

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
2000**

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i Foreword

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

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

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

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating agents. Eight Tasks have been established, and currently seven are active.

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

ii Introduction

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

This National Survey Report of PV Power Applications in the UK has been produced following discussions with, and input from, organisations and individuals involved in the development and implementation of PV Technology in the UK. It represents an overview of the key developments and achievements in the UK PV sector during the year 2000.

iii Definitions, symbols and abbreviations

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

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

DNO: Distribution Network Operator.

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

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

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

Final annual yield is defined as the total energy delivered to the load during the year per kWp installed.

Grid-connected centralised: PV systems performing the function of a centralised power station.

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

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

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

NC: National Currency

Performance ratio is defined as the ratio of the final yield to the reference yield, where the reference yield is the theoretically available energy per year per kWp installed.

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

PV system: Modules, inverters, batteries and all installation and control components for modules, inverters and batteries with a PV capacity of 40 Wp or more.

Stand-alone domestic: PV systems installed in households and villages which are not connected to the utility grid.

Stand-alone non-domestic: PV systems used for a variety of applications such as water pumping, remote communications, safety and protection devices, etc. which are not connected to the utility grid.

Turn-key price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid system, the prices associated with battery maintenance/replacement are excluded.

1 *Executive summary*

The year 2000 proved very encouraging for the PV sector in the UK:

- There was a sizeable increase in installed generation capacity, continuing the overall market trend observed in 1999, as illustrated in Figure 1.

The key growth sub-market was the grid-connected distributed sector, which increased by 89 % from 412 kWp installed during 1999 to \approx 770 kWp during 2000. This expansion was again heavily influenced by BP's initiatives to incorporate solar electricity generators on its petrol stations and on several of its buildings (Conference Centre and Sunbury office complex).

Cumulative installed grid-connected generation capacity now exceeds 1.5 MWp. Approximately 3/5 of this capacity is owned by BP.

There was sustained growth (\approx 17 %) in the stand-alone non-domestic sub-market. However, sales for stand-alone domestic applications fell in 2000.

Total installed PV generation capacity in the UK is now estimated to amount to 1 929 kWp

