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 2006

Prepared by

Sarah Davidson, IT Power

October 2007

Department for Business Enterprise and Regulatory Reform

Department for Business Enterprise and Regulatory Reform

Client contract No.: S/P2/00489/00/00

IT Power reference: 0842

UK National Status Report 2006

October 2007

Contractor:

IT Power
Grove House,
Lutyens Close, Chineham,
RG24 8AG, United Kingdom.
Tel. +44 1256 392700
Fax. +44 1256 392701
E-mail: itpower@itpower.co.uk
http://www.itpower.co.uk

Document control	
File path & name	I:\0WorkITP\0Projects\0842 Task 1\2 work\NSR\2006\Report\UK NSR 2006 v4.0UK.doc
Author	Sarah Davidson and Claudia Raimundo
Project Manager	Sarah Davidson
Approved	Rebecca Gunning 10/10/07
Distribution level	Final version for website

Template: ITP REPORT Form 005
Issue: 02; Date: 27/08/04

TABLE OF CONTENTS

Definitions, Symbols and Abbreviations

For the purposes of this and all IEA PVPS National Survey Reports, the following definitions apply:

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

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25^{o}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 Wp.

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 Wp or more.

Module manufacturer: 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.

Grid-connected centralized PV power system: 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.

Turnkey price: 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).

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

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

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.

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

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 kWp of installed PV power.

Currency: The currency unit used throughout this report is Great Britain Pound (GBP), £

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 and the European Photovoltaic Industry Association are also members.

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. Ten tasks have been established and currently six are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning PV environmental safety and health 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.

1 EXECUTIVE SUMMARY

1.1 Installed PV power

The annual installed PV capacity in 2006 was 3390 kWp. This compares to 2713 kWp in 2005 and 2261 kWp in 2004). The cumulative installed PV generation capacity increased by 31 % during 2006 reaching a total of 14.26 MWp. Government support through the Major Demonstration Programme and the new Low Carbon Buildings Programme supported approximately 75% of the total new capacity. Figure 1 shows the cumulative installed PV capacity up to the end of 2006.

