Information Guide

Photovoltaic Systems

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MITSUBISHI ELECTRIC
LIVING ENVIRONMENTAL SYSTEMS

Guide to Photovoltaic Systems

This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today. The guide accompanies a series of seminars, all of which are CPD accredited.

As oil and gas prices rise, using energy from the sun as a power source for our buildings is becoming an increasingly viable financial alternative. There are three fundamental ways in which solar energy can be harnessed for use in buildings; photovoltaic (PV) energy is one of these. Photovoltaic systems use silicon cells to convert solar radiation into electricity.

Building integrated photovoltaic systems can provide clean, renewable power, reducing electricity bills for the end-user as well as cutting CO_2 emissions. Feed-in Tariffs (FiTs) have encouraged more UK householders to take up photovoltaic technology with the potential to earn money from their installations.

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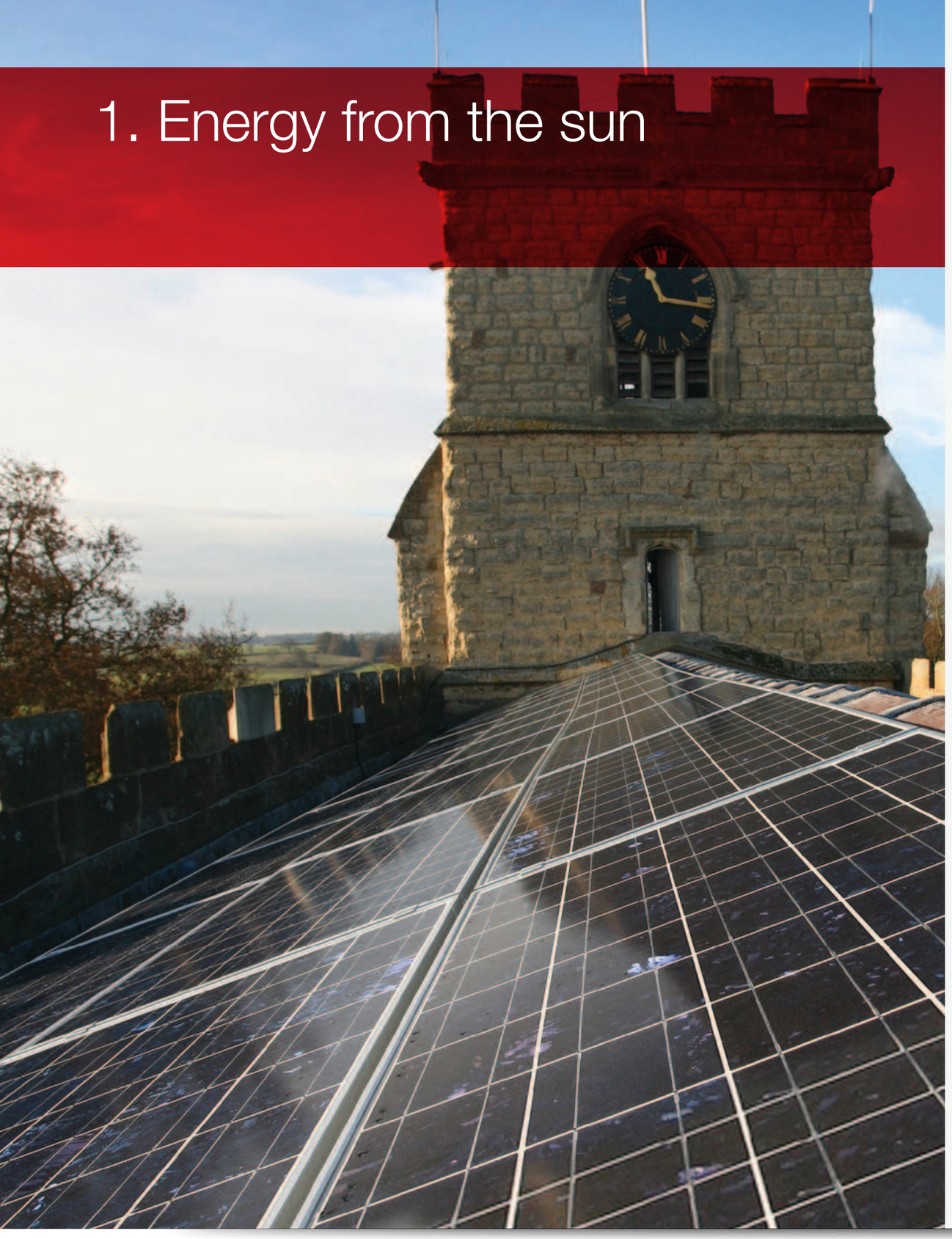
1. Energy from the sun



