generation capacity increased by 38 % during 2004 reaching a total of 8.2 MW. Much of this increase is due to the rapid expansion of the grid-connected market, accounting for 97 % of the 2004 installations. Government support of the Major Demonstration Programme launched in 2002 as well as Field Trials accounted for approximately 93 % of the total new capacity. Figure 1 shows the cumulative installed PV capacity up to the end of 2004.

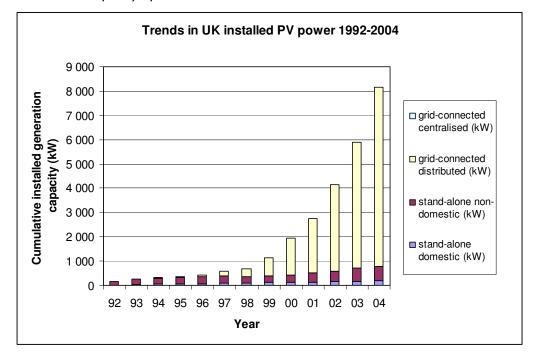


Figure 1: Cumulative installed PV capacity 1992-2004

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#### 2.2 Costs & prices

Average module prices are similar to those in 2003, typically in the range £2.5 to £3.7 per W for reasonable volume orders. For small orders (few modules) retail prices range from approximately £2.7 per W up to £5 per W. Lower minimum prices have also been achieved. The lowest module price achieved during 2004 was £2.28 per W for crystalline modules imported from mainland Europe.

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 £4.2 per W to £9.7 per W. However the average turnkey price for a standard 1 to 3 kW system was £6.2 per W, compared to £6.7 per W in 2003.

#### 2.3 PV production

Crystalox, producers of multi-crystalline silicon blocks, increased production by 42 % in 2004 (compared to 2003). Total production in 2004 was sufficient for 170 MW of cells. The company increased production capacity from 130 MW in 2003 to 185 MW in 2004.

The UK's only major indigenous cell manufacturer, ICP Global Technologies, reduced its production from 2.5 MW in 2003 to 1.5 MW in 2004 and plans to move production to India.

Sharp's new PV module manufacturing facility in the UK was officially opened in July 2004. The plant produces 160 W and 175 W crystalline silicon modules and produced a total of just over 8 MW of modules during 2004. The facility expanded its capacity from 20 MW to 40 MW during its first 6 months of operation.

Romag, a specialist glass manufacturer started producing semi transparent crystalline PV laminates in October 2004 at its new 6 MW lamination facility in Consett, County Durham. A small output was produced during 2004.

#### 2.4 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 in 2004. A large proportion of this funding (£5.59 million) has been for the demonstration and field trial programmes, provided by the DTI.

#### 3 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 2004 statistics if the PV modules were installed between 1 January and 31 December 2004 although commissioning may have taken place at a later date.

#### 3.1 Applications for photovoltaics

Installed photovoltaic generation plant contributed an estimated 4 GWh to the UK's total energy supply in 2004. This remains very small compared to a total electricity consumption of approximately 376 TWh<sup>1</sup>. Nevertheless, PV provides an invaluable cost-effective service in a 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.

#### 3.1.1 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 64 kW was installed off-grid in 2004. Of this one third was installed on residential properties with the remaining installations for a range of applications including street lighting and furniture.

Over 20 kW of off grid PV capacity was installed in 2004 for London Bus Services as roof-integrated panels to provide electricity for lighting in bus shelters. This brings the total capacity installed at bus stops and shelters for London Bus Services to just under 50 kW. Plymouth City Council has installed a total of 330 solar bus shelters of which approximately 230 shelters were completed in early 2004. The Plymouth bus shelters were designed by Solar Century and JCDecaux and each use a 64 W Unisolar thin film PV module.

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.

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

END-USERS	TYPICAL APPLICATIONS		
INSTITUTIONAL			
Environment Agency, British Waterways	<ul><li>Lock and sluice operation</li><li>Water pumping</li><li>Water quality monitoring</li></ul>		

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<sup>&</sup>lt;sup>1</sup> Digest of UK Energy Statistics 2004. Table 5.5