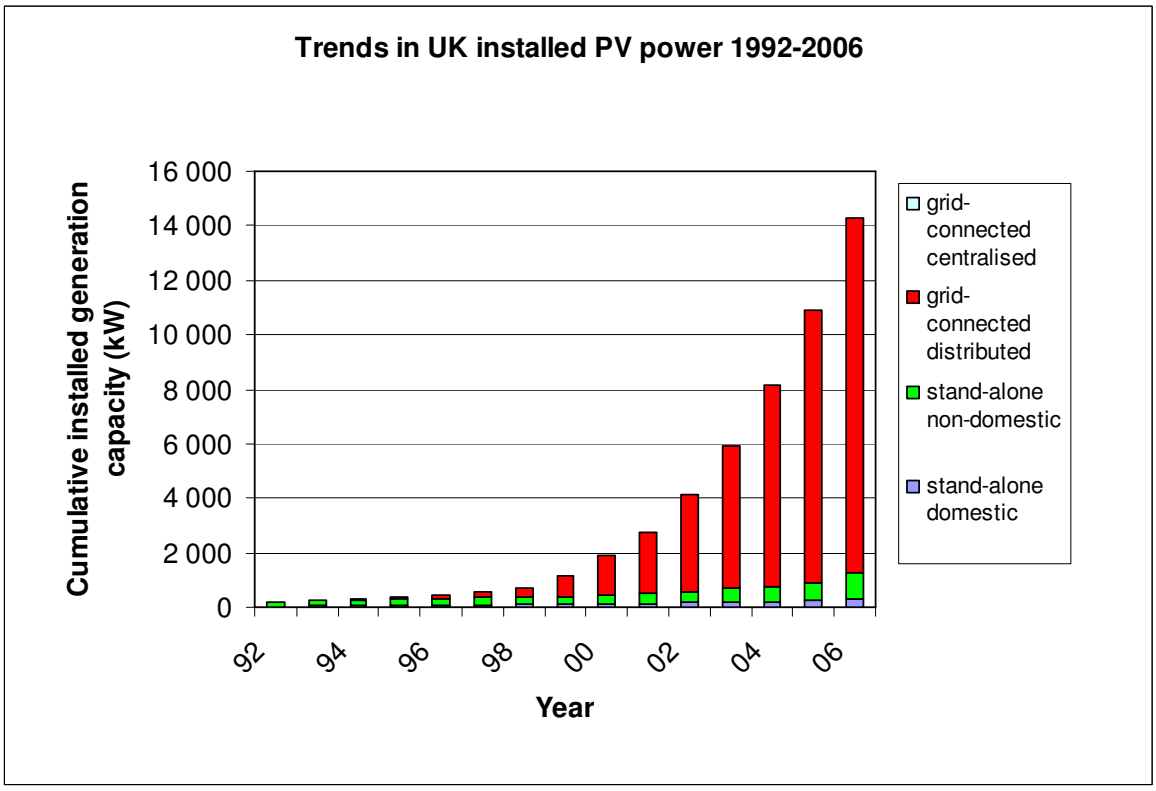

Figure 1: Cumulative installed PV capacity up to the end of 2006

1.2 Costs & prices

Average retail module prices are similar to those in 2005, typically around £3.5/Wp for reasonable volume orders. For small orders (few modules) retail prices are around £3.9/Wp. Minimum prices remain the same as in 2005, around £2.5/Wp for polycrystalline 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 installed prices ranged from £4.9/Wp to £9.9/Wp. However the average turnkey price for a standard 1-3 kWp system was £6.1/W, compared to £6.3/W in 2005 (at 2006 prices).

1.3 PV production

Crystalox Limited, an operating subsidiary of PV Crystalox Solar plc is one of the world's largest producers of multicrystalline silicon ingots, exporting to PV companies in Europe and Japan. In 2006 the company produced 2150 tonnes of multicrystalline silicon ingots, enough for 215 MWp.

Sharp's module assembly plant in Wrexham uses EVA lamination encapsulation and produced 85 MWp of crystalline PV modules during 2006. Further capacity expansion took place during 2006 which will bring the total production capacity to 220 MWp in 2007.

Romag's Building Integrated Photovoltaic (BIPV) lamination facility in Consett produced 2 MWp in 2006. The facility will double its capacity to 12 MWp by the end of 2007.

GB Sol based in Taffs Well, South Wales produced 0.25 MWp of crystalline modules. 2006 saw the start of construction of an additional 5 MW of production capacity.

ICP Solar Technologies UK Ltd (ICP UK) in Bridgend increased total production from 1.8 MWp in 2005 to 1.9 MWp in 2006. The Bridgend facility was sold to EPOD in May 2007 and the company is now known as Epod Solar Wales.

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 £15.03 million in 2006. This compares to a total of £12.06 million in 2005. A large proportion of this funding (£7.83 million) has been for the demonstration and field trial programmes, provided by the DTI.

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 Wp 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 2006 statistics if the PV modules were installed between 1 January and 31 December 2006, although commissioning may have taken place at a later date.

2.1 Applications for photovoltaics

2.2 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 increasingly common. A total of 380 kWp was installed off-grid in 2006.

The table below presents an overview of stand-alone applications for photovoltaics in the UK, categorised by end-users. Some of the applications have an installed capacity of less than 40 Wp.

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 and shelter 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

END-USERS	TYPICAL APPLICATIONS
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	
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)

2.3 Grid-connected applications

The total capacity of grid connected installations during 2006 was 3010 kWp, which represents 95 % of the annual total. The majority of projects were supported by grant funding under the DTI's Major Demonstration Programme.

2.4 Total photovoltaic power installed

The total PV capacity installed during 2006 was 3390 kWp. A summary of the cumulative installed PV Power, from 1992-2006, broken down into four sub-markets is shown in Table 1.

Table 1: The cumulative installed PV power in 4 sub-markets.

	Cumulative installed capacity as at 31 December														
Sub-market /application	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Stand-alone domestic	7	47	52	57	69	83	108	119	121	135	162	172	193	227	320
Stand-alone non-domestic	166	213	232	252	279	316	254	276	302	385	406	542	585	697	980
Grid-connected distributed	0	6	54	59	75	190	328	736	1 506	2 226	3 568	5 189	7 386	9 953	12 960
Grid-connected centralised	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL (kWp)	173	266	338	368	423	589	690	1 131	1 929	2 746	4 136	5 903	8 164	10 877	14 260

The cumulative installed power includes power installed before 1992.

The stand alone installed capacity in 2006 differs from that published in the International Trends Report 2006 due to one installer submitting information after the Trends report had gone to press. The amended figures will be added in next year's edition of the Trends report.

2006 figures are reported to the nearest 10 kWp.

2.5 Key PV policy initiatives, promotional activities and other market drivers of significance in 2006

During 2006, the Government launched its Microgeneration Strategy for Great Britain. The term microgeneration effectively refers to low and zero carbon technologies (>50kW electricity and >45kW heat). It includes solar photovoltaics, small wind turbines, micro hydro, solar thermal, ground/water/air source heat pumps, bio-energy, renewable CHP, micro-CHP (combined heat and power) and fuel cells. The objective of the new strategy is to create conditions under which microgeneration becomes a realistic alternative or supplementary energy generation source for the householder, communities and small businesses. Its wide ranging actions include a certification scheme for products and installers and a code of practice, a review of planning procedures, a pilot to assess the benefits of smart metering, as well as the new Low Carbon Buildings Programme. The Low Carbon Buildings Programme, also launched during 2006, provides grants to support installations of microgeneration technologies including PV for householders, community organisations, schools, the public sector and businesses. A total of £80 million was announced for the 3 year programme. £50 million of which is to be used for public sector and not for profit organisations with the aim of reducing costs of microgeneration installations. The programme is UK wide (apart from the Channel Islands and the Isle of Man) and aims to demonstrate how energy efficiency and microgeneration will work hand in hand to create low carbon buildings.

