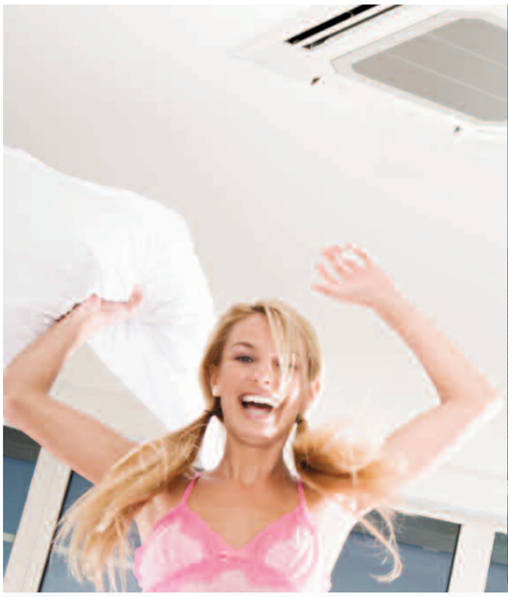





Information Guide:

Photovoltaic Systems

Issue 31

CPD CERTIFIED
Construction CPD Certification Service

MITSUBISHI ELECTRIC
LIVING ENVIRONMENTAL SYSTEMS

Information Guide:

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.

The changing face of construction in the 21st Century demands that designers, specifiers and suppliers work as teams to create better buildings - or occupants and the environment.

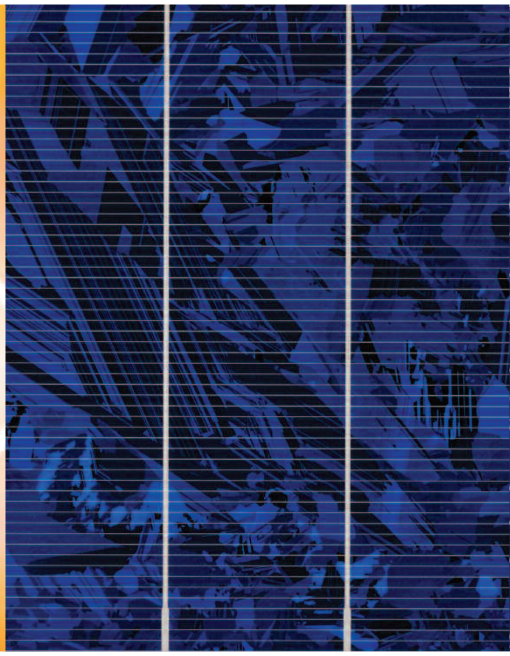
Mitsubishi Electric aims to be a part of this by encouraging employees and customers to work together to increase their knowledge of the latest technology, legislation and markets.

Contents

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.

Building integrated photovoltaic systems can provide clean, renewable power, reducing electricity bills for the end-user as well as cutting CO_2 emissions. Solar power is also silent in operation, and very reliable, requiring little planned maintenance.



MITSUBISHI ELECTRIC
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Photovoltaic Systems

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.

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 system 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 (monocyrstalline) or from a block of silicon crystals (polycrystalline).

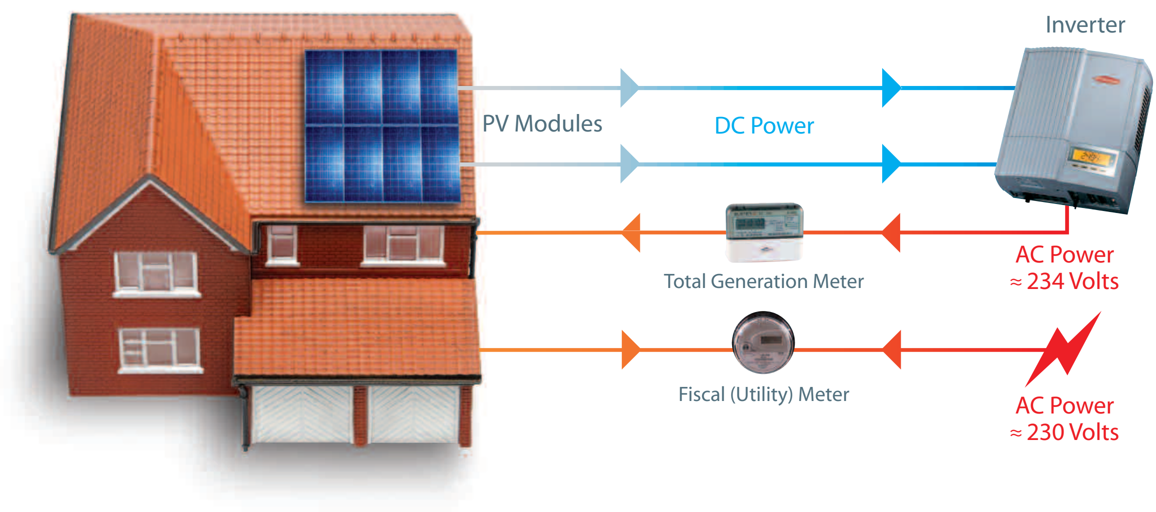
Thin film photovoltaic modules are produced by deposits of very thin layers of photosensitive layers onto a backing such as glass or plastic. The photosensitive layers can be made from a number of materials including amorphous silicon or cadmium telluride. Simply put, the PV modules convert sunlight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

