



Solar Photovoltaic Technology



This document aims to outline the facts behind solar photovoltaic (PV) technology and dispel common misconceptions around such issues as energy payback; design; application and cost. It is a valuable guide to all those seeking to understand the role of solar photovoltaic technology in the built environment.

The world is currently dependent on fossil fuels for energy. There are two major issues which makes this unsustainable. First, fossil fuels are finite and will eventually run out. Secondly, when burned they release large volumes of carbon dioxide (CO₂) into the atmosphere, causing global warming and destabilising the planet's climate.

Solar photovoltaic technology is a clean, reliable and readily available alternative. It is used to create carbon emission free electricity by using silicon cells (semi-conductors) which produce electric power directly from daylight. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow. The greater the intensity of the light, the greater the flow of electricity.

Key Solar Photovoltaic Facts

The earth receives a continuous power input from the sun of 200×10^{15} Watts - that's 200 followed by 15 zeros. An unimaginably huge amount of energy which completely dwarfs the capabilities of fossil fuels or nuclear fission; and it is clean and free.

Solar PV generated power could, in theory, provide 10,000 times more energy than the world currently uses.

If we covered just three percent of the Sahara desert with PV we could generate all the world's electricity requirements.

Who uses it?

Use of solar PV has dramatically increased over the past ten years, but varies widely across the world with Japan, the US, Germany and Spain using it with increasing frequency. In 2005 Germany alone installed over 800MW of solar technology. That's the equivalent of 320,000 solar roofs. By comparison, the UK installed just 0.6% of this figure in the same year. However if every household and business in the UK installed a basic 1kW PV system, we could achieve the governments target of reducing carbon emissions by 12% within one year.

Ireland, however, has already made a large commitment to action on climate change, and aims to obtain 30% of its electricity from renewable energy by 2020. Northern Ireland is now amending building regulations to include on site renewables on new developments.

Common Misconceptions **About Photovoltaics**

Myth 1: **Photovoltaics are expensive**

The global market for solar PV is expanding at 30% per annum and this expansion is pushing prices down each year. This virtuous cycle has been fuelled by a number of factors including:

- Rising global energy prices
- The rise in local and national legislation, and international commitments designed to reduce carbon emissions
- A realisation of the risks associated with global warming and climate destabilisation
- An increase in subsidy support for PV from national governments.

In addition to this competitive drive to lower prices, there is a considerable amount of research being undertaken around the world focused on making solar cells cheaper and/or more efficient, so that they can produce ever cheaper electricity and continue to expand into new markets. Manufacturing cost is now decreasing by 10% per annum, meaning conventional 'payback times' are decreasing all the time. Against higher electricity prices from the grid, this means PV is increasingly competitive.¹

Analysing the cost of photovoltaics should not be considered solely in terms of 'upfront costs', since they have many additional benefits:

- The inclusion of PV has recently been proven to add 8.6% to house value. This was the case on a new Gleasons Homes development in the Peak District, when new home owners paid significantly more for PV integrated properties
- PV also 'future proofs' your home or commercial property against rising fuel prices
- You can also sell any excess electricity you produce back to the National Grid, the rate for which varies according to your supplier
- PV owners can gain additional income by selling the ROCs (Renewable Obligation Certificates) they can claim from their systems output.

Many buildings use cladding materials which cost £1000 or more per square metre. The bronze facade of Portcullis House, opposite Big Ben which was built in 2000, cost over £7000 per square metre. By contrast, solar PV cladding - which can look every bit as attractive as marble or bronze - costs as little as £600 per square metre. It also provides clean and free power for the building, the CIS Tower in Manchester, the UK's largest solar installation, is an example of this.

Myth 2: **PV's cost makes it the least popular renewable energy**

In October 2006, St James homes surveyed almost 100 potential buyers for their new 'envirohome', Kennett Island in Reading. They found that solar thermal and PV were the priority requirements for those considering this new type of home. The BBC also found similar statistics in 2006. PV was rated above a wind turbine, grey water recycling, and other energy saving features. As a maintenance free, long lasting technology, many consumers are attracted by its unique 'fit and forget' potential.