The new grants programme replaces the PV Major Demonstration Programme (MDP) which ran from 2002 and closed for new grant applications in 2006. The MDP provided funding for over 70% of PV installations in the UK during 2006.

In Northern Ireland, where energy is the responsibility of the Northern Ireland Assembly, the Energy and Environment Fund was launched in February 2006. This package of funding includes £8 million over two years for householders installing renewable energy systems including PV. Additional funding is made available for promotion of renewable energy.

Other highlights include the Code for Sustainable Homes, a voluntary initiative in England, by Government and Industry, to actively promote the transformation of the building industry towards more sustainable practices. The code was launched by the Department for Communities and Local Government in December 2006. It is a standard for key elements of design and construction which affect the sustainability of a new home. There are minimum standards for energy and water efficiency at every level of the Code, with the lowest levels raised above the level of mandatory building regulations. The higher levels of the code require the installation of Microgeneration technologies such as PV.

Local planning policies, requiring new developments or refurbishments to include on-site renewables have also become increasingly important in encouraging PV as well as other small scale renewables. Of the 410 local councils in England and Wales, 19 have adopted such a policy (usually placing a requirement on developments over 1000m^2 to reduce carbon dioxide emissions from building energy use by 10% over the minimum standards of the building regulations), and over 100 councils are actively progressing the introduction of such a policy. In Scotland 2006 saw the development of a new draft Planning Policy on renewable energy. The new national policy will require local policies on the provision of on-site low carbon and renewable sources of energy in new developments. Developments with a total floorspace of 500 m^2 or more will need to incorporate on-site renewables or CHP to contribute at least an extra 15% reduction in CO_2 emissions beyond the 2007 building regulations requirements.

While many of the large utilities have announced their support of microgeneration technologies including PV, seeing potential particularly within the domestic market, export tariffs for microgenerators vary widely between different electricity suppliers. Arrangements are structured in different ways making comparison difficult for consumers. Domestic customers may be offered around £0.06 to £0.08 /kWh for export, which is similar or less than the average retail price of electricity. Alternatively between £0.035 and £0.045 /kWh for total generation may be offered. Many such preferential rates are available only to domestic customers. Further information is provided in section 4.1.

Northern Ireland Electricity continued to offer top up grants for PV installations in Northern Ireland during 2006, providing an extra 15% of the total capital cost in addition to the government grants.

2.6 PV implementation highlights, major projects, demonstration and field test programmes

During 2006 80% of all PV installations in the UK received grant support from one of the government grants programmes. The programmes, together with the installed capacity supported were as follows (projects can only receive support from one of these schemes):

- Major Demonstration Programme 2300 kWp
- Low Carbon Buildings Programme (Householders) 213 kWp
- Energy and Environment Re-connect fund (Northern Ireland only) 9 kWp

The Major Demonstration Programme closed for applications in March 2006 but installations under the programme will continue until April 2007. The programme provided up to 50% capital grants for PV installations during 2006 with maximum levels per kWp set for small scale installations (<5kWp). Over 99% of installations completed were grid connected.

The new Low Carbon Buildings Programme proved to be very popular with householders. During 2006 up to £3000 per kWp or 50% of the capital cost (whichever is lower) was available for householders installing a PV system. For larger projects including community organisations and small and medium enterprises, a total of 46 applications were received, although none of these installations took place during 2006. For projects of this size, successful applicants receive up to 50% of their total eligible installation cost with a maximum grant of £1 000 000. These projects aim to deliver standard low carbon buildings across different sectors from 2007 offering up to 50% of the total installation cost for PV systems. Projects will aim to demonstrate the business case for these low carbon developments and be used to encourage replication working with the construction industry.

Phase 2 of the programme has a clear focus on schools both from the point of reducing carbon emissions but also from the educational angle.

The Energy and Environment Re-connect fund provides householders with up to £3 000 per kWp PV installed (or 50% of the total installed cost, whichever is lower). Two systems were supported during 2006.

Northern Ireland Electricity provided top up grants for 42 projects (137 kWp) during 2006, providing an additional £125 000.

UK PV installation highlights during 2006 include:

- The start of the installation of a large solar shading array using thin film PV for Manchester University. The highly visible 42 kWp installation uses semi-transparent thin film photovoltaic laminate modules mounted to provide shading to the building atrium below.
- The completion of a 35 kWp roof mounted system as part of the York EcoDepot, the largest straw bale clad building in Europe.
- Further installations by Kirklees Metropolitan Borough Council on council housing and care homes, bringing the total number of installations in the local authority area to over 500.