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.**

A basic photovoltaic system

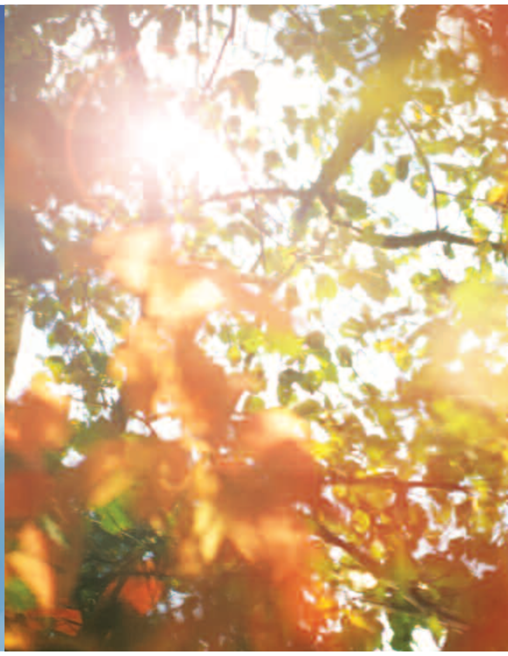


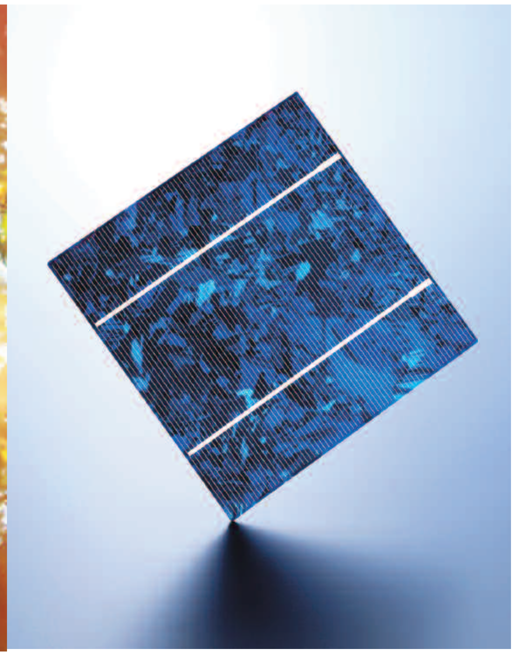
Photovoltaics - markets and drivers

According to the latest figures from the European Photovoltaic Industry Association (EPIA), Europe leads the world in use of photovoltaic systems. In 2009 Europe had 16GW of installed capacity, which is around 70% of the world's total PV power. By comparison the USA has only 1.6GW installed and Japan 2.6GW.

Within Europe, Germany is the foremost user of solar energy, with almost 10GW of installed power. Of this amount, 3.8GW was installed in 2009. Feed in tariffs have been an important driver for the German market, and since these are set to be reduced from 2010, it seems likely that market growth will slow.

The importance of these tariffs is an indicator of how Government incentives can help to increase demand for renewable technologies.





To date, the UK has not been a great user of photovoltaic technology. However the EPIA sees a healthy future for the technology, given the right incentives. The new Feed-in Tariffs (FiTs) should boost use of building integrated photovoltaics and combined with other 'green' energy incentives such as the Renewable Heat Incentive (RHI) the UK could see an increase in its PV usage. The EPIA predicts that the market should reach between 20MW and 40MW in 2010, rising to 250MW in 2014 (figures from EPIA publication Global Market Outlook for Photovoltaics until 2014). The Association adds that with stronger political support this figure could double.

The UK has a legislative commitment to reduce the nation's CO_2 emissions by 80% by 2050. A number of regulations and laws are intended to ensure that the UK building stock cuts its carbon footprint. These are helping to drive the market for renewable technologies such as photovoltaics.

At local government level, most Local Authorities have now introduced a requirement for use of on-site renewables through their planning rules. This is known as the Merton Rule, after the first London Borough to introduce the requirement. The amount of on-site energy generation required can vary from between 10% to 25% in some cases.