The Guardian Newspaper (Ashley Seager, 11 September 2006), and **The Financial Times** (Robert Budden, 21 October 2006), have recently analysed photovoltaics versus their costs and concluded they are obvious and sound investments. With net yield at around 3% - without even considering the rise in energy prices - many are realising the financial benefits of solar power.²

1. <http://www.greenenergy.org.uk/pvuk2/faq/faqs.html>

2. http://www.solarcentury.com/news/industry_news/the_financial_times_solar_makes_sense
http://www.solarcentury.com/news/industry_news/the_penny_finally_drops_for_solar

Myth 3: **The UK Government does not support PV**

PV has been backed by a range of government initiatives since 2001. The present scheme, the Low Carbon Buildings Programme, provides funds for commercial and domestic customers (ex. VAT)³ to install Solar PV. Support includes:

- Households: Maximum of £2,000 per kWp of installed capacity, subject to an overall maximum of £2,500 or 50% of the relevant eligible costs, whichever is the lower.
- Public organisations: Organisations can apply for between 30% and 50% of the cost of installing approved microgeneration technologies, (depending on technology), supplied and installed by Framework Suppliers.

Local government has recently taken the initiative to encourage the use of renewable energy. In a revolutionary turn, Merton Borough council introduced its own 'Renewable Energy Policy' as part of their LDF (Local Development Framework) in 2003, which demands 10% cuts in carbon emissions from new developments through the use of on-site renewables. This 'Merton Rule' has since been adopted by 18 local councils including Woking, Croydon, Cambridge and Manchester. Woking Borough Council has made many strides in this area, and is truly a blueprint for future development. Manchester is also making significant progress, pushing this policy to 20% reduction.⁴

Myth 4: **Electricity providers do not support PV**

There are many electricity providers that do accommodate PV electricity production. The Electricity Act 1989 licensed suppliers in the UK to supply a certain percentage of their total sales from renewable sources. Commonly with PV systems, you are connected to the grid so can use this at any time. For good 'buy-back' tariffs however, check with uswitch.com and select 'green' provider. Currently the trend amongst suppliers is not to install export meters but to pay a fixed amount per kilowatt peak installed. This means that you will be rewarded for the electricity generated from your system even when you use it in your home – potentially doubling its value.

Most of the big utility companies will buy back the energy you generate at a slightly cheaper rate than they sell it to you but, if you do need to switch supplier it is not a complicated process. Good Energy for example pay an output tariff of 5p per unit for all electricity produced.

Myth 5: **Commercial enterprises aren't interested in solutions to climate change**

There is no better evidence that the world is turning to solar power to combat climate change than the rising number of installations.

In October 2006, the Chief Executive of Google announced that the Google Head Quarters in Silicon Valley, US, was turning solar.⁵ Sharp Electronics is supplying 9,212 solar panels for the Google project, joining thousands of commercial companies, across the world, including recently General Motors, who have turned to photovoltaics for clean and secure energy production. Further commercial commissions in the UK market include: Tesco, Gazeley Ltd, Sainsburys, Channel 4, BBC, The Environment Agency, Co-operative Insurance, The Highways Agency, Transport

3. See DTI website: <http://www.lowcarbonbuildingsphase2.org.uk/>

4. www.themertonrule.org

5. <http://www.marketwatch.com/news/story/ei-solutions-build-largest-us/story.aspx?guid=%7B23379300-DB81-4B7D-8E73-E5A9FD59662A%7D>

for London. House builders include: Gleeson Homes, St James, Barratt, Laing Homes, Carla Homes. Since 1999, Solarcentury alone has installed PV for over 500 projects, and helped thousands of homes go solar through our network of associate installers.⁶

Myth 6: **PV is neither a versatile or aesthetic design solution**

Innovation has produced dramatically different PV products over the last few years. Products now available include thin film technology, solar louvres to shade buildings and Solarcentury's award winning Complete Solar Roof which comprises C21e and C21t 'solar tiles'. These sit flush on a roof and are available in dark grey and black to mimic traditional roof tiles. As such they have been recommended by the building industry and consumer watchdogs as the most innovative low carbon product on the market.

Lord Richard Rodger's Urban Taskforce, in its seminal report "Towards an Urban Renaissance"⁷ explicitly called for the use of PV within a "design-led approach to regeneration".

In November 2006 solarcentury project MANCAT was honoured with a RIBA award for excellence in design. Other award winning projects include 'The Core' at The Eden Project, with its unique fibonacci design and complex integration of PV. Glass laminates, where PV cells are sandwiched in glass, are very popular with architects for their sensitive modern design – in 2005 they were used in the 'House of the Future' commissioned by the popular mobile phone brand Orange.