2.7 Highlights of R&D

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 Department of Trade and Industry (DTI) mainly under the Technology Programme. The DTI's Technology Programme funds industrially focused collaborative research. During 2006 the DTI sought proposals for research leading to cost reductions in silicon PV modules, process development for thin film PV and research into novel PV cells.

The EPSRC Sustainable Power Generation and Supply (Supergen) Programme currently supports two multi-disciplinary consortia focused on advanced PV materials:

- The **'Photovoltaic Materials for the 21st Century'** consortium was launched during 2004 and aims to develop low-cost thin-film solar cell devices fabricated from inorganic semiconductors. Technical achievements so far include the development of an innovative electrochemical deposition method for copper indium diselenide (CIS) PV. This thin film process has the potential for considerable cost reductions.

- The **Supergen Exitonic Solar Cells consortium**, led by the University of Bath, is researching dye and nanoparticle- sensitized and organic cells which may offer the possibility of low toxicity, flexible and easy to manufacture PV materials. Consortium members are concentrating on understanding the factors which limit efficiencies as well as on combining their expertise to devise entirely new types of solar cell.

  In the initial phase, Cambridge has fabricated solar cells based on polymer/polymer blends, and has characterised the response of these cells to pulsed optical excitation in order to determine how charge transport processes depend on the nanostructure of the blends. Cambridge has also performed X-ray microscopy giving unprecedented high resolution images of chemical composition in polymer blends. Meanwhile, Imperial College is studying the structure and performance of a range of organic solar cells fabricated in a sophisticated vacuum deposition apparatus as well as dye-sensitised solar cells incorporating new materials. In Bath, work is focusing on dye-sensitised solar cells at the moment but preliminary collaborative work with Cambridge on polymer blend has also begun. In Edinburgh, the synthetic programme is in full swing, and interesting new materials have already been supplied to both Cambridge and Imperial College. Future plans centre around three principal themes:

  - New materials for light harvesting and hole/electron transport.
  - New hybrid cells (organic/inorganic).
  - A collaborative approach to characterisation methods.

NaREC's Photovoltaic Technology Centre was officially opened in October 2006. It is the only commercial crystalline cell research and development laboratory in the UK. Using a pilot production line, NaREC is creating new manufacturing techniques, working to provide the rapidly expanding photovoltaics industry with the bespoke manufacturing operations it needs.

2.8 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 2006, the EPSRC provided £6.8 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 21st Century, as mentioned above.

Budgets for Pre-competitive R&D and Demonstration / Field Trials (supported by the Department for Trade & Industry) totalled £15.03 million, this compares to £9.8 million in 2005 and £8.05 million in 2004.

Table 2: Public budgets for R&D, demonstration/field test programmes and market incentives.

		R & D (£)	Demo/Field test (£)	Market incentives (£)
National	EPSRC	6 794 600	-	-
	DTI	400 000	7 813 963	-
Northern Ireland Re Connect Programme		24 000		
Total		15 032 563		

Table 2a: DTI funding (in £million) for field trials and demonstration programmes

Programme	£
Major Demonstration Programme (MDP)	6 548 000
Large scale BIPV and PV Residential field trials	650 000
Low Carbon Building Programme (PV only)	615 963
TOTAL	**7 813 963**

3 INDUSTRY AND GROWTH

3.1 Production of feedstocks, ingots and wafers

Crystalox Limited, an operating subsidiary of PV Crystalox Solar plc, 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 one of the world's largest producers of multicrystalline silicon ingots, exporting to PV companies in Europe and Japan where the material is processed to produce cells for PV modules.

Table 3: Production and production capacity information for the year for silicon feedstock, ingot and wafer producers

Producer	Process & technology	Total Production	Maximum production capacity	Product destination
Crystalox	mc-Si ingots	2150 tonnes	2900 tonnes/year	25% to Europe, 75% to Asia

3.2 Production of photovoltaic cells and modules

Total PV cell and module manufacture together with production capacity information is summarised in Table 4 below.

Table 4: Production and production capacity information for 2006 for each manufacturer

Cell/Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production (MW)			Maximum production capacity (MW/yr)		
		Cell	Module	Concentrators	Cell	Module	Concentrators
Crystalline silicon PV manufactures							
Sharp	sc-Si, mc-Si	*zero*	85	*zero*	*zero*	110	*zero*
Romag	sc-Si, mc-Si	*zero*	2	*zero*	*zero*	6	*zero*
GB Sol	sc-Si, mc-Si	*zero*	0.25	*zero*	*zero*	4	*zero*
Total		*zero*	87.25	*zero*	*zero*	120	*zero*
Thin film manufacturers							
ICP Solar Technologies	a-Si	1.9MW	1.9	*zero*	2.5	2.5	*zero*
TOTALS		**1.9MW**	**89.4**	***zero***	**2.5**	**122**	***zero***

