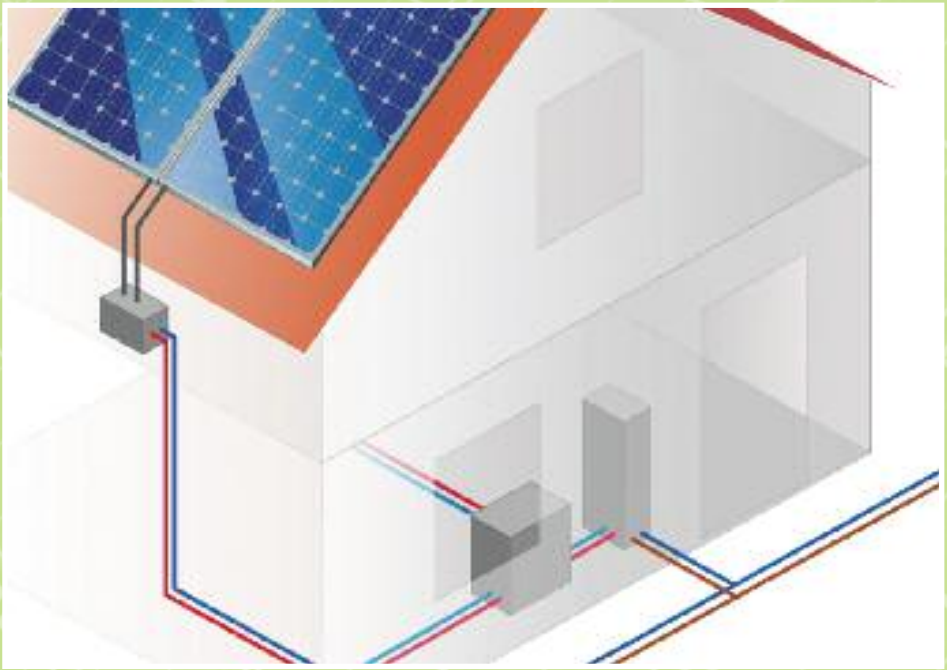
Here comes the sun!

In the second of a three-part series, *Stephen Andrews* of Ecoskies Training looks at photovoltaic energy systems, a more expensive technology but one with no running costs

The term photovoltaic, commonly referred to as PV, is derived from a combination of photo, the Greek word for light, and Volta, the name of the Italian physicist, Alessandro Volta, who invented the chemical battery in 1800.

PV technology isn't new – the photoelectric effect was discovered in 1838 by physicist Edmund Becquerel, although it wasn't until the 1950s that the technology was developed enough to produce efficient working cells. During the 1960s the technology was developed further by NASA to power satellites but it was still too expensive for general use.

The next few decades brought better technology with lower prices and solar PV installations are now commonplace throughout the UK, particularly grid-connected systems in which there have been massive growth in installations since the 1990s.



How the solar window works in the UK.

Multiple modules

The photovoltaic process converts sunlight, the most abundant energy source on the planet, directly into electricity. A PV cell consists of two or more thin layers of semi-conducting material, most commonly silicon. When this cell is exposed to light, electrons are released causing a small electrical charge to be generated – which can be conducted away by metal contacts as direct current.

The electrical output from a single cell is very small, therefore multiple cells are connected together to provide a more useful output. Cells connected in this way are encapsulated – usually behind glass – to form a weatherproof module or panel.

Multiple modules can likewise be connected together in an array in order to provide sufficient power.

In the UK, we typically receive 1000kWh/m^2 per annum, so there is plenty of potential energy falling on to the average roof-top. However the electrical output of a PV cell is dependent upon the intensity of the light to which it is exposed, so PV cells will tend to generate more electricity on bright days than when skies are overcast. They do not need to be in direct sunlight to work, so even on overcast days a PV cell will generate some electricity but orientation and shading can dramatically effect the performance.

PV performance is also affected by the angle the sun strikes the cells, UK latitude is 56 degrees and determines how high the sun appears above the horizon. Therefore to maintain high efficiency the angle of the array should maintain a 90 degree angle to the sun.

Optimum tilt angles:

- year round loads – tilt angle equals latitude
- winter loads – tilt angle equals latitude + 15
- summer loads – tilt angle equals latitude – 15.