Solar power offers an alternative to fossil fuels with many benefits for the built environment. As oil and gas prices rise, using energy from the sun as a power source for our buildings is becoming an increasingly viable financial alternative. Figures from the European Photovoltaics Industry Association (EPIA) show that in 2010 the EU was the world's largest PV market, growing significantly in the past two years.

There are three fundamental ways in which solar energy can be harnessed for use in buildings. Passive heat is received from the sun naturally, and the design of buildings can harness this through orientation and glazing to reduce the need for heating. A second method of using solar energy is through solar thermal systems that provide hot water for heating systems. The third method is to use photovoltaic (PV) energy.

Building integrated photovoltaic systems can provide clean, renewable power, reducing electricity bills for the end-user as well as cutting CO_2 emissions. Feed-in Tariffs (FiTs) have encouraged more UK householders to take up photovoltaic technology with the potential to earn money from their installations. Solar power is also silent in operation, and very reliable, requiring only a simply annual maintenance check.

Photovoltaic systems use silicon cells to convert solar radiation into electricity. There are a number of different types of PV, each offering different performance/capital cost ratios for the specifier to consider.

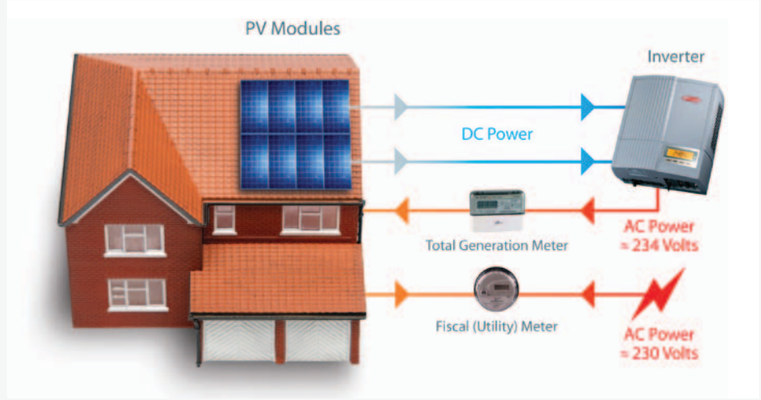
The main categories of PV systems available on the market today are crystalline silicon (c-Si) and thin film (CdTe, or CIGS). Crystalline silicon cells are the most commonly used today, representing almost 90% of the market. They are manufactured from thin slices cut from a single crystal of silicon (monocrystalline) or from a block of silicon crystals (polycrystalline).

Thin film photovoltaic modules are produced by deposits of very thin layers of photosensitive layers onto a backing such as glass or plastic. The photosensitive layers can be made from a number of materials including amorphous silicon or cadmium telluride.

Simply put, the PV modules convert sunlight into DC electricity which is then converted to AC by inverters. The electricity can be used on-site or exported to the grid. The UK's weather has raised some doubts about the viability of using sunlight as an energy source. However, for photovoltaic systems it is the intensity of the light that affects the amount of electricity produced. A PV system does not require bright sunlight to operate and will produce energy even on cloudy or rainy days.

The inverter is an important part of the PV system. It ensures that the output voltage from the PV modules is slightly higher than the voltage coming in from the grid. This means that appliances will use electricity from the PV system before drawing from the grid – thus reducing consumption of more expensive electricity. Metering is also crucial to keep track of how much energy is produced and used. Surplus energy from the PV system will be automatically exported back to the grid.