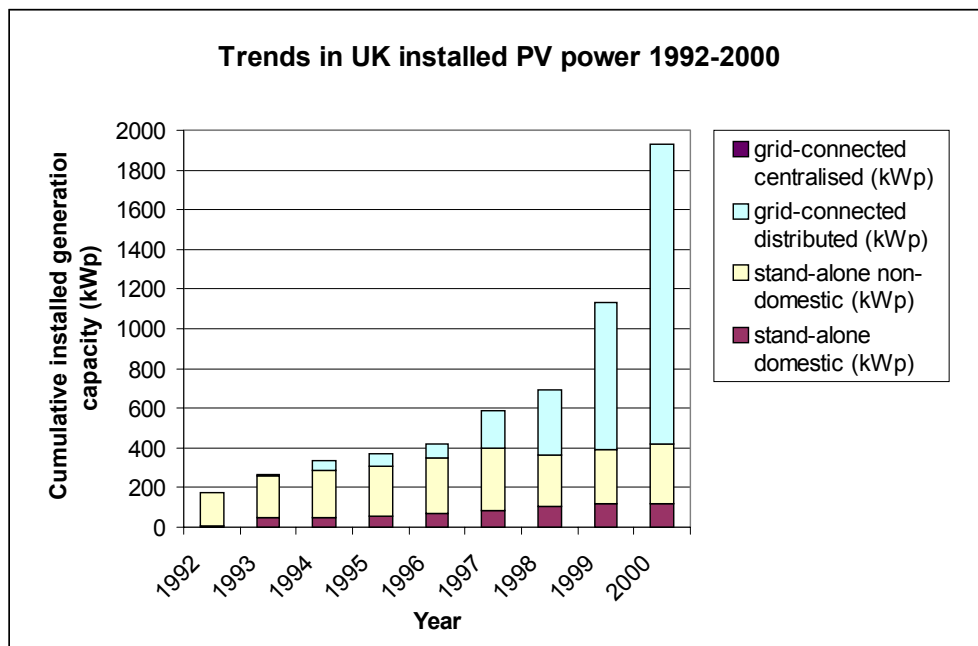


Figure 1: Trends in UK cumulative installed PV generation capacity 1992-2000

- The government-sponsored Domestic Field Trial (popularly referred to as the 100 roofs programme) kicked-off in 2000. A budget of approximately £ 1.4 million has been assigned for the installation and monitoring of PV on 9 clustered projects across the UK. This is expected to provide a total of approximately 221 kWp on more than 160 residences. The Project Management Contractor had been appointed, and the majority of projects had been successfully contracted by the

end of 2000. The first of the Field Trial systems will be commissioned in 2nd quarter 2001.

- Distribution Network Operators' exposure to PV is continually improving. A good working relationship has been established between representatives of the electricity and photovoltaics industries, particularly through the G77 Working Group. Engineering Recommendation G77, which addresses grid-interconnection of domestic scale PV systems, is expected to be adopted by the electricity industry by the end of 2001.
- The public profile of PV is being enhanced by high visibility projects and high-profile marketing campaigns, particularly by Solar Century.
- The government, principally through DTI, is also co-operating with industry to define the future direction for UK PV industry and market development. A Government-Industry Working Group was established in autumn 2000; the final report presenting the Group's conclusions was published in March 2001. Lobbying continues via the trade-association, PV-UK.

In early 2001, the government announced its intention to establish the UK as a credible player in the photovoltaics market, alongside Germany and Japan, through a major PV demonstration programme.

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.

2.1 Applications for photovoltaics

Photovoltaics currently make only a minute contribution to UK total energy supply, generating an estimated 1.0 GWh in the year 2000, compared to total electricity consumption of around 330 TWh¹. Nevertheless, PV provides an invaluable cost-effective service in a wide variety of niche applications, particularly where power requirement is relatively small and/or accessibility is poor. The sector currently experiencing most growth, however, is the distributed grid-connected sector.

2.1.1 Stand-alone applications

A prime example of PV niche value is for maritime navigation devices – lighthouses, light ships and light buoys. Trinity House, one of the UK's main lighthouse authorities, has completed upgrading of all of its 420 buoys to photovoltaics and is continuing upgrading of lighthouses and lightships to operate on PV. Although relatively expensive in terms of price per Wp installed (typically total project cost of refurbishment equates to \approx £ 50 /Wp) these systems, which range in size from a few 100 Wp to around 4 kWp, typically have a payback of 7 years against a life-cycle of 15 years, due to reduced O&M costs.

Other industrial stand-alone applications for PV in the UK include:

- Telecommunications equipment, such as repeaters and telephones in remote areas
- Environmental monitoring stations (weather, air and water-borne pollution, and sewage)
- Cathodic protection against corrosion of pipelines and other metal structures

In addition, numerous commercial stand-alone devices with very low power requirements (typically < 10 Wp) are operational in the UK, even in urban locations:

- In the order of 1000 traffic monitoring units fitted with small PV modules (8-10 Wp) were deployed in 2000
- Several local authorities are using PV powered parking ticket machines
- Greasing systems are used on railway points to reduce wear

Stand-alone domestic applications include systems of several kWp, usually in diesel-hybrid configuration, providing mains equivalent AC power for remote houses. Sales of such systems were very limited in 2000. Smaller systems, often at 12 V or 24 V

¹ DTI Energy Statistics.

DC, are used for remote holiday homes, caravans and boats. Single modules providing up to a few 10s of Wp are used to power leisure items such as garden fountains, waymarkers and wireless alarm systems.

2.1.2 Grid-connected applications

PV generated electricity in the UK is currently not competitive with respect to mains electricity, typically remaining 5-8 times more expensive per unit than current retail prices. As the UK does not currently have a market incentive (e.g. subsidy) programme for the domestic or large-scale building sectors, the majority of grid-connected projects to date have been installed for demonstration purposes, or by companies wishing to demonstrate their environmental concern/credentials (see section 2.3)

Despite the lack of financial assistance and current cost-disincentive for the domestic sector, an increasing number of environmentally conscious home owners are purchasing PV systems. In 2000, some 90-100 kWp of grid-connected PV was installed for residential applications in the UK.