Sharp's module assembly plant in Wrexham uses EVA lamination encapsulation and produced 85 MW of crystalline PV modules during 2006. The PV manufacturing plant employs 377 full time equivalent staff. PV cells used in the modules are imported from Japan. The plant produces a full range of modules from 153 W to 185 W modules certified to IEC 61215. The typical warranty length for modules produced is 25 years. The majority of modules produced during 2006 were exported to mainland Europe with a small

percentage being used for projects in the UK. About half of all modules exported are sold to Germany and the rest to Spain, Italy and France. Sharp introduced additional production lines during February 2006 increasing the facility's capacity from 50 MW to 110 MW. Further capacity expansion took place during 2006 which will bring the total production capacity to 220 MW in 2007.

Romag's Building Integrated Photovoltaic (BIPV) lamination facility in Consett uses crystalline silicon PV cells and produces glass/glass and glass/tedlar laminates. The units can be produced in any size and type of glass, up to 3.3 m x 2.2 m in size and can also be supplied as Insulating Units. The 6 MW production facility exports 70% of its output. Further capacity is under construction. The facility will double its capacity to 12 MW by the end of 2007. The company is certified to ISO 9001 and its products are certified to IEC 61215.

GB Sol based in Taffs Well, South Wales started producing PV modules for power production during 2005. The plant uses EVA encapsulation in a vacuum laminator. The company has a range of five IEC 61215 certified modules from 60 to 120 W. During 2006 the construction of an additional 5 MW of production capacity was started. 35 % of the modules produced during 2006 were exported. The facility in Taffs Well employs 15 people.

ICP Solar Technologies UK Ltd (ICP UK) manufactures thin-film amorphous silicon cells and modules at its factory in Bridgend. The company operates to ISO 9001-2000. ICP UK was, until May 2007, part of the ICP Group of Companies, which has its head Office in Canada. The Bridgend facility was sold to EPOD in May 2007 and the company is now known as Epod Solar Wales.

The Bridgend facility increased total production from 1.8 MW in 2005 to 1.9 MW in 2006. Most of the company's production in 2006 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. During 2006 32 staff were employed at the Bridgend factory.

The new owners plan to increase capacity to 4 MW through investment in new equipment and automation and by operating 24 hours per day. IEC certification for certain modules is planned for 2007.

In October 2006 a recently established renewable energy company, **G24 Innovations Ltd**, announced plans to build the first plant to make dye sensitized solar cells (DSSC) on a commercial scale at a facility in Cardiff, Wales. A 30 MW facility opened in early 2007 and there are plans to expand to 200 MW production capacity by the end of 2008.

3.3 Module prices

Average retail module prices are similar to those in 2005, typically around £3.5/W for reasonable volume orders. For small orders (few modules) retail prices range from approximately £3.4/W up to £5/W. Minimum prices remain the same as in 2005, around £2.5/W for polycrystalline modules imported from mainland Europe.

Table 4a: Typical module prices for a number of years

Year	2001	2002	2003	2004	2005	2006
Average retail module prices for large orders, £(2006)/W	4.4	4.4	4.2	3.9	3.8	3.5
Average retail module prices for small orders, £(2006)/W	4.5	4.5	4.3	3.9	4.5	3.9
Best price, £(2006)/W			2.3	2.4	2.5	2.5

3.4 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. The most popular inverters being used for grid connected applications are SMA and Fronius, both of which are imported from Germany and Austria respectively.

2006 saw the launch of some new PV mounting systems including solar century's 'SB1000 Energy Roof', a modular PV system designed for use with a range of PV modules to allow easy installation of PV on industrial roofs.

Solar century also launched its new PV roof tile product which incorporates 52 W monocrystalline PV per tile. Systems using the tile require less than 8 square metres per kWp.

Lafarge Roofing continued to offer two integrated PV roofing systems rated at 40 W and 80 W. The PV laminates used in the product are now manufactured by Romag in Consett.

Sollatek launched its new off-grid solar street light in 2006.

3.5 System prices

Table 5: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Price per Wp in £
OFF-GRID Up to 1 kWp	Modules for leisure market (holiday homes, traffic monitoring, bus stops)	5-7.5
OFF-GRID >1 kWp	Remote homes with battery storage or backup generator	5.6-7.4
ON-GRID Specific case	1-3 kWp domestic roof mounted	4.9-9.9
ON-GRID up to 10 kWp	Roof or ground-mounted systems (e.g for commercial building retrofits)	4.5-9.0
ON-GRID >10 kWp	e.g. 20 kWp roof mounted system (on commercial / industrial buildings)	4.6-8.9

Table 5a: National trends in system prices (current) for 1-3 kWp domestic roof mounted

YEAR	2000	2001	2002	2003	2004	2005	2006
Price /W:	5.6 - 7.9	6.2 - 9.6	4.8 - 14.4	4.9 - 14.6	4.5 - 10.3	5.0 - 15.7	4.9 -9.9

3.6 Labour places

An estimate of (full-time equivalent) labour places related to the photovoltaics sector in the UK is presented as Table 4. The total number of labour places is estimated at 894. This represents an increase of over 20% over the figure for 2004. Over half of this increase has been within manufacturing.