END-USERS	TYPICAL APPLICATIONS				
Local Councils	<ul> <li>Parking meters and "pay &amp; display" machines</li> <li>Car park security lighting</li> <li>Street/path lighting</li> </ul>				
Highways Authorities  Rail network	<ul> <li>Bus stop lighting</li> <li>Emergency phones</li> <li>Road-side information and hazard warning signs</li> <li>Mobile units for temporary warning signs</li> <li>Speed cameras</li> <li>Remote junction/crossroads lighting</li> <li>Powered 'cats-eyes'</li> <li>Vehicle weigh-in-motion measurement</li> <li>Traffic and pollution monitoring</li> <li>Remote rail stations – lighting</li> <li>Point greasers</li> <li>Signalling and warning signs</li> <li>Lighthouses</li> </ul>				
Harbour Authorities / Trinity House	<ul> <li>Offshore (buoy-mounted) navigation beacons</li> <li>Harbour navigation beacons and warning signs</li> </ul>				
Met Office	<ul> <li>Weather stations - wind speed, temperature, etc.</li> <li>Air quality monitoring</li> </ul>				
National Trust, Youth Hostel Association, etc.	<ul><li>Remote visitor centres / hostels</li><li>Wardens' huts and workshops</li></ul>				
Universities, Research Laboratories	Remote monitoring of equipment				
UTILITY					
Gas suppliers	<ul> <li>Unmanned oil/gas platforms</li> <li>Remote meter reading</li> <li>Gas pressure and flow measurement</li> <li>Valve operation</li> </ul>				
Electricity suppliers	<ul><li>Remote meter reading</li><li>Monitoring of HV cable insulation</li></ul>				
Water companies	<ul> <li>Remote meter reading</li> <li>Valve operation</li> <li>Anti-freeze heating ("trace" heating)</li> <li>Water level measurement</li> <li>Water pumping, treatment and purification</li> <li>Energy recovery in water supply lines</li> </ul>				
Telecoms companies	<ul><li>Mobile phone local transmitters</li><li>Telecoms repeater stations</li></ul>				
COMPANY					
Farming and agriculture	<ul> <li>Electric fencing</li> <li>Pest control - flashing lights, bird-scarers</li> <li>Waterpumping for livestock drinking water</li> <li>Lighting for stables and out-houses</li> <li>Fish farm pond aeration</li> <li>Fish farm feeding systems</li> <li>Greenhouse lighting &amp; heating</li> </ul>				

END-USERS	TYPICAL APPLICATIONS
General	<ul><li>Alarms for remote buildings</li><li>Area lighting</li><li>CCTV</li></ul>
	<ul> <li>Advertising</li> </ul>
INDIVIDUAL	
Leisure boats	Electric boat battery-charging
Camping & remote homes	Battery charging (lighting/TV)

#### 3.1.2 Grid-connected applications

The total capacity of grid connected installations during 2004 was 2 197 kW, which represents over 97 % of the annual total. This was an increase of 35 % with respect to that installed during 2003. 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 2004 260 projects were completed under Stream 1 (small systems up to 5 kW) of the DTI's Major Demonstration Programme and 35 projects were completed under Stream 2 (medium and large scale systems over 5 kW systems) (see section 2.3). Also during 2004, PV was installed at 2 separate multi-occupancy domestic buildings under the DTI's Domestic Field Trial (DFT) totalling 60.33 kW and three large scale projects were completed under the DTI's Large Scale BIPV programme, with a combined capacity of 192 kW.

About 148 kW (7%) of grid connected PV was fully paid for by the customer or received funding from sources other than the DTI. These projects include an 86 kW system installed for Woking Borough Council and an 11 kW installation on a sound barrier for the Highways Agency. This installation consists of two systems, one of which uses standard modules and the other is based on a "peel and stick" thin film solar technology which is bonded to the aluminium sound barrier. The thin film material is designed to be robust enough to withstand impacts from stones and other motorway debris. The trial system is the first of its kind in the UK.

#### 3.2 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.

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

Sub-market/ Dec. application Stand-alone domestic (kW) Stand-alone non-domestic (kW) Grid-connected distributed (kW) 1 506 2 226 3 568 5 189 7 386 **Grid-connected** 

1 131

1 929

4 136

5 903

8 164

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

#### 3.3 Major projects, demonstration and field test programmes

#### 3.3.1 Major Demonstration Programme

centralised (kW)

TOTAL (kW)

The PV Major Demonstration Programme (MDP) was officially launched on 26<sup>th</sup> March 2002. £20 million was originally made available for the three-year programme from the Department of Trade and Industry. A further £5 million additional funding for Stream Two was announced in February 2004 and another £6 million in September 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 scheme, managed 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 subsidy level has been reduced over time. The maximum eligible subsidies during 2004 were as follows:

- Public Sector buildings: 50 % of the nominal cost (Originally 65% at the start of the programme).
- Large profit making organizations: 50% (Originally 40 % at the start of the programme).
- All others, including SMEs and homes (Stream 1): 50 %.

From June 2003 maximum grant levels for Stream One were introduced. These maximum grant levels were reduced further during 2004:

- Bolt-on systems were eligible for a capped grant of the lesser of £2 800 /kW or 50%
- Integrated systems were eligible for a capped grant of the lesser of £4 000 /kW or 50%

Two additional maximum grants levels were also introduced:

 The maximum grant for semi-integrated systems was capped at the lesser of £3 400 /kW or 50%.

 The maximum grant for glass/glass systems was capped at the lesser of £5000 /kW or 50%.

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.

By the end of 2004, a total of 516 systems (2 724 kW) had been installed under the programme as a whole. The installations completed during 2004 are broken down as follows:

- In Stream One, 260 systems were installed during the year (approximately 559 kW).
  The vast majority of installations (93%) are for grid connected systems. Projects have
  been installed all over the country but approximately 50 % of all approvals are situated
  in the south of England (South-West, South-East and London regions).
- In Stream Two, 35 systems (1259 kW) were installed in 2004 and grant applications for 66 systems (1811 kW) were approved for funding.

The current programme will continue until March 2006 or until the current funding has been allocated, with installations continuing until March 2007. The programme will be superseded by a new 'technology blind' building integrated renewables programme which will continue to provide support for PV but which will also support other small scale renewable energy technologies.