2.2 Total photovoltaic power installed

The year-on-year total cumulative installed PV power for the UK sub-markets (stand-alone domestic, stand-alone non-domestic, and grid-connected distributed) from 1992 onwards are presented in Table 1.

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

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

Sub-market/application	1992	1993	1994	1995	1996	1997	1998	1999	2000
stand-alone domestic (kWp)	7	47	52	57	69	83	108	119	121
stand-alone non-domestic (kWp)	166	213	232	252	279	316	254	276	302
grid-connected distributed (kWp)	0	6	54	59	75	190	328	736	1506
grid-connected centralised (kWp)	0	0	0	0	0	0	0	0	0
TOTAL (kWp)	173	266	338	368	423	589	690	1131	1929

The 2000 data indicates continued exceptional growth in the grid-connected distributed market sector, showing an 89 % increase over the capacity installed during 1999². In terms of the cumulative installed capacity, grid-connected distributed applications rose by approximately 105 %.

There was also steady annual growth (approximately 17 %) reported in the off-grid non-domestic sector. The market for off-grid domestic applications appears to have shrunk in 2000, compared to previous years.

² data from UK NSR 1999

Overall, cumulative installed PV generation capacity increased by over 70 % during the year, with annual growth rate exceeding 80 %.

2.3 Major projects, demonstration and field test programmes

2.3.1 Domestic PV Field Trial

Implementation of the DTI's field trial of PV systems in the Domestic Sector commenced in March 2000. The field trial is supporting the installation and monitoring of clusters of systems on new-build housing developments or major domestic refurbishment projects. The overall objective is to use the design, construction and monitoring of the installations as a learning opportunity for utilities, building developers and other key players. Information will be gathered on buildability, operating performance, reliability and 'maintainability' of the various systems. The systems will also be monitored to assess possible electricity network effects of PV clusters.

The information obtained will be used to refine the guidelines for monitoring, to improve PV system design and to develop Best Practice recommendations for future installations.

A Call for Proposals announced in 2nd quarter 2000 prompted a good response, with 25 proposals submitted by the July 20th deadline. The projects were evaluated by ETSU and considered by the Solar Energy Advisory Committee to identify a suitable spread of installations, both geographically and technologically.

On the basis of the evaluation, the DTI allocated \approx £ 1.4 million – an increase over the expected budget of £ 1 million - to support nine projects. This should result in the installation of over 220 kWp, benefiting over 160 homes. The programme covers the entire system cost and provides for system monitoring for a two-year period.

A Project Management Consortium, led by the Building Research Establishment (BRE), was appointed in October 2000 to oversee implementation of the nine projects. The first installations will be installed early in 2001, with commissioning of the first systems likely to occur in 2nd quarter 2001.

In May 2001, the new Minister for Energy, Peter Hain, announced a £ 3 million second round of the field trial which should see a further 300 systems installed nation-wide.

2.3.2 The S_{olar} Programme for Photovoltaics

The four year S_{olar} Programme for Photovoltaics, which aimed to equip 100 schools with grid-connected PV systems, drew to a close in 2000. In total, approximately 80 systems have reportedly been installed, amounting to some 50 kWp, with over half of this coming online in 2000.

The S_{olar} Programme for Photovoltaics was initiated as a response to the Government's Foresight Challenge to develop photovoltaic technology and to raise

awareness of PV in schools and other educational establishments, both through demonstration systems and the provision of educational material.

The Solar Consortium consists of a number of UK organisations which are active in PV, from both industry and academia. The Consortium is led by UK PV manufacturers, Intersolar.

2.3.3 BP 'Sunflower' and 'Harmony' programmes

As in 1999, BP's ongoing international programmes to equip its petrol stations with PV generators accounted for a major part of the total installed grid-connected generation capacity in the UK in 2000. 400 kWp of crystalline modules were installed under the 'Sunflower' programme, while a further 45 kWp of thin-film PV were incorporated in filling stations under the company's new 'Harmony' initiative.