The Government has recognised the potential for photovoltaic systems for domestic and commercial buildings, and has introduced some important incentives to encourage take-up. Our next feature looks at the UK market drivers and incentives for householders and businesses.



2. Feed-in Tariffs driving PV installations

According to the latest figures from the European Photovoltaic Industry Association (EPIA), Europe leads the world in use of photovoltaic systems. In 2010 Europe had 30GW of installed capacity, which is around 75% of the world's total PV power. By comparison the USA has only 2.5GW installed and Japan has 3.6GW.

Within Europe, Germany is the foremost user of solar energy, with 7.4GW of installed power, and a national target of 51GW for 2020. Feed-in Tariffs have been an important driver for the German market, and although these are now reducing, PV technology is still a popular choice. The importance of these tariffs is an indicator of how Government incentives can help to increase demand for renewable technologies.

Table 1

Technology	Domestic installations	Domestic installed capacity (MW)	Commercial installations	Commercial installed capacity (MW)
Anaerobic digestion	0	0	6	5.077
Hydro	162	1.807	42	10.661
Micro CHP	162	0.163	0	00
Photovoltaic	**43076**	**117.129**	**435**	**3.835**
Wind	1184	8.626	239	11.646
Total installed capacity	–	127.725	–	32.219
Total installations	44584	–	722	–

(Figures from Ofgem up to 5th July, 2011)

The UK introduced its own Feed-in Tariffs (FiTs) in April 2010, and they have proved a driver to greater take-up of photovoltaics, particularly in the domestic market. In fact, residential installations of this technology outnumber non-domestic by some way – making the UK unique in Europe. Graph 1 shows the types of PV installation across Europe according to EPIA figures.

FiTs are available for other types of renewable technology, but figures from Ofgem (Table 1) show just how popular photovoltaics have been. Ease of installation, operation and maintenance are the main reasons for this technology's popularity with specifiers and end-users.

Feed-in Tariffs are available to owners of a wide range of buildings including homes, small businesses, schools and churches. The FiTs work by giving the owners of the photovoltaic equipment payments for all electricity generated, as well as bonus payments for power exported back to the grid. A third financial incentive comes in the form of reduced electricity bills for the owner. FiTs for photovoltaic systems last twenty five years from the date of installation.

The Government has recently (April 2011) updated the FiTs payments for generated electricity, placing greater focus on smaller building-integrated systems. Table 2 shows the generation tariffs offered for smaller building-integrated photovoltaic installations registered up to the end of March 2012. The tariff for electricity exported back to the grid (ie not used on-site by the building occupants) is currently 3.1p per kilowatt hour.

Graph 1

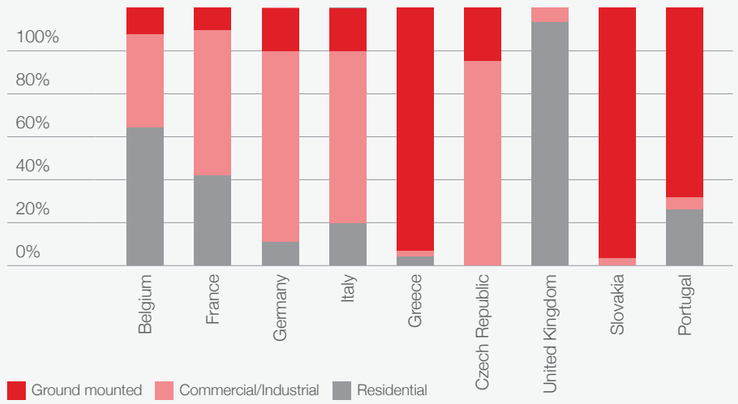


Table 2

System type *(solar photovoltaic)*	System size	Generation tariff for installations registered between 15/7/09 to 31/03/12
Installation on new-build before first occupation	4kW or less	37.8 pence per kilowatt hour (p/kWh)
Installation on existing building that is already occupied	4kW or less	43.3 p/kWh
Installation on new or existing building	Greater than 4kW but less than 10kW	37.8 p/kWh

(Figures from the Ofgem website www.ofgem.co.uk)

Table 3 outlines the generation tariff levels for installations above 50kW which will be in place from August 2011. Export tariffs are set at a minimum of 3.1 p/kWh.