#### 3.3.2 Department of Trade and Industry's Domestic Field Trial

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, 27 sites, constituting over 474 dwellings have benefited from the £4.7 million funding provided under DFT. The final 2 projects of the programme were installed during 2004. This brings the total installed capacity under this programme, at the end of 2004, to 741 kW. 3 of the projects installed under the programme completed monitoring during 2004.

Two thirds of the projects are in social housing or mixed developments. The projects investigate a variety of 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. 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. These key lessons include the need for good co-ordination between PV installers, architects and building contractors. On new build projects communication between the PV installer and the building contractor can be made easier by contracting the PV installer to the main contractor. Some issues arose in the monitoring of the installed systems due to technology problems. PV is also seen to enhance or at least not alter the appearance of a property. The views of the occupants themselves are being reviewed in the Post Occupancy Survey. From results to the end of December 2004, 85 % of responses have indicated that they do like the PV systems on their homes. The monitoring programme will continue until the end of 2005.

#### 3.3.3 Large-Scale BIPV Field Trial

In November 2001 and March 2002 together a total of £7.2 million was allocated for 18 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

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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. The programme so far has provided between 60% and 100% funding and a total of around £3 million for 11 completed projects. One further installation is underway. The remaining 6 projects are not proceeding for a variety of reasons including lack of matching funding and some of the new buildings being abandoned at design stage. All the designs are for true building integrated systems, on a variety of construction types. The completed projects use a variety of PV technologies and include new build and retro-fit applications. All completed installations are being performance monitored for a period of two years and the results of this are to be used to make best practice recommendations. Data collected to date has shown some discrepancies between measured system performance and expected design output. The main reasons for this were unexpected shading and inverters failures. Other problems with hardware were noticed including erratic maximum power point tracking and G59 relay tripping due to high grid voltage conditions. General lessons learned as part of the programme include a need for trained PV roofers who encompass a range of skills including DC and AC electrical, roofing and glazing skills. The systems installed within the programme are all high profile installations on public buildings and as such are playing an important role in raising public awareness of PV.

#### 3.4 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 precompetitive industrial Research and Development projects are supported by the Department of Trade and Industry (DTI) mainly under the Technology Programme.

The DTI's Technology Programme funds industrially focused collaborative research. Funded research projects relating to PV are currently focused on third generation technologies and cost reduction measures.

The EPSRC Sustainable Power Generation and Supply (Supergen) Project 'Photovoltaic Materials for the 21st Century' was launched during 2004. The project consortium is made up of six universities (University of Wales Bangor, University of Durham, University of Bath, University of Northumbria, University of Loughborough and University of Southampton) and seven companies. The project aims to develop low cost thin film solar cell devices fabricated from inorganic semiconductors. To this end, the consortium is studying a number of materials for use in these devices. For example Bath University will involve the development of novel low cost electro-deposition routes to fabricate films of materials such as copper indium sulphide/selenide (CIS/CIGS). In Southampton research aims to establish production capabilities for crystalline silicon and thin film polysilicon. The Southampton team will look at innovative nano-structured light-trapping techniques and explore third generation concepts. The project was launched in June 2004 and the main accomplishments during the year were recruitment of researchers and purchase of equipment.

PV-ERA-NET "networking and integration of national and regional programmes in the field of photovoltaic (PV) solar energy research and technological development (RTD) in the European Research Area (ERA)" was launched during 2004. The European project brings together national and regional photovoltaic research programmes from ministries, energy agencies and research councils from 11 countries. Its overall objective is to strengthen Europe's position in photovoltaic technology through increasing cooperation and coordination of fragmented research efforts.

The UK Energy Research Centre was opened during 2004, a multi-million pound investment by the Research Councils, and part of the Towards a Sustainable Energy Economy Programme (TSEC). The Centre will provide a focus for energy research including PV in the UK, and for co-operation between the UK and researchers from other countries.

PV Catapult is a new Coordination Action within the 6th Framework Programme of the EC, it started in 2003 and will run over 2 years. It involves more than 70 partners from the European industry, the research community and other major stakeholders of the PV sector. The objective of PV Catapult is to coordinate specific activities in the field of photovoltaics. CREST at Loughborough University is part of the project consortium and will focus on modeling and measurement aspects of photovoltaics.

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

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. In 2004, EPSRC provided £2.22 million in funding for photovoltaic and photovoltaic-related research. This funding is part of both short term and long term projects including the Supergen PV materials for the  $21^{\rm st}$  Century, as mentioned above in section 3.4 and another new strategic research project, for organic material photovoltaic research: The SUPERGEN Excitonic Solar Cell Consortium, led by Prof. L.M. Peter at University of Bath, will fund £1.09 million into organic photovoltaic research. In 2004 the top universities in terms of photovoltaic funding were: University of Cambridge, The University of Manchester, University of Sheffield, Imperial College London, University of Oxford, University of Bath, University of Durham, Cranfield University (Shrivenham Campus) and University of Southampton.

Budgets for Pre-competitive R&D and Demonstration / Field Trials (supported by the Department for Trade & Industry) totalled £8.74 million in 2004, this compares to £8.74 million in 2003 and £8.01 million in 2002.

Table 3: Public budgets (in £ million) for R&D, demonstration/field test programmes and market incentives.