2.3.4 BP Conference Centre

The largest PV system installed to date in the City of London can be found on the BP Conference Centre. The 50 kWp system consists of a roof mounted array of high efficiency modules, 15 PV rooflights where the PV cells also provide shading, and a glazed PV canopy installed over the entrance stair. The system is grid connected and the energy generated is recorded on a display positioned in the conference centre lobby.

Together with installations on 54 filling stations and the Sunbury Office Complex, BP is now by far the biggest user of PV in the UK with approximately 950 kWp installed on its facilities nation-wide.

2.3.5 Sainsbury's Petrol Station, Greenwich

Sainsbury's, the UK's second largest supermarket chain, commissioned Solar Century to install a 6.75 kWp monocrystalline silicon PV system on the roof of the customer petrol station at its North Greenwich branch.

The system is mounted on top of the high steel canopy and is not directly visible from ground level. However, a large format display on the cashier kiosk provides instantaneous and cumulative information on electricity generated by the PV system.

All power generated is used on site: the PV system is connected to Sainsbury's on-site CHP generation system. It also provides power for a free plug-in port for charging electric cars, promoting the use of cleaner transport options.

2.3.6 Glen Farm Barn, Innerleithen

Solar Century were also commissioned to install a 10.24 kWp roof integrated system for a private solar electricity generator, supplying power for four nearby cottages. The array comprises 80 Unisolar 128 Wp amorphous silicon structural standing seams, configured as four equal sub-arrays, each generating power for a single cottage.

The tenants will purchase all the electricity generated by their associated sub-array, exporting any excess to the grid under TXU-Eastern Energy's 'Solarnet' net metering scheme.

2.3.7 Mabley Street (Self-build live)

PV systems have been installed on 6 houses at Mabley Street in East London in a new development by the Circle 33 Housing Trust. The development comprises 12 houses, 6 of which are being built to Circle 33's current specification, while the other 6 are being built to an improved specification and include PV and solar water heating systems.

The PV systems have been designed by IT Power to provide a minimum of 40 % of the predicted annual electricity requirement of the residences, each of which has been equipped with low energy appliances. A total of 11.5 kWp of PV has been installed. The procurement of the PV system was designed to fit in with normal construction practices, and this resulted in the UK's lowest cost domestic PV installation at that time (approximately £ 5.80 /Wp installed).

Regularly updated progress reports were available online during the construction phase at www.selfbuildlive.co.uk.

Table 2: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2000/problems and lessons learned	Funding	Project management	Remarks
Domestic Field Trial 2000-2002	£1.4m assigned for 9 cluster projects - total >220kWp for >160 residences	To use the design, construction and monitoring of the installations as a learning opportunity for utilities, building developers and other key players. Geographical spread and technologically varied systems will maximise lessons learned.	Project Management Contractor appointed. 7 of 9 projects contracted. First installations underway, due for commissioning in 2nd quarter 2001.	Up to 100% DTI (some projects have secured complementary EC funding)	Project Management consortium: BRE (leader), EMC Ltd., IT Power, NPAC	Second Round with additional £3m budget announced in May 2001
SCOLAR Programme 1996 - 2000	PV systems for installation in schools and colleges. 100 installations planned. 500-690Wp. Mostly mono-crystalline silicon.	To provide an opportunity for students to gain real time experience of photovoltaic power. The project demonstrates the opportunities offered by PV as an attractive architectural medium as well as an energy source in the built environment.	Approximately 80 systems installed in total	Foresight Technology Challenge Programme: 40%, Schools/Colleges: 40%,Partners: 20%	SCOLAR Consortium, led by Intersolar	Programme concluded at end of 2000.
BP Sunflower 1999 -	Crystalline PV installed on canopies of new service stations. 400kWp installed in UK in 2000	International programme - to project a 'green' image and raise public awareness of PV power systems	Total of 734kWp installed on 43 stations in UK as at end of 2000	BP / BP Solar	BP Solar	Largest 'single' contribution to UK installed capacity in 1999 and 2000
BP Harmony	Programme to install thin-film PV on all BP filling stations. (Harmony has replaced Sunflower) 45kWp installed in UK in 2000	As above	Total of 139kWp installed on 11 stations as at end of 2000.	As above	As above	