The Government will not act retrospectively and any changes to generation tariffs implemented as a result of the recent review will only affect new entrants into the FiTs scheme. Installations which are already accredited for FiTs at the time the changes come into force will not be affected.

The key questions that householders want answered are what size of PV system would I require? And how much of a financial benefit can I expect? The important point for anyone considering installing a photovoltaic system on their home is that both the product used and the installer must be registered with the Microgeneration Certification Scheme. The website has a full list of products and installers: *www.microgenerationcertification.org*

A typical domestic installation might be a 2.2kW retrofit system (see picture above for example). Tables 4 and 5 below show the typical assumptions and benefits that the owners might see from such a system:

Table 3

System type	System size	Generation tariff
Retrofit and new build	up to 50kW to 150kW	19.0 p/kWh
Retrofit and new build	150kW to 250kW	15 p/kWh
Retrofit and new build	250kW to 5MW	8.5 p/kWh

(Figures from DECC)

One very important point to bear in mind is that although the owners of a PV system will continue to receive the same level of FiTs payments offered at the time of installation for the life of the scheme (20 to 25 years), the level of payments is scheduled to decrease over the twenty-five year life of the FiTs scheme.

Those who adopt the technology early will therefore receive the greatest financial benefits in terms of generation payments. However, as utility bills continue to rise, the benefits of using self-generated electricity will continue to increase.

Table 4

Assumptions	
Annual generation	1,760kWh
Generation tariff	43.3 p/kWh
Cost of electricity to the householder	10 p/kWh
Export tariff	3.1 p/kWh
Proportions consumed/exported	50/50

Table 5

Benefits	
Generation tariff income	£762.08
Savings on grid electricity	£88.00
Export income	£27.28
Total annual financial benefits	£877.36
Annual CO_2 savings	1 tonne

(This is index linked, and assumes that 50% of electricity is generated by the PV array, and 50% is exported back to the grid. Based on an average of 10p per kWh charged by the energy supplier.)

3. Specifying and installing photovoltaic systems

Correct specification and installation are vital to ensuring the long-term efficient performance of a photovoltaic system. There are a few useful rules of thumb to bear in mind when working with this type of renewable technology.

A key consideration when specifying PV is 'kilowatt peak' (kWp). This is a measure of capacity and represents how much electricity a system will generate under standard test conditions. Annual Yield (kWh) is the amount of energy a PV system will generate in one year, and this depends on location and orientation. So a system that has 1kWp has a yield of approximately 800kWh per year.

This is based on 7.5m^2 of surface area on a pitched roof or 15m^2 of flat-roof area.

There are different types of photovoltaic system on the market. Each offers a different cost/efficiency ratio, as well as different performance levels. Specifiers need to think about a range of factors when selecting the right type for their clients. One very important point is that in the UK, to be eligible for the FiTs scheme, a photovoltaic system must be accredited under the Microgeneration Certification Scheme (MCS).

Thin film PV technologies have been regarded as cheaper per kWp in the past, but this price gap is closing as silicon prices fall. Thin film also offers lower efficiencies than the silicon products, and there are also question marks about its durability. Within the range of silicon products, monocrystalline systems have also been viewed as more efficient than polycrystalline. However, PV technologies are advancing and this difference in performance is also reducing quickly.