		R & D	Demo/Field test	Market incentives
National	DTI	0.93	5.59	-
	EPSRC	2.22	-	-
State/regi	onal	n/a	n/a	n/a
	Total		8.74	

Table 4: DTI funding (in  $\pounds$  million) for field trials and demonstration programmes.

Programme	Amount, £ million
Major Demonstration Programme (MDP)	3.99
Large scale BIPV and Residential field trials	1.60
TOTAL	5.59

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.

Information on Local Authority funding programmes has not been accessible.

#### 4 INDUSTRY AND GROWTH

#### 4.1 Production of feedstocks, ingots and wafers

Table 5: Production and production capacity information for the year for silicon feedstock, ingot and wafer producers

Producer	Process & technology	Total Production in 2004 (MW)	Maximum production capacity (MW/yr)	Product destination
Crystalox	Directional solidification of multicrystalline silicon	170	185	Export to Europe and Japan

Crystalox, based in Wantage near Oxford, pioneered the development of directional solidification of multi-crystalline silicon as an industrial production process for the PV industry. The company has grown to become the world's largest producer of multicrystalline silicon exporting over 90% of its material to PV companies in Europe and Japan where the material is processed to produce cells for PV modules.

The company employs 92 staff. The firm increased its total annual production capacity from sufficient for 130 MW of PV cells in 2003 to 185 MW in 2004. It also has 10 MW of production capacity under construction. The company has ISO 9001 accreditation and its business value is £51 million.

#### 4.2 Production of photovoltaic cells and modules

Table 6: Production and production capacity information for the year for each UK manufacturer

Cell/Module manufacturer	<b>Technology</b> (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)	Maximum production capacity (MW/yr)
Sharp	Crystalline Silicon Cells –module manufacture	8.13 MW	40 MW
ICP Solar	Amorphous Silicon Cells –module manufacture	1.5 MW	3.5 MW
Romag	Crystalline Silicon Cells - Lamination into glass/glass and glass/tedlar	Small (facility started operation late 2004)	6 MW (lamination only)
TOTALS		9.63 MW +	49.5 MW

Sharp's first European module assembly plant in Wrexham was officially opened in July 2004. The plant uses EVA lamination encapsulation and produced just over 8MW of modules during 2004. During its first 6 months of operation it expanded its capacity from 20 MW to 40 MW. The PV manufacturing plant employs 177 full time equivalent staff. PV cells used in the modules are imported from Japan. The plant produces 175 W and 165 W modules certified to IEC 61215. The typical warranty length for modules produced is 25 years. 100% of modules produced are exported to mainland Europe. The majority of modules are sold to Germany and rest to Spain, Italy and France. The plant will begin to sell some modules to the UK market in 2005.

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.

ICP UK decreased production at the Bridgend factory from 2.5 MW in 2003 to 1.5 MW in 2004 and the company plans to move production to India. Most of the company's production in 2004 was exported, 30 % of which to North America, 8 % to Europe, 29% to Asia and 32 % to Africa. The production figure also includes cells produced for a variety of consumer products manufactured in-house.

The average size of modules produced by ICP Solar at Wrexham is around 18 W however the company is currently developing 42 W and 84 W modules.

Typical module prices are given in Table 7 below:

**Table 7: ICP Solar Technologies Wholesale module prices** 

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

Romag's 6 MW lamination facility started operation in September 2004. The factory in Conssett, County Durham employs 15 people within the PV lamination facility. Approximately 50 kW of cells were purchased on the international market to produce a very small output of PV laminates in 2004. The company has ISO 9001 certification. IEC 61215 certification is pending for some products and 10 year warranties are provided with all laminates. The facility is capable of manufacturing any type of laminate up to a maximum size of 3.3m x 2.2m in any thickness of glass. Only a small output was produced in 2004 but it is anticipated that in the future at least 30% will be exported to mainland Europe and the Far East. Pricing varies depending on the type of laminate required. The company reported that it is too early to estimate the business value of its lamination facility.

Table 8: Typical module prices (£) for a number of years

Year	2001	2002	2003	2004
Typical retail module prices for small orders, £ (current)/W	4.1	4.1	3.9	3.7
Typical retail module prices for large orders, £ (current)/W	-	-	-	3.5
Best price, £ (current)/W	-	-	2.2	2.3

Average module prices are similar to those in 2003, typically in the range £2.5 to £3.7 /W for reasonable volume orders. For small orders (few modules) retail prices range from approximately £2.7 /W up to £5 /W. Lower minimum prices have also been achieved. The lowest module price achieved during 2004 was £2.28 /W for crystalline modules imported from mainland Europe. Higher prices (up to £9.8 /W) were paid for bespoke glass-glass laminates for one off building integrated projects.

#### New products

Solar Century's <u>C21 solar PV</u> tile was launched in April 2004. It was developed specifically for the UK housing market. Its integrated design and aesthetic appeal means that for most developments it will not need planning permission. It is designed to fit quickly and easily to standard battens and integrates with common interlocking roof tiles.

<u>AluPlusSolar</u> combines UNI-SOLAR triple junction thin film PV laminates and Kalzip standing seam roofing to give a solar metal roofing solution for the UK. The product is a result of collaboration between Solar Century and Corus.