The Code for Sustainable Homes is another legislative driver to use photovoltaics. The Code requires that all new homes reduce their carbon emissions against Building Regulation standards. For private sector builders this is set at 25% but Housing Associations must achieve a 44% cut. Use of building integrated renewables such as PVs is an important part of achieving low carbon dwellings.

Perhaps the most significant development for the UK market for photovoltaics is the introduction in April 2010 of the Clean Energy Cashback Scheme, or Feed-in Tariffs (FiTs). The tariffs apply to both domestic and commercial buildings, and have attracted significant interest. Under the FiTs scheme, electricity suppliers are legally obliged to make payments to the owners of renewable energy generating equipment such as photovoltaics.

There are two parts to these payments: the generation tariff and the export tariff. The first is paid on the basis of all electricity generated; the second is paid for any excess, unused electricity that is exported to the grid. Owners of a PV system would therefore benefit from these payments, as well as the reduction in their electricity bills. Payment levels for the generation and export tariffs have been set, and are based on the size of system installed. Table 1 below outlines the tariffs:

Table 1:

System Size	Generation Tariff	Export Tariff
<4kW (Retrofit)	41.3p	3p
<4kW (New build)	36.1p	3p
4-10kW	36.1p	3p
10-100kW	31.4p	3p
100kW-5MW	29.3p	3p

The FiTs scheme brings photovoltaic technology much more within the reach of private householders. With electricity prices set to rise over the next few years, the use of renewables means that savings on energy bills are very likely to increase. The tariffs are set for 25 years - and will be paid whether the household uses the power or not.

An important point to note is that the tariffs shown in the table will gradually reduce over the 25-year life of the scheme, but each system will benefit from the tariff level set at the time of its installation. This means that early adopters will benefit more in the long-term. To illustrate the sort of benefits that an average household might see, table 2 below shows the typical payments and savings accruing from installation of a Mitsubishi Electric 12 module PV system (generating 2.2kWp).

In order to get the most from a photovoltaic system it is very important to ensure that the correct system is specified, and that installation is carried out to the highest standards.

Our next feature offers some useful rules of thumb.

Table 2:

Assumptions	
Annual Generation	1,778kWh
Generation Tariff	41.3p per kWh
Cost of Grid Electricity	10p per kWh
Export Tariff	3p per kWh
Proportion Consumed/Exported	50/50

Benefits	
Generation Tariff Income	£734
Savings on Grid Electricity	£89
Export Income	£26
Total Annual Financial Benefit	**£849**
Annual CO_2 Savings	**1 Tonne**

Rules of thumb - 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.

A key consideration when specifying PVs 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.

As discussed earlier, 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). At the moment only silicon products have achieved this MCS accreditation.

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 quickly and this difference in performance is also reducing quickly.

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 PVs on a particular project.

Table 3: Relative efficiencies of PV cell materials

Cell Material	Cell Efficiency Lab (%)	Cell Efficiency Prod (%)	Module Efficiency Prod (%)
Monocrystalline silicon	24.7	21.5	16.9
Polycrystalline silicon	20.3	16.5	14.2
Ribbon silicon	19.7	14	13.1
Crystalline thin film	19.2	9.5	7.9
Amorphus silicon	13	10.5	7.5
Micromorphous silicon	12	10.7	9.1
CIS	19.5	14	11
Cadmium telluride	16.5	10	9
III-V semiconductor	39	27.4	27
Dye sensitized	12	7	5
Hybrid HIT cell	21	18.5	16.8

Table 4: Comparison of cell material against area required to achieve 1kWp

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

Efficiency of PV Systems

Orientation and pitch are probably the most important factors affecting system efficiency after the type of module selected. The **orientation calculator** opposite 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°.

Orientation: compass bearing (°) measured from north

Angle (°) from horizontal	West 270°	255°	240°	SW 225°	210°	195°	South 180°	165°	150°	SE 135°	120°	105°	East 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 - in roof**
- **Tiled roof - on 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. On a flat roof, there is often opportunity to place a higher density of PVs.

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 15sqm is required for a 30° mounted flat roof array for 1kWp, whereas 10sqm 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. Photovoltaic systems are advancing rapidly in terms of performance and will become an increasingly viable option for customers looking to reduce energy bills and their carbon footprint.

Tiled roof - in roof

Tiled roof - on roof

Open frame support

Further **information**

You can find more information on the topic of **Photovoltaic Systems** and related issues at the following websites:

www.mitsubishielectric.co.uk/pv

The Department for Energy and Climate Change website contains the latest information on the Renewable Heat Incentive, and will offer updates on progress towards its introduction in April 2011: **www.decc.gov.uk**

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.

Please call one of the numbers below:

London North East & East Anglia	**01707 282480**
London North West	**01707 282480**
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