Table 4: Estimated PV-related labour places in the UK

Research and development (not including companies);	52
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D;	522
Distributors of PV products;	49
System and installation companies;	238
Utilities and government.	10
Other	23
Total	**894**

3.7 Business value

As shown in Table 6, the total value of the PV business in the UK is estimated at £154 million. This estimate is calculated from the value of the installations completed during 2006, the value of export sales from PV manufacturers (figures provided by ICP Solar Technologies and Crystalox and estimated at £2.5/W for Sharp and GB Sol and £3/W for Romag), minus the value of imports of PV products. The value of imports is calculated assuming a wholesale price of £2.5/W and assuming that 100% of all PV inverters installed are imported at a wholesale price of around £0.4/VA.

Table 6: Value of PV business

Sub-market	Capacity installed in 2006 (kWp)	Price per kWp (£)	Value (£)	Totals (£)
Off-grid domestic	70	6700	469000	
Off-grid non-domestic	260	6700	1742000	
Grid-connected distributed	3010	6180	18602800	
Grid-connected centralised	0	-	0	
Total value of PV installations				20,813,800
Export of PV products				289,488,000
Change in stocks held				unknown
Import of PV products				155,503,000
Estimated value of PV business				**£154 million**

4 FRAMEWORK FOR DEPLOYMENT (NON-TECHNICAL FACTORS)

Table 5 lists the main support measures for PV in the UK during 2006. Further details on these are provided on the following pages.

Table 5: PV support measures

	National / Regional / Local
Enhanced feed-in tariffs	No
Direct capital subsidies	Yes, national grants programmes provide up to 50% grants. Household scale installations are automatically awarded a grant provided they meet minimum energy efficiency criteria and use approved installer. Larger projects must compete for funding via quarterly competitions.
Green electricity schemes	Yes, offered by most electricity suppliers
PV-specific green electricity schemes	Yes, offered by many electricity suppliers. Generally schemes reward export
Renewable portfolio standards (RPS)	Yes, the Renewables Obligation places an obligation on electricity suppliers to source 6.7% of their electricity from renewable sources. The mechanism encourages 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.
PV requirement in RPS	No
Investment funds for PV	No
Tax credits	VAT on professional installations of PV systems for domestic customers has been set at the reduced rate of 5% since April 2000.
Net metering	Yes, depending on the electricity supplier –see above
Net billing	Yes, depending on the electricity supplier –see above
Commercial bank activities	Yes – supporting Phase 2 projects
Electricity utility activities	Yes, Northern Ireland Electricity has provided top up grants for installations in Northern Ireland which are awarded a government grant.
Sustainable building requirements	No

4.1 Tariffs and metering

A number of electricity utilities offer to pay either for exported electricity from a PV system or electricity generated, where the price paid is based on the value of the *Renewables Obligation Certificates* (ROCs –see section 4.3) associated with all of the electricity generated by the PV system. Most require a separate export meter or generation meter to be installed. Most export tariffs pay less than the average price domestic customers pay for imported electricity.

The tariffs are available to domestic customers include:

- npower juice pays domestic cusomters the same amount for their export as they do for their import. ROCs can be claimed separately.
- EDF Energy's Green Tariff pays 6.4p/kWh exported
- Trade Link Solutions, an Independent company which aggregates ROCs on behalf of small generators pays 3.5p per unit generated, electricity can be sold separately.
- Ecotricity pays 4.5p per unit generated (export is not measured)
- Equipower offers 4p per unit electricity generated plus 3.8p per unit electricity exported

The microgeneration strategy (see 2.5) will support the introduction of smart metering. In the 2006 budget the UK Government announced £5 million as co-financing for energy suppliers to conduct a pilot study of "smart" energy meters.

4.2 Capital grants and tax incentives

The Microgeneration strategy and the Low Carbon Buildings Programme, which provides up to 50% grant funding for PV installations are described in section 2.5.

Northern Ireland Electricity continued to offer top up grants for PV installations in Northern Ireland during 2006, providing an extra 15% of the total capital cost in addition to the government grants.