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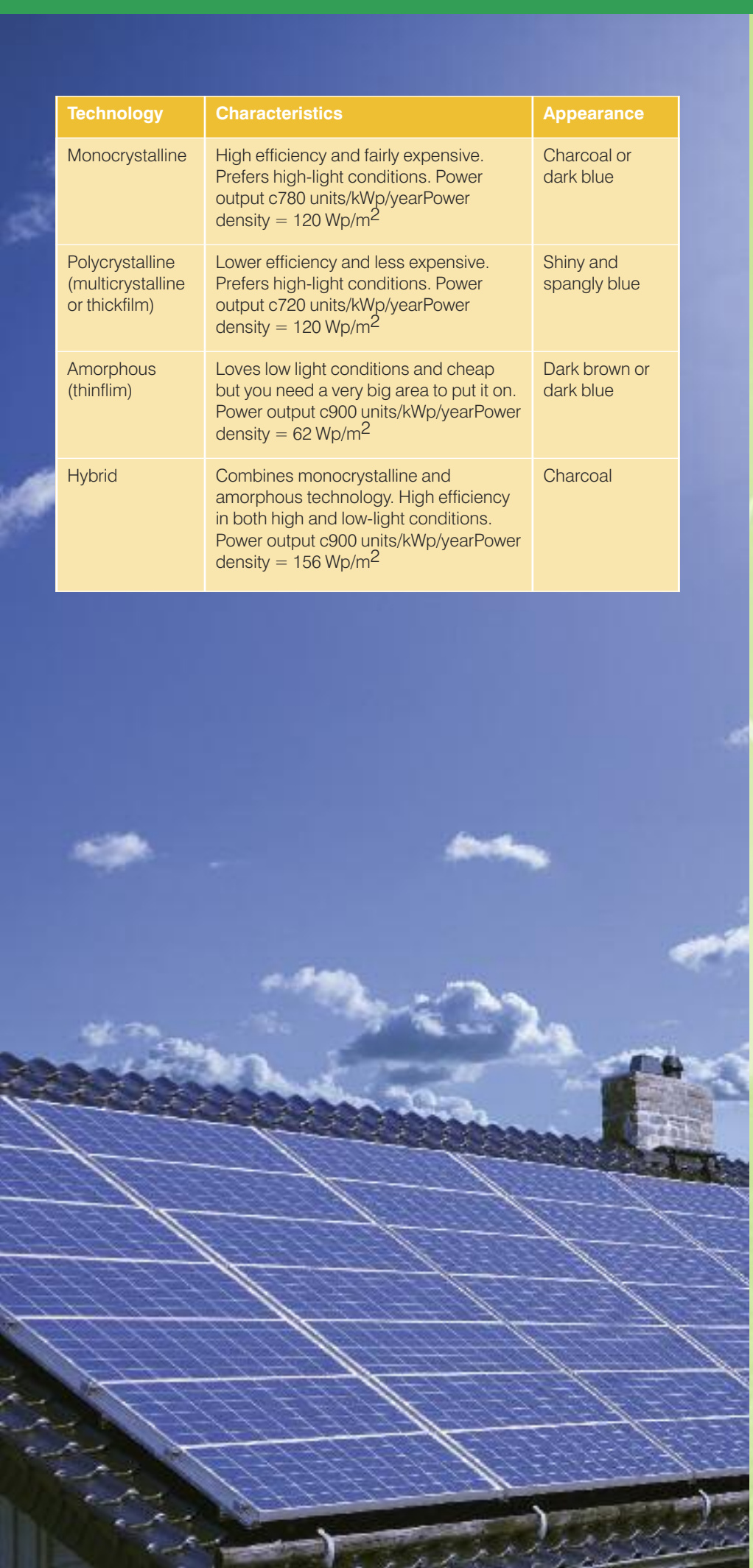
Technology	Characteristics	Appearance
Monocrystalline	High efficiency and fairly expensive. Prefers high-light conditions. Power output c780 units/kWp/yearPower density = 120 Wp/m^2	Charcoal or dark blue
Polycrystalline (multicrystalline or thickfilm)	Lower efficiency and less expensive. Prefers high-light conditions. Power output c720 units/kWp/yearPower density = 120 Wp/m^2	Shiny and spangly blue
Amorphous (thinflim)	Loves low light conditions and cheap but you need a very big area to put it on. Power output c900 units/kWp/yearPower density = 62 Wp/m^2	Dark brown or dark blue
Hybrid	Combines monocrystalline and amorphous technology. High efficiency in both high and low-light conditions. Power output c900 units/kWp/yearPower density = 156 Wp/m^2	Charcoal



Panels come in all shapes and sizes and can mounted on a frame, flat or pitched roofs. They can be used to clad the outside of buildings, can be integrated into the roof, matching the existing tiles, or can even be semi-transparent replacing the window glass or in sky lights.