MORE INFORMATION

www.pv.mitsubishielectric.co.uk
The website contains further information on systems, installation and case studies.

www.energysavingtrust.org
Information on the Feed-in Tariff Scheme for householders, including how to take part. Also has a free downloadable copy of the 2006 DTi Guide to Installation of PV Systems (2nd Edition, 2006) in the Publications section.

www.microgenerationcertification.org
Includes information on MCS certified systems and installers.

www.ofgem.gov.uk/sustainability/environment/fits
Offering data on uptake of FiTs across the UK for PV and other eligible technologies.

www.epia.org
Website of the European Photovoltaic Industry Association which includes its latest market figures including projections on growth to 2015.

The type of module selected will affect the area required to achieve the required energy outputs. Clearly, this is a very important consideration as it will be influenced by the area available for PV on a particular project. Table 6 shows a comparison of cell material against area required to achieve 1kWp.

Orientation and pitch are probably the most important factors affecting system efficiency after the type of module selected. The orientation table to the right shows that maximum efficiencies are achieved at pitch of around 35°, facing due south. Near horizontal pitches should be avoided, as the self-cleaning element of modules cannot be guaranteed up to 10°.

Table 6

Cell material	Required area for 1kWp (m^2)
Monocrystalline	7 to 9m^2
High performance cells	6 to 7m^2
Polycrystalline	7.5 to 10m^2
Copper indium diselenide (CIS) (Thin Layer)	9 to 11m^2
Cadmium telluride (CdTe) (Thin Layer)	12 to 17m^2
Amorphous silicon (Thin Layer)	14 to 20m^2

Orientation: compass bearing (°) measured from north

Angle (°) from horizontal		West			SW			South			SE			East
		270°	255°	240°	225°	210°	195°	180°	165°	150°	135°	120°	105°	90°
Horizontal	0°	90	90	90	90	90	90	90	90	90	90	90	90	90
	10°	89	91	92	94	95	95	96	95	95	94	93	91	90
	20°	87	90	93	96	97	98	98	98	97	96	94	91	88
	30°	86	89	93	96	98	99	100	100	98	96	94	90	86
	40°	82	86	90	95	97	99	100	99	98	96	92	88	84
	50°	78	84	88	92	95	96	97	97	96	93	89	85	80
	60°	74	79	84	87	90	91	93	93	92	89	86	81	76
	70°	69	74	78	82	85	86	87	87	86	84	80	76	70
	80°	63	68	72	75	77	79	80	80	79	77	74	69	65
Vertical	90°	56	60	64	67	69	71	71	71	71	69	65	62	58

Note: Near horizontal 0° angles are not recommended as self-cleaning cannot be relied on up to about 10°.
Source: Guide to the installation of PV systems, 2nd Edition

Less Efficient (%) — More Efficient (%)

For installers, the choice of fixing system will depend on the type of roof and system selected. There are a number of fixing options available:

- **Tiled roof** – on roof
- **Tiled roof** – in-roof
- **Standing seam**
- **Flat roofs** – fixed
- **Flat roofs** – ballasted
- **Facades**

The tiled roof options are most often to be found in domestic installations, as shown in the illustrations here. For in-roof fixings, the tiles are replaced by a weatherproofed tray.

An anchored system has the added advantage of delivering good airflow (which increases the system performance) if mounted at a lower angle such as 10° to 12° as opposed to 30°. This is because the shading gap between each array impacts how much PV can be applied to the space. For example 15m^2 is required for a 30° mounted flat roof array for 1kWp, whereas 10m^2 is required for 1kWp at 10°. Airflow is better with open frame support rather than a ballasted 'bin' type system that may hinder airflow and subsequent panel performance.

As photovoltaics become a more common choice for commercial and domestic buildings, specifiers and installers need to be aware of the technologies and options that are available. A wide range of options does mean more choice for a wider range of building types. Photovoltaic systems are advancing rapidly in terms of performance and are now a realistic option for many domestic, housing association and small commercial customers looking to reduce energy bills as well as their carbon footprint.

Further information

If you missed the CPD seminar on **Photovoltaic systems** you can call your Mitsubishi Electric Regional sales office to arrange an in-house presentation of this information.

If you would like to receive invitations to future CPD events, please email **lesmarcomms@meuk.mee.com**

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