Marley Roofing's <u>SolarTile</u> is a 23 W PV roof tile. The SolarTile is compatible with Marley Modern Interlocking Tiles. Each SolarTile has a PV laminate top, which fits into the tile base. Production of the PV laminate top began in 2002 by Romag Glass who are based in Consett. The product was officially integrated into the Marley Roofing product portfolio during 2004.

#### 4.3 Manufacturers and suppliers of other components

A large proportion of balance of system components installed in the UK are imported from mainland Europe and sold through distributors in the UK.

#### PV inverters and their typical prices

Fronius and SMA are the most common manufacturers of PV inverters for grid connection available in the UK and are available in sizes from 1.3 kVA to 4.6 kVA. The Fronius IG range features an LCD screen showing system parameters. The Mastervolt range of grid connected inverters became approved for use in the UK (under electricity regulation G83). A 5.2 kVA model became available in the UK in 2004.

An approximate price ranges for a range of inverter sizes are presented in Table 9.

Table 9: Price (in £) of inverters for grid-connected PV applications

Size of inverter	<1kVA	1-10 kVA	10-100 kVA	>100kVA
Average price of inverter per kVA (£)	500-1000	350-600	~ 300	~ 300

For off-grid applications popular manufacturers include Xantrec /Trace, Victron and Studer.

#### Storage batteries

Batteries for PV applications available in the UK include Trojan, Elecsol Carbon Fibre and Exide Solar. SEC battery, based in Corby, Northants manufacturers the Cellyte TSG Solar range of valve regulated rechargeable batteries designed for use in daily cyclic renewable PV Solar energy applications. The 6 and 12 volt batteries come in a range of capacities between 60 Amp Hours and 300 Amp Hours although the larger sizes will not become available until 2005. The batteries have a design life up to 10 years.

#### Battery charge controllers

Charge controllers from a variety of manufacturers are available in the UK including Steca, Solarix, Morningstar, Trace, and BP Solar. One of the largest available is the Canadian OutBack MX60 which is rated up to 60 Amps DC and incorporates Maximum Power Point Tracking (MPPT). Several UK manufacturers exist including Sollatek of Slough which also has a range of other off-grid PV system components and Blackwater Electronics of Torpoint, Cornwall.

#### Supporting structures

The Solion's Sunmount system was launched during 2004 and offers a new solution to mounting PV modules on flat roofs without the need to penetrate the roof. The system uses a series of interlocking pieces made from recycled plastic and is designed to withstand wind speeds of more than 100 mph.

#### Off grid PV powered street furniture

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 range of solar powered lighting products for public lighting and information and warning signs.

#### 4.4 System prices

**Table 10: Turnkey Prices of Typical Applications** 

Category/Size	Typical applications in your country and brief details	Current prices per W in £
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
GRID- CONNECTED Specific case	1-3 kW roof-mounted system, average price	6.2
GRID- CONNECTED	Roof or ground-mounted systems (e.g for commercial building retrofits)	5.0-6.5
	One-off true building-integrated designs will be more expensive	6.5-11.4
	e.g. 20 kW roof mounted system (on filling stations, commercial / industrial buildings)	4.8-6.5
>10 kW	One-off true building-integrated designs will be more expensive	6.5-10.8

Table 11: National trends in system prices (current £) for 1-3 kW roof-mounted system

YEAR	2000	2001	2002	2003	2004
Price /W:	5.3 – 7.4	5.8 – 9.0	4.6 – 13.6	4.6 -13.8	4.2-9.7

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 2004. Under Stream 1 (< 5 kW) the average turnkey price for all systems was £6.2 /W. However the prices ranged from £4.2 /W up to £9.7 /W.

The prices for the projects approved in Stream 2 of the MDP (> 5kW) in 2004 were similar to the small-scale projects. The costs ranged from £4.8 /W up to £11.4 /W with an average of £6.5 /W. The lowest reported turnkey system price in 2004 was £4.8 /W for a 10.5 kW retrofit system for a housing association multi occupancy domestic building.

#### 4.5 Labour places

An estimate of (full-time equivalent) labour places related to the photovoltaics sector in the UK is presented as Table 12. The total number of labour places is estimated at 580. This represents an increase of over 40% over the figure for 2003. The majority of this increase has been in manufacturing as a result of Sharp's new module manufacturing facility in Wrexham which employs 177 staff.

Table 12: Estimated PV-related labour places in the UK

Research and development (not including companies)	32
Manufacturing of PV system components, including company R&D	328
Distributors of PV products	28
System and installation companies	158
All other, including within electricity companies, consultancies etc.	35
	F00
Total	580

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

#### 4.6 Business value

As shown in Table 13, the total value of the PV business in the UK is estimated at £78 million. This is calculated from the cost of the installations completed during 2004 and the business value of the PV manufacturing (figures provided by ICP Solar Technologies and Crystalox and estimated at £2 /W for Sharp), minus the value of imports of PV products. The value of imports is calculated assuming 100% of all PV modules being installed are imported at a wholesale price of around £2 /W and 100% of all PV inverters installed are imported at a wholesale price of around £0.4 /VA.

Since Romag's total PV laminate production during 2004 was small and the company reported that it was too early to report on the business value of its lamination facility, no figure has been included for Romag in these calculations.