2.4 Budgets for market stimulation, demonstration/field test programmes and R&D

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

		R&D	Demo / Field Test	Market
National	DTI	2.3		
	EPSRC	2.52	-	-
Regional		-	-	-
Total	(£)	4.82		

The EPSRC figure of £ 2.52 million includes awards funded specifically through the Renewable & New Energy Technology (RNET) programme as well as other 'unsolicited' research proposals, and proposals funded through other programmes (e.g. materials, chemistry, physics). In 2000, the RNET programme had a budget of around £ 4 million per year, of which about 38 % was spent on PV related research.

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Table 4: Production and production capacity information for the year for each module manufacturer

Module manufacturer	Technology (sc-Si, mc-Si, a-Si, CdTe)	Total Production		Maximum production capacity (MWp)
		Cell (MWp)	Module (MWp)	
Intersolar	a-Si	1.6		3

The UK has only one major manufacturer of PV modules: Intersolar manufactures thin-film amorphous silicon cells and modules at its factory in Bridgend, South Wales. Encapsulation method is glass-glass, EVA. Production capacity was increased from 2.5 MWp to 3.0 MWp in 2000. A large proportion of Intersolar's production is exported. The production figure also includes cells produced for a variety of consumer products manufactured in-house. The company operates to ISO 9001 Quality Assurance procedures. Intersolar also initiated and headed the Sclar Programme for Photovoltaics in the UK.

A number of companies produce small volumes of (mainly) low power modules for specific applications using bought-in cells:

- NAPS encapsulates approximately 10 kWp of cells per annum in the UK for specialist commercial applications, mainly roadside traffic counters.

- Romag, a specialist glass company based in County Durham, has capabilities to produce bespoke photovoltaic solutions for specific applications, mainly for the BIPV sector. The company was not active in PV in 2000, but is expected to become progressively more involved in the industry in the next few years.

Crystalox, based in Wantage near Oxford, pioneered development of multi-crystalline silicon directional solidification as a production process for the PV industry and delivers automated equipment to many of the world's leading PV companies. The company currently produces multi-crystalline silicon ingots sufficient for 10 MWp of cells per annum. These are wafered by PV Silicon in Germany. The company, which is the UK's second largest employer in the PV sector has major expansion plans, aiming to increase production capacity to 50 MW in 2001. This will result in the creation of a number of new jobs.

PV Systems of Cardiff manufacture and install laminators and associated equipment for module production, notably for (small-scale) indigenous encapsulation facilities in developing countries.

3.2 Manufacturers and suppliers of other components

Prices of inverters available on the international market have been affected by recent currency fluctuations. The strength of the Pound against the Euro has helped to reduce prices of inverters from the Continent. Approximate price ranges for a range of inverter sizes are presented in Table 5.

Table 5: Price (in £ Sterling) of inverters for grid-connected PV applications

Size of Inverter	<1kVA	1-10kVA	10-100 kVA	>100kVA
Av. Price per kVA (£)	750-1000	450-750	~300	-

- Dulas Engineering is a worker-owned company specialising in renewable energy system design and supply. The company designs and manufactures a range of robust electronic control equipment in-house. Dulas is also UK agent for Fronius inverters. Fronius' inverters for grid-interconnection applications have been type-test certified to G77 standards.
- Invertec Ltd, traditionally a low-voltage lighting manufacturer, supply a range of inverters for stand-alone PV applications.
- Futronics Power Designs Ltd, based in Hertfordshire, introduced a new range of inverters for stand-alone applications in 2000. All models in the '*Sustain*' range are capable of operation in parallel with each other. Solutions are available for hot-plug 19"/23" rack mounting, (T Series) and wall/panel mounting, (R Series). All units are rated for continuous operation at elevated temperatures.
- I-Power of Gateshead (formerly Nada) produce a range of Stand-Alone and Grid Linked Inverters for (PV) Applications. The company is currently the only UK manufacturer of inverters for grid interconnected applications. I-Power was also the first company to receive G77 (type-test) Certification for its inverters (applicable to units under 5 kVA).
- Labcraft of Romford is a specialist manufacturer of low voltage fluorescent lighting and inverters for PV and other alternative energy applications.