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

4.3 Indirect policy issues

The Renewables Obligation (RO) is the Government's key mechanism for encouraging new renewable generating capacity. It was introduced in 2002 and requires licensed electricity suppliers to source a specific and annually increasing percentage of their sales from eligible renewable sources. For 2006/07 the level of the RO is 6.7% rising to 15.4% in 2015/16. Suppliers can meet their obligation by either presenting Renewable Obligation Certificates (ROCs); paying a buyout price (£33.24 per MWh in 2006/07 rising each year with inflation); or a combination of the two. Renewable Obligation Certificates (ROCs) are issued to generators for every 1 MWh of eligible renewable electricity that they generate. These ROCs can then be sold to suppliers. At the end of an obligation period the money in the buyout fund is recycled to those suppliers who presented ROCs on a pro rata basis.

The Government's report on the Energy Review: "The Energy Challenge" was released on 11 July 2006. The review focused on the two major long-term challenges in UK energy policy: the need to tackle climate change by reducing carbon dioxide emissions; and the need to deliver secure, clean energy at affordable prices. As part of the 2006 Energy Review the Government announced a number of proposals for changes to the Renewables Obligation as well as proposals for aggressive implementation of the Microgeneration Strategy to remove barriers to household renewables. The proposed changes to the RO include providing differentiated levels of support to different technologies and extending the level of the RO to 20%. A preliminary consultation on these changes was published in late 2006 and will be followed by further consultation. The earliest these proposals could be implemented would be 1 April 2009. Alongside this consultation a consultation on some

more limited changes to the RO was also published including changes to make it easier for small generators to access the benefits of the RO.

Table 6 shows the number of PV systems that were registered for the RO, NIROCS and ROS as at the end of 2006 as well as the total capacity.

Table 6: Number of PV systems that were registered for the RO, NIROCS and ROS as at the end of 2006

	RO (England and Wales Renewable Obligation)	NIROCS (Northern Ireland RO)	ROS (Renewable Obligation Scotland)	Total
Number of PV systems registered by the end of 2006	102	11	7	120
Total Capacity of registered PV systems (kWp)	614	42	55	711

Note: Stations accredited for the RO and for the RO & CCL, DTI

The 2006 Energy Review also called for a comprehensive review of the incentives and barriers that impact on distributed electricity generation, to be undertaken jointly with Ofgem. This was launched in November 2006 and reviewed all aspects of these incentives and barriers, including:

- The economic and other incentives for suppliers to buy electricity from distributed generators;
- Options for resolving potential barriers to the sale of electricity from small generators, such as licensing procedures and technical standards for connection and for network operation;
- The economic costs and benefits, and other incentives, for Distribution Network Operators (DNOs) to connect new generators and to invest in upgrading distribution networks in order to accommodate increasing amounts of distributed generation; and
- The incentives for DNOs to engage in innovation aimed at minimising the costs and capturing the benefits of distributed generation

Planning Policy Statement on Renewable Energy (PPS 22) and its Companion Guide are intended to encourage the appropriate development of new 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 renewable energy technologies, including biomass, hydro, solar and wind. It aims to provide planners with 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. The government committed to a review of PPS 22 (which was originally published in 2004) in March 2006 to analyse whether emerging plans contained a policy that reflected paragraph 8 of PPS 2. Paragraph 8 of PPS 2 states that local planning authorities may include policies in local development documents that require a percentage of energy to be generated from on-site renewable energy developments. The review showed that of the vast majority of new-style emerging

developing plans did include a policy requiring renewable energy to be included in certain new developments.

Plans for a new Planning Policy Statement on Climate Change for England were announced following the 2006 Energy Review. The new PPS will make it clear that the location and design of new developments should also promote the reduction of carbon dioxide. This will encourage the use of microgeneration technologies such as PV.

During 2006 the Scottish Executive consulted on its proposals for the first Energy Efficiency and Microgeneration Strategy for Scotland. The proposals are aimed at ensuring that energy efficiency and microgeneration make an increased contribution to sustainable development, climate change and energy objectives.

In May 2006 the devolved Government for Scotland published a new annex to Planning Advice Note 45 on Renewable Energy Technologies - Planning for Micro-Renewables. The document explains how the planning system can support the micro-renewables industry in the rollout of the technology and provides information and best practice on renewable energy development.

The Scottish Executive also consulted during 2006 on a new Scottish Planning Policy: Renewable Energy (SPP6). The consultation stated that the Scottish Executive is minded to require planning authorities to ensure that certain new developments include on-site renewable energy equipment.

The UK Climate Change Programme 2006 sets out the strategy for action at international and national levels to meet the challenge of climate change. The Programme's key principles include the need for a long term view to combating climate change. It also sets out domestic actions to meet the near term UK commitments under the Kyoto Protocol and its additional domestic target of reducing carbon dioxide emissions to 20 per cent below 1990 levels by 2010. The programme recognises the importance of microgeneration (within which PV is included) and refers to the Microgeneration Strategy.

The International Energy and Climate Change Strategy aims to ensure security of energy supply and accelerate the transition to a low-carbon global economy. Within this strategy the UK government has been active in promoting the integration of climate change and energy policies in the international stage, particularly in Europe. In the Summit led in the UK in 2005, the EU leader gave the European Commission a mandate to develop for the first time a common energy policy. Thus in March 2007, the European commission approved an ambitious climate change and energy package to build a low carbon economy in Europe.