Table 13: Value of PV business

Sub-market	Capacity installed in 2004 (kW)	Price per W (£/W)	Value (£)	Totals (£)
Off-grid domestic	21	8	168000	168000
Off-grid non- domestic	41	7	284060	284060
Grid-connected distributed	2197	6.5	14281380	14281380
Grid-connected centralised	0	0	0	0
Total	14700940			
Module, cell and feeds	68610000			
Change in stocks held				unknown
Import of PV products				5377700
Total Value of PV business				77979740

#### **5 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)**

#### 5.1 New initiatives

#### Utility perception of PV

All UK Distribution Network Operators (DNOs) have experience of PV systems. Due to the 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, particularly by the DNOs in the south of the country where PV systems are more common, and all DNOs are keeping a watching brief to see how the sector develops.

#### Changes in public perceptions of PV

In general there is still limited awareness of PV among the general public. This is largely because PV is still too expensive for a homeowner to consider for their own home. Various initiatives and projects have been launched to encourage the use of PV. The Department of Trade and Industry's 'It's only Natural' campaign, launched during 2004 aims to promote renewable energy, including PV and to provide information on the subject to planners, local councillors and the general public.

#### Other issues

<u>Regional targets</u> are being set for energy generation from renewable energy technologies including PV. For example South West England has a renewable electricity target of 563-665 MW by 2010 as a result of the REvision 2010 project. Targets have been adopted by counties in the region and are being incorporated into county renewable energy strategies. Different UK regions are at different stages of adopting targets. In the East Midlands the Regional Planning Guidance (RPG8) proposes a target of 15.9 MW of photovoltaic capacity

by 2010. The Scottish Executive has set a target of 40% of its electricity to be met by renewable energy by 2020.

Marketing of the <u>Major Demonstration Programme</u> is 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. The scheme is due to come to an end in 2006 and will be replaced by a new programme which will support a range of small scale renewable energy technologies.

March 2004 saw the publication of 'Investing in Renewable Energy', the first piece of research to focus solely on the attitudes of the UK investment community to renewables. The key finding of the report is that the majority of investors have a strong appetite for investing in renewable energy. They have a good understanding of the opportunities and risks and believe there is a definite business case.

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

- EDF Energy: If no export meter is fitted, EDF will pay £10 per year per kW installed. If an export meter is fitted, EDF will pay £0.0764 per kWh for exported electricity
- Powergen: will either estimate the exported electricity, or supply and install an
  export meter (paid for by the customer) under the *solarnet* scheme.
   £0.0688 to £0.0854 per kWh paid for export depending on the region.
- npower: will pay £0.05 per 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.
- The Royal Society for the Protection of Birds' (RSPB) 'Going Solar' scheme, encourages 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. The scheme also makes available a net metering arrangement through Scottish and Southern. An export meter is required.

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

Northern Ireland Electricity (NIE) runs the <u>Smart Programme</u> which aims to encourage the local market for small scale renewable energy options including PV and the take up of the nationally available grants. The scheme was started in 2003 when following a zero uptake of the MDP solar grants in Northern Ireland, NIE started to offer an additional 25% grant of the total installed cost of a PV system in addition to the 50% grant available through the MDP. During 2004 this was reduced to 15%, granted automatically once a grant from the MDP has been approved. Within this programme, NIE has negotiated a bulk discount with a PV system installer so that together with an NIE contribution of 25% it is able to offer Local Authorities in Northern Ireland a 5KW PV system on one of their public buildings for around £7 500.

The <u>Solarplan partnership</u> consisted of Daventry District Council, as the lead organisation, with the other local authorities in Northamptonshire and Powergen plc. The project included a variety of activities to:

 encourage the development of a local solar industry and develop a local network of installers

- encourage the incorporation of systems in new housing by housing associations and other developers
- raise awareness for council and housing association staff, and others who give advice on housing related issues
- further improve cost effectiveness by targeting properties that are having major works carried out to their roof and targeting new housing developments.

  So far the partnership has resulted in the installation of 8 PV systems in the area.

#### 5.2 Indirect policy issues

The Renewables Obligation (RO) was introduced in the UK on 1st April 2002. The Renewables Obligation provides an incentive for the development of new renewable generating capacity that will be needed to meet the UK's target of 10% of electricity generation by 2010. The Renewables Obligation requires licensed electricity suppliers to source specified percentages of the electricity they supply from renewable sources, or make a 'buy-out' payment to Ofgem for all or any part of the percentage which is not covered by the presentation of certificates. The percentage target is set to increase each year from its current level of 4.9 per cent in 2004/05 to reach 10.4 per cent by 2010/11. The buyout payments made by suppliers under each order are combined into a fund, the proceeds of which are recycled to all suppliers in proportion to the extent to which they have correctly presented certificates. The penalty or buy-out price for 2002/3 was £0.03 /kWh and this was increased in line with inflation to £0.0305 /kWh for 2003/4 and to £0.03139 /kWh for 2004/2005. To qualify for ROCs generators must generate at least 0.5 MWh per month.

The obligation is a technology-neutral support mechanism which provides the same level of subsidy for all eligible renewable technologies. This has meant that thus far it has encouraged the development of the least cost, nearest market renewable energy technologies, but has not thus far incentivised the longer-term renewable technologies that are presently more expensive such as photovoltaics.