- Mastervolt UK is the UK sales and distribution arm of Mastervolt, headquartered in Amsterdam. The company designs and manufactures inverters, battery chargers and related components, and distributes batteries and modules.
- Redland Technologies 'PV 700' Roofing System is designed to integrate into a pitched roof, each PV panel replacing four standard (Redland) tiles. The system is modular, the basic unit consisting of 20 PV modules, mounting fixtures and appropriate inverter. The units are rated at 700 Wp each.
- Solar Century is the main agent for SMA inverters in the UK. SMA Sunny Boy 700, 850, and 2500 inverters are G77 type-test approved.
- Sollatek manufacture low-voltage DC lights and battery charge controllers for stand-alone applications, predominately for the export market.
- Wind & Sun is the main agent for Trace inverters in the UK

3.3 System prices

Table 6: 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, boats, caravans)	~10
OFF-GRID >1 kWp	Remote homes with battery storage or backup generator; Pumping Systems	~8.5
ON-GRID Specific case	1-3 kWp domestic roof mounted	5.0 - 7
	1-3 kWp domestic roof integrated (e.g. slates or tiles)	6.7 - 8.6
ON-GRID up to 10 kWp	Roof or ground-mounted systems (e.g for commercial building retrofits)	5.2 - 7.8
ON-GRID >10 kWp	e.g. 20 kWp roof mounted system (on filling stations, commercial / industrial buildings)	~4
	One-off true building-integrated designs will be more expensive!	

3.4 Labour places

An estimate of (full-time equivalent) labour places related to the photovoltaics sector in the UK is presented as Table 7

Table 7: Estimated PV-related labour places in the UK

Research and development (not including companies)	50
Manufacturing of PV system components, including company R&D	150
All other, including within electricity companies, installation companies etc.	100

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

4.1.1 Promotional initiatives

As of 1st April 2000, VAT on professional installations of PV systems has been reduced from 17.5 % to 5 % (currently the minimum permissible under EC law). However, the reduced rate does not currently extend to Do-it-Yourself (DIY) installations, which is seen by some parties as a deterrent to more widespread deployment of small-scale systems and particularly 'AC' modules³.

TXU-Europe (Eastern Energy) under an agreement with Greenpeace is offering net-metering of up to 1000 residential PV systems under the '*Solarnet*' scheme. In the deregulated UK market, the scheme is accessible to PV owners throughout the UK⁴.

4.1.2 Utility perception of PV

The DTI is continuing its support of the Working Group established to develop Engineering Recommendation G77 '*Recommendations for the connection of inverter-connected single-phase PV generators up to 5 kVA to public distribution networks*'. This forum, which draws together representatives of the Distribution Network Operators (DNOs) and Electricity Industry with representatives of the PV Industry (Halcrow - consultants, Sundog - installers and I-power - inverter manufacturers) has been helpful for establishing good working relationships between the two sectors, which in turn should assist sensible deployment of grid-connected (domestic) PV systems in the UK. PV installers now have an identified contact point within each of the DNOs to whom applications and queries regarding interconnections can be directed. The DNO contact list, draft application and commissioning pro-forma, and flowchart of the G77 application procedure are available for download from the British Photovoltaic Industry Associations Website: www.pv-uk.org.uk.

Nation-wide initiatives like the Sclar programme, BP's sunflower project and, the new Domestic Field Trial programme are increasing DNOs exposure to PV, and most DNOs now have a number of PV systems connected to the network in their region. However, while network connections are increasingly straightforward, the metering/supply aspect is currently far from helpful. Some suppliers require the customer to have a new meter installed to monitor exports to the grid. Typically this

³ There are other issues relating to AC modules - notably grid-interconnection requirements of Engineering Recommendation G77 (See section 4.3) which must also be addressed before such devices can have any significant impact in the UK.