There are different types of solar cell technology. The size of available roof space, angle to the sun, pitch of the roof and budget will have an effect on how much solar electricity you can produce. Below is an overview of the different solar panel types and their relative performance.

Panels are rated in Wp, which means peak Watts. In other words, a 100Wp panel will produce a maximum of 100W in peak conditions (1kW/m^2 solar irradiation) – this is equivalent to a bright sunny midsummer day.

A typical domestic system of 1kWp array will produce approx 750kWh/year which is around a quarter of the annual demand of an average family household – taking the average demand to be around 8 kWh per day. However, calculating the system size depends on many factors; for example whether the system is grid connected, orientation of the panels, tilt angle, inverter/cable losses and energy demand of the household.

Over the last 20 years the price of PV modules have fallen dramatically in the UK, from around £15 per Wp in 1990 to current prices of around £1.60 per Wp. That means that a single module, typically generating 60W of power under standard test conditions, now costs around £100.

Monitoring stations

Solar PV is still a more expensive technology than most other forms of renewable energy but it has many advantages over other systems: there are no running costs whatsoever – once installed all the electricity generated is free; the equipment has no moving parts and as a result requires minimal maintenance; the electricity is generated with no emissions and no noise and it has an estimated working lifespan of 20–25 years.

PV technology has many applications in the UK, both for stand-alone systems and for integration on to buildings and has been used for many years in the UK in applications such as monitoring stations, radio repeater stations, telephone kiosks and street lighting, to name just a few examples. There is also a substantial market for PV technology in the leisure industry, with battery chargers for boats and caravans, as well as for powering garden equipment such as solar fountains.

The market of most interest to the installer is an integrated grid-tied system. This feeds any electricity generated directly in to the existing mains electrical system through a grid-tie inverter, harmonising with the existing supply providing supplementary power to the installation.

The inverter matches the sine wave of the supply exactly and provides the electricity at a slightly higher voltage to ensure that the electricity generated by the PV is used before drawing from the grid. Any excess power generated is fed back into the grid.

If you generate enough unused energy you can sell back to the supplier via an export meter; however for a correctly sized system there should not be enough excess to make this viable. If you do decide to sell back any excess you can expect 8–10p per kWh plus another 4p/kWh for the ROC entitlement.

Photovoltaic panels clad this tower block.

Roof-mounted panels at the Farnham Woolhouse sun station.

Close-up of integrated roof-top solar panels.

Photovoltaic panels – saving energy for homeowners

Homeowners

While there is now no requirement to notify the supply authority prior to installing a PV system of less than 3.5kwp, you will need to ensure than the inverter is certified to G83 and you will need to complete the appropriate inspection and commissioning certificates.

In addition to following the electrical regulations associated with any normal electrical installation, PV systems now have a dedicated section in BS7671:2008 17th Edition, Section 712, which goes into specific detail on isolation, protection and cable types. Installations in dwellings also fall under the Building Regulations, in particular Part P and Part L.

Grants are available for PV Installations, via the Low Carbon Building Programme, which covers up to 50 per cent of the installation cost up to a maximum of £2500 for householders but with no upper limit for not profit or public organisations. One of the conditions of the grant scheme is that you have received planning consent from your local council – please note, this is different from planning permission. For the majority of homeowners the addition of solar PV panels falls within "permitted development rights", which means that the panels will be more or less flush with the roof.

Natural beauty

If your property is in a conservation area, Area of Outstanding Natural Beauty or is a listed building, you may need to apply for full planning permission. I would recommend checking with your local council to see what their stance is on solar PV panels.

To recap, the benefits of installing a PV system:

- practical and economically viable option for many applications in remote areas
- pollution free, installing a small domestic system of around 1.5 kW would provide around 1000 kWh of electricity every year – this would save around half a tonne of CO_2 annually
- can be integrated into the fabric of a building
- electricity can be supplied at the point of use
- will run silently
- little maintenance
- after initial installation, there are no further fuel costs
- they are modular and can be added to at any time
- they can add around eight per cent to the value of your property.