A <u>review of the Renewables Obligation</u> will take place in 2005-06, with the aim of improving the effectiveness of the Obligation and strengthening the development of electricity generation capacity using renewable energy sources.

A previous consultation on the Renewables Obligation took place in 2004 and the following measures in the Renewables Obligation Order 2005 came into force on 1 April 2005:

- Extension the level of the Renewables Obligation beyond 2010/11 to 2015/16;
- Allowing tradeability between Northern Ireland Renewables Obligation Certificates (NIROCs) and Great Britain ROCs;
- Introduction of measures that will further secure the buy-out fund in the event of a shortfall occurring;
- Introduction of more flexibility for small generators.

Renewable Energy Guarantees of Origin (REGOs) were introduced in 2003 to enable producers of renewables electricity to demonstrate that the electricity they sell is produced from renewable sources. This will in turn enable electricity suppliers to use REGOs to demonstrate that the electricity to which the REGO applies is generated from renewable sources for the purpose of green electricity tariffs. The REGOs will be issued in units of 1kWh, and along with the proposals to relax the qualifying conditions for ROC's; will make

the scheme attractive to smaller generators including PV. The scheme will work alongside the existing RO.

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. A number of modifications of the trading arrangements were made in the course of 2002 and 2003 to protect renewables and small generators, including a reduction in the gate closure time from 3.5 hours to 1 hour to enable generators, especially small generators, to better manage their risk, and a change to the way in which prices in the balancing mechanism were calculated. The British Electricity Transmission and Trading Arrangements (BETTA), came into effect on 1 April 2005, and have brought into existence a single electricity market for Great Britain by introducing a single set of trading rules across Great Britain, thereby reducing 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  $\underline{'Climate\ Change\ Levy'}$  (CCL) on non-domestic use of energy was introduced on 1st April 2001. The levy on electricity is set at £0.0043 /kWh, plus VAT. 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 <u>UK Energy White Paper</u> 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. Since then, the <u>Renewables Innovation Review</u> was published in February 2004 and stated that PV was not expected to be fully economic in terms of the cost of the electricity produced until after 2020 although a next generation solution could bring forward economic entry. The review identified:

- the key renewable technologies for the delivery of the UK targets and aspirations for renewables.
- the barriers to the development and deployment of the key renewable technologies;
- the most cost effective Government measures to facilitate delivery of the UK targets.

<u>Planning Policy Statement 22</u> (PPS 22) and its Companion Guide are intended to encourage the appropriate development of further renewable energy schemes throughout England.

The guide advises planners how to implement PPS22 in their local communities. It explains what makes a 'good' renewable energy application, how to assess the impact of plans on the landscape and how to give the community greater involvement. The guide provides advice on the broad range of renewable energy technologies, including biomass, hydro, solar and wind. Planners will now have the guidance they need to make informed decisions, enabling the renewable energy sector to expand while safe-guarding the interests of local communities and the environment.

Regional policies favouring and encouraging renewables include the London energy strategy which requires new developments over 1000m<sup>2</sup> to obtain 10% of its energy requirement from renewables as well as aiming for 7000 domestic PV systems to be installed by 2010.

#### 5.3 Standards and codes

CLC/TC/82

<u>International Standards for PV Systems and components</u> are developed and published under the auspices of the International Electrotechnical Commission (IEC), through its Technical Committee No.82 (TC/82). European Standards are also made in a similar way by the European Committee for Electrotechnical Standardisation (CENELEC), through committee CLC/TC/82. International and European Standards, once released, automatically become British Standards, and are published by the British Standards Institution (BSi).

The UK participates in the work of IEC/TC-82 and CLC/TC-82 through the British National Committee established by BSi, BSi/GEL-82. The UK has appointed experts to most of the Working Groups (WGs), as shown in Table 14.

Committee	_	UK Representation
IEC/TC-82	International Standards	Yes
WG1	Glossary	No
WG2	Modules	Yes
WG3	Systems	Yes
WG5	Quality and Certification	Yes
WG7	Concentrators	Yes
JCG TC82/88/21	Rural Electrification	Yes

**Table 14: IEC committees and UK Representation** 

An Action Plan for UK participation in standardisation was prepared by a PV-UK team in 1999 and is still under discussion.

**European Standards** 

The last meeting of IEC/TC-82 was in Beijing in May 2004. The UK sent a delegation of five, which provided strong representation. The UK is leading one project, the development of IEC Standard 82377: "Minimum Documentation Requirements and Commissioning Checklist".

Yes

The UK also has a member on the Board of the Global Approval Programme for Photovoltaics (PV-GAP). PV-GAP publishes Recommended Specifications as an interim measure while IEC/TC-82 develops full standards.

The <u>European Energy Performance of Building Directive</u> (EPBD) will be implemented in the UK in the forthcoming revisions to <u>Approved Document L of the Building Regulations</u>. The suggested amendments would substantially raise performance standards but would not

require micro-generation to be incorporated in the design of new buildings. The installation of such technologies will, however, help builders to achieve the levels of carbon emissions necessary to comply with the regulations.