As mentioned in section 2.5, there are now a number of local governments which require significant new developments in their area to use onsite renewable energy to reduce annual carbon dioxide emissions. North Devon has chosen to demand 15% CO_2 reduction from renewables and Oldham requires 10%. Kirklees Council have proposed that by 2011, 30% of energy consumption in its new buildings will come from renewable sources.

4.4 Standards and codes

The Code for Sustainable Homes is a new national standard for key elements of design and construction which affect the sustainability of a new home. Launched in December 2006, it is intended as a means of driving continuous improvement, greater innovation and excellent achievement in sustainable home building. Environmental performance is expressed on a scale of Level 1 to Level 6, where Level 1 is the entry level, already above the Building Regulations, and Level 6 is the highest level, corresponding to exemplar development in sustainability terms. The Code for Sustainable Homes is currently voluntary, but may become mandatory in 2008, with increasingly tougher standards being phased in. Higher

levels of the code require the installation of Microgeneration technologies such as PV. Currently the code applies only in England. In Scotland and Wales the Ecohomes standard, from which the new Code was developed still applies. The Ecohomes continues to apply for refurbishments of existing homes in all parts of the UK.

The European Energy Performance of Building Directive (EPBD) came into force on 4th January 2006. This is being implemented in the UK partly by changes to the building regulations: in England the Approved Documents L of the Building Regulations, which came into effect in April 2006. The amendments raise performance standards and set maximum carbon dioxide emissions for whole buildings. This performance-based approach enables designers to choose solutions that best meet their needs, and that are cost-effective and practical. The raised performance standards provide a stronger incentive to designers to consider Low and Zero Carbon systems including PV.

A revised version of the Department of Trade and Industry's Photovoltaics in Buildings: Guide to the installation of PV Systems was published in 2006. The document was first published in 2002 and aims to provide best practice guidance on the installation of small scale PV systems. The new version updates the reference and settings required in the grid interface document ER G83/1 which now covers all micro-generation, to supersede those in ER G77/1 which it replaces. The scope has also been extended in this 2nd edition to provide some guidance on larger systems and off-grid battery installations, and also modify some of the wording to include much of the valuable practical experience gained by installers in the PV demonstration programmes.

The grid connection of PV systems is governed by two Electricity Association Engineering Recommendations:

- G 83/1 'Recommendations for the connection of small-scale embedded generators (up to 16A per phase) in parallel with public low voltage distribution networks' 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. Under G83/1 the generator is required to inform the DNO on the day of connection and then provide full details within 30 days.

- Grid-interconnection of PV systems over 16 Amps per phase 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*'.

International Standards for PV Systems and components 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 of the Technical Committee . An Action Plan for UK participation in standardisation was prepared by a PV-UK team in 1999 and is still under discussion. UK representatives contributed to the IEC/TC-82 meeting in Japan in October 2006.

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.

5 HIGHLIGHTS AND PROSPECTS

2006 saw continued growth of the UK PV industry, both in terms of installed capacity, manufacturing output and number of staff employed in PV activities.

Continued growth in installations can be expected in 2007, supported by the Microgeneration Strategy and the Low Carbon Buildings Programme and also through the increase in demand for low carbon buildings as a result of planning policy, the Code for Sustainable Homes and local government targets.

2007 will see significant growth in PV manufacturing capacity at Sharp, Epod Solar Wales and Romag.

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	Industrial
Retail electricity prices (year and reference)	9.64p per kWh (10.12p per kWh including VAT) 2006, DTI Energy Prices Chart 5.5.1)	6.12p per kWh (6.34 including taxes) 2006, DTI Energy prices Chart 5.3.1)

2) Typical household electricity consumption (kWh)

The typical annual household electricity consumption is 3 300 kWh, including VAT. (2007, DTI Average annual domestic electricity bills for UK countries, Table 2.2.2)

3) Typical metering arrangements and tariff structures for electricity customers

There is a choice of credit, credit debit, direct debit and pre-payment meters for domestic costumers, of which pre-payment meters have a slightly higher tariff then direct debit, which is slightly cheaper, where a fixed amount is automatically debited from the costumer's account each month. The majority of consumers pay a small standing charge and are then charged for each kWh of consumed energy. Some consumers, particularly those with electric heating and hot water, use an Economy 7 tariff which has a tiered electricity tariff with 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 settled for a fixed amount of time. A contract could be for a set amount of years, normally between 1 to 5 years for small to medium business.

4) Typical household income

According to the Office of National Statistics: Family Spending Survey 2006, the average household gross income in the UK was £32 800.

5) Typical mortgage interest rate

Typical mortgage interest rates in 2006 were around 5.5%