⁴ For customers outside these regions the exports may be estimated unless a suitable meter is installed.

may add an additional £ 300-400 on the system price for the customer - equating to a 3 to 4 year payback just for the meter on a typical 2 kWp system.

4.1.3 Public perceptions

Changes in public perception of PV are difficult to gauge, but the specific inclusion of PV in positive high-profile speeches by the Prime Minister and the Energy and Environment Ministers can only help to stimulate public interest and confidence. The inclusion of PV in the mainstream political agenda represents a success for the PV industry who have been lobbying for such recognition for many years.

High visibility projects such as BP's Sunflower initiative likewise serve to improve public awareness. Solar Century has been actively undertaking a high profile marketing campaign, taking out full-page advertisements in weekend magazines accompanying some of the quality broadsheet newspapers and in other lifestyle magazines. The campaign is presenting a high-quality, professional image to the general public that raises the profile of the technology and of the industry as a whole.

The British PV Association, with assistance from the DTI, also launched its new online information service '*PV-WEB*' in July 2000. The site provides a description and examples of applications in the UK, and a searchable listing of installers, suppliers etc. to help potential PV users identify quality service providers.

4.1.4 Major new projects / initiatives

As indicated in 2.3, the Domestic Field Trial is well underway, and is expected to see over 220 kWp of PV installed in 2001/2002. In May 2001, Peter Hain, Minister for Energy, announced a further £ 3 million government investment into the solar housing trial. The Minister called for home builders and housing developers to get involved in the solar revolution and bid for a share of the money. This new funding is expected to add a further 300 homes to the 200 covered by the first round of funding.

The DTI is also to support a Large-Scale BIPV Field Trial with a budget of £ 3 million over three years. This aims to provide a capital contribution of a maximum of £ 300 000 for 12-15 large, high-profile and innovative non-domestic installations, i.e. over 20 kWp. Terms of reference for the Large-scale BIPV Programme were developed in 2000, and the first projects contracts are expected to be let in 2001.

4.1.5 Other new issues

A Government-Industry Photovoltaics Group was established in autumn 2000 following discussions between the (then) Energy Minister, Helen Liddell, and the President of BP Solar, Harry Schimp. Following broader industry consultation, the Working Group produced a report presenting the consensus view of prospects for PV market development and the implications for the UK.

The report considered that 'A relatively modest investment by the UK government today can, in parallel with PV industry investment and marketing, ensure that the UK

becomes an important player in tomorrow's PV industry, with subsequent positive socio-economic benefits.'

A number of options for stimulating uptake of PV in the UK were also proposed, including:

- A 50 % capital grant programme for 70 000 domestic houses and a similar programme for non-domestic buildings
- Voluntary Agreement with Licensed Electricity Suppliers.
- Voluntary Agreement with major Private & Social Housing Developers
- Tax Allowances for businesses and individuals installing PV

The full text of the report can be downloaded from the DTI website:
www.dti.gov.uk/renewable/photovoltaic/photovolt.pdf

4.2 Indirect policy issues

The 'Climate Change Levy' (CCL) on business use of energy was introduced on 1st April 2001. The levy on electricity is initially set at 0.43 p/kWh, plus VAT and is set to rise year-on-year. Renewable energy, however, is exempt from the levy and businesses that sign up to a green 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. £ 39 m of funds generated through the levy will be used to assist development of new renewables capacity, via capital grants for offshore wind projects. The remainder will be redistributed to businesses through reductions in National Insurance contributions.

In October 2001 a new Renewables Obligation will be introduced in the UK, aimed at seeing 5 % of UK electricity generated from renewable energy sources by 2003 and 10 % by 2010. All suppliers of electricity in the UK will need to supply a set percentage of electricity from renewables, or pay a penalty. For each 10 MWh of electricity produced from accredited renewable energy schemes, the generator will be awarded a 'Renewables Obligation Certificate' (ROC) which can then be sold to an electricity supplier as evidence of a renewables purchase. A penalty/buy-out price of 3 p/kWh is proposed (linked to the Retail Price Index), which effectively sets the upper price suppliers will pay for the ROCs. The obligation should encourage development of near cost-effective renewable energy schemes, but is unlikely to promote photovoltaic generation capacity in the near to medium term.