A review of the Department of Trade and Industry's <u>Photovoltaics in Buildings: Guide to the installation of PV Systems</u> took place during 2004. The document was first published in 2002 and aims to ensure provide best practice guidance on the installation of small scale (less than 5 kW) PV systems. The revised guide will be published in 2005.

The grid connection of PV systems is governed by two engineering recommendations made by the Electricity Association:

- <u>G 83/1 'Recommendations for the connection of small-scale embedded generators</u> (up to 16A per phase) in parallel with public low voltage distribution networks' was issued in September 2003. This superseded Engineering Recommendation G77/1. It contains a generic first section addressing the network requirements of all distributed microgenerators (including PV and micro-CHP), complemented by a series of annexes focusing on technology-specific issues, including annex C on photovoltaics. Under G83/1 the generator is required to inform the DNO on the day of connection and then provide full details within 30 days.</u>
- Grid-interconnection of PV systems over 16 Amps per phase is governed by <u>Engineering Recommendation G.59/1</u>, Amendment 1 (1992) and Amendment 2 (1995),
   'Recommendations for the Connection of Embedded Generating Plant to the Public Electricity Suppliers' Distribution Systems'.

#### 6 HIGHLIGHTS AND PROSPECTS

Further installations under the Major Demonstration Programme will facilitate a continued healthy rate of grid-connected PV installation during 2005. The current programme is due to end in March 2006 and will be replaced by a new programme which will support PV as well as other renewable energy technologies suitable for building integration. There will be a consultation on the form and structure of the new programme in June 2005.

PV module manufacturing is set to increase in 2005, following the opening of two new manufacturing facilities by Sharp and Romag during 2004 and subsequent increase in capacity at the Sharp factory from 20 MW to 40 MW. An increase in silicon feedstock production capacity sufficient for a further 10 MW of PV cells is due to be completed during 2005 at the Crystalox plant.

#### 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 2004 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 2004 data is  $\pm$  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  $\pm$  5 % or better.

#### ANNEX B: COUNTRY INFORMATION

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

#### 1) Retail electricity prices

	Household	Commercial (Manufacturing)	Public institution
Retail electricity prices (Year and reference)	£0.0776 /kWh (2004, DTI press release P/2005/1)	£0.03065 /kWh, (2004, DTI Energy prices Table 3.1.3)	Unavailable

The costs above do not include taxation. Electricity is taxed at 5% for domestic and small users (up to 33 kWh per day) and 17.5% for commercial users. In addition there is a Climate Change Levy of £0.043 /kWh on commercial use for non-renewable electricity (see section 5.2).

#### 2) Typical household electricity consumption (kWh)

3 300 kWh/year (DTI)

#### 3) Typical metering arrangements and tariff structures for electricity customers.

Domestic customers have a choice of credit, direct debit and pre-payment meters, of which pre-payment meters have a slightly higher tariff and direct debit, where a fixed amount is automatically debited from the customer's account each month, is slightly cheaper. The majority of customers pay a small standing charge and are then charged per kWh of electricity used. Some customers, particularly those with electric heating and hot water use an economy 7 tariff which has a lower rate for electricity used during off-peak times.

Domestic contracts are usually rolling contracts with the option of cancelling at any time and moving to a different supplier within 28 days. Industrial and commercial contracts are usually for a fixed amount of time. A contract could be for a set amount of years, normally between 1 and 5 years for a small to medium business.

#### 4) Typical household income

According to the Office of National Statistics Family spending survey 2002-2003 the average annual household income in the UK was £33 376 .

#### 5) Typical mortgage interest rate

The average interest rate in the UK in 2004 was 5.03 % (Council of mortgage lenders, www.cml.org.uk)

#### 6) Voltage

Household	230V 50 Hz AC
Distribution	11 kV and 33kV 50 Hz AC

#### 7) Electricity industry structure and ownership

The liberalisation process of the UK electricity industry started in 1990 and has created a highly competitive market underpinned by open access to transmission and distribution networks. Privatisation of the industry has created different structures for England & Wales, Scotland and Northern Ireland. However, all are based on the same principles. In England and Wales, the monopoly transmission and distribution businesses are clearly separated from those based on competition, so that no supplier is put at a disadvantage in the competitive process. Where the generation market was once totally dominated by a single supplier, it now includes about 40 companies regarded as major power producers.

Electricity is traded in bulk on a wholesale market heavily revised in 2001 to bring it more in line with other commodity markets and reduce opportunities for price manipulation by major players. National Grid has a focal role as the owner and operator of the principal high voltage highways of power. The distribution networks operate at lower voltages within each designated region. They are monopoly businesses, legally separated from the competitive retail activity.

Further information on the UK electricity industry can be obtained from the following organisations:

- Ofgem (The Office of Gas and Electricity Markets) is the regulator for Britain's gas and electricity industries. Its role is to promote choice and value for all customers.
- The Association of Electricity Producers
- The Energy Networks Association (ENA) represents the licensed gas and electricity transmission and distribution companies in the UK.
- The Energy Retail Association, formed in 2003, represents suppliers in the competitive UK energy market.

#### 8) Price of diesel fuel

£0.8593 /litre (December 2004, DTI Energy Prices Table 4.1.1)

#### 9) Typical values of kWh / kW for PV systems

The industry agreed figure for annual average electricity production of a PV system is 750 kWh / kW/ annum.