4.3 Standards and codes

The draft Engineering Recommendation G77 '*Recommendations for the connection of inverter-connected single-phase⁵ PV generators up to 5 kVA to public distribution networks*' is currently open to consultation with a view to completing essential modifications by the end of 2001, prior to adoption by the Electricity Industry.

G77 aims to facilitate the deployment of (domestic) grid-connected PV by providing a straightforward procedure for installers, backed by simple pro-forma and checklists, for application to connect, and for commissioning of systems. The procedures will be common to all DNOs. To ensure all such connections meet network performance parameters and safety requirements, all inverters for PV grid-interconnection (< 5 kWp) must undergo independent G77 type-testing. Connection of a non-approved inverter will require additional commissioning and acceptance tests to be carried out, as defined by the local DNO⁶. A list of approved inverters will be available on the PV-UK website.

Grid-interconnection of PV systems rated above 5 kWp is governed by Engineering Recommendation G.59/1, Amendment 1 (1995), '*Recommendations for the Connection of Embedded Generating Plant to the Regional Electricity Companies' Distribution Systems*'. G59 requires adherence to somewhat more stringent protection procedures than G77, including the incorporation of an additional inverter disconnect relay, providing for faster disconnect responses in the event of loss of mains, or other mains fault.

5 Future trends

The trend in growth, particularly of the grid-connected distributed sector, is expected to continue in the near term. Installations of Residential PV systems will be strengthened by the Domestic Field Trial during 2001, probably until 2003. A number of major BIPV projects will be completed in 2001 and 2002, including the Peabody Trust's 109 kWp BedZED (Beddington Zero Energy Development) and 200 kWp Canalside Housing Project at Ladbroke Grove. Other major buildings projects are likely to emerge in the near future as the DTI's large-scale BIPV programme

⁵ Multi-phase connections will also be covered by G77, though the total system capacity must not exceed 5 kW and injections must be balanced across all phases.

⁶ To gain type-test approval, the inverter must incorporate protection to isolate the generator from the network in the event of over/under voltage, over/under frequency or loss of mains supply. Currently this must be achieved by a separation of mechanical contacts. This has implications for 'AC' modules (or 'module integrated converters'), which tend to use solid-state technology to control disconnection from the grid. Work is being undertaken by EA Technology, Halcrow and Sundog, supported by DTI, to investigate the safety / reliability of solid state Vs. mechanical protection. As it is mandatory to gain DNO authorisation prior to connection of a generator to the distribution network, AC modules are unlikely to take off in the UK while solid-state protection remains unapproved.

commences in 2001. BP Solar estimates that over 1 MWp of its modules will be installed in the UK in 2001.

Although there are no firm long-term targets for installed PV generation capacity, considerable interest for the UK PV community is held in the government's White Paper entitled 'Enterprise Skills and Innovations: Opportunities for all in a World of Change', published by DTI and DfEE in February 2001.

The paper states the following:

'We (the government) will embark on a major initiative with industry and others to achieve a UK solar photovoltaic demonstration programme in line with those of our main competitors.' The paper claims that the programme '... will establish the UK as a credible player in the PV market, alongside Germany (100 000 roofs by 2007) and Japan (70 000 roofs by 2002). It will encourage R&D and manufacturing investment in this field in the UK. We will also encourage British industry to move direct to the innovative thin-film technologies, which have greater potential for cost-reduction than existing technologies.'

6 Annex A Method and accuracy of data

The information for this survey report has been drawn from many sources. The assistance of Isabelle Michel in respect of data collection and verification, and co-operation of all parties who provided information for the 2000 survey is gratefully acknowledged.

Data was gathered directly from most of the UK industry players via e-mail questionnaire and personal discussions. The British Photovoltaic Association (PV-UK) and Altechnica provided access to their records for comparisons. The various data was collated in a spreadsheet, sorted into the required categories and totalled.

The estimated accuracy of the year 2000 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.