Myth 7: **PV can't provide all of my electricity**

Individual cases differ according to the energy efficiency of a building and energy consumption, however evidence has shown that it is certainly possible to get a household's electrical needs out of a PV system. According to Energy Savings Trust, the average household consumes 3,300 kWh per year. An example of PV producing more electricity than used in a home is presented by the Garside Family: Since their **sunstation**[®] was installed the Garside family have become suppliers of electricity, consuming just 2,600 kWh a year, which is less than the 2,930kWh they produce. This has allowed them to sell their excess production back to their electricity supplier and feed it into the national grid. far higher than the price we pay in economic terms today.

Myth 8: **PV is time-consuming to install**

Again, this is completely untrue. Installing PV is relatively easy. Installing a typical 3000kWp system to power a family home takes about one day. There is a common misconception that solar power is a major mechanical and electrical (M&E) and roofing challenge and a complicated addition to any building. However, experience has proven the opposite. Advances in the industry have meant installers are now provided not only with easy to use technology but comprehensive installation designs and thorough risk assessments; leaving installers content and able to work independently.

Myth 9: **PV is unreliable, and its value will diminish over time**

With no moving parts PV does not require any routine maintenance. Its 'fit and forget' nature is one of its main appeals. A visual inspection of the panels and the inverter is recommended every year and after 15 years the inverter may need to be replaced but this is only 5% of the system price. PV is a very low risk technology, with no ongoing engineering costs associated with servicing unlike all other renewable technologies. The longevity and reliability of PV is one of its key strengths as a renewable

⁶ <http://www.solarcentury.com/projects/>

⁷ Towards an Urban Renaissance (1999), report of the Urban Taskforce chaired by Lord Richard Rogers, available from DEFRA.

energy source. PV comes with a 20 to 25 year warranty to produce at least 80% of its optimal production.⁸ Manufacturers claim it has at least a 60 year life-span, the very first Sharp module installation in Japan in 1963 is still working today, some 43 years later.⁹

Myth 10: PV uses more energy to produce than it gives back

There is a common but mistaken notion that solar cells never produce more energy than it takes to make them. The term 'energy payback' captures this idea. How long does a PV system have to operate to recover the energy - and associated generation of pollution and CO₂ - that went into making the system, in the first place? Reaping the environmental benefits of solar energy requires spending energy to make the PV system, but the investment is small. Specifically, paybacks for standard, multicrystalline modules are four years for systems using recent technology and two years for anticipated technology. For new, thin-film modules, paybacks are three years using recent technology, and could be just one year for anticipated technology.

Myth 11: PV is not a proven technology

PV is a proven technology, as established by the PV DTI field trials in 2005.¹⁰ PV is an indisputably clean technology and uptake in the UK could save many millions of tonnes of carbon emissions, and effectively help to prevent further climate change and reach the UK's Kyoto protocol reduction targets of 12.5% by 2010. The average 1 kW system saves 460kg of CO₂ a year. This is the equivalent of 30,000 party balloons, equating to one persons contribution to reaching the UK's Kyoto 2010 target. If you install a solar PV tiled roof, you could prevent over 70 tonnes of greenhouse gas emissions during its lifetime.¹¹

Myth 12: PV will only work if it is south facing

The optimal orientation is south facing, however south west and south east orientations are also effective and produce about 70% as much energy as a south facing installation. It is also important to consider inclination: a 35 degree inclination is optimal, but over 90 percent of the maximum annual energy can be created at 10 degree and 50 degree tilts from the horizontal.

Myth 13: PV only makes sense for new buildings

PV certainly makes sense when building new commercial buildings or homes, as the cost decreases with economies of scale, and deployment is simpler when incorporating PV from the outset of the project. However, many existing homes have installed PV, since it is also easily 'retro-fitted'. It's important to install energy efficiency equipment at the same time to maximise the savings from the PV. If a house holder is replacing an existing roof it is the obvious time to install PV tiles.

Myth 14: Solar thermal is less expensive than PV, so a better option

Solar thermal systems and solar PV are very different technologies. Solar thermal heats water, while PV creates electricity. Both are excellent means of reducing carbon emissions, and it is possible to have both. However, in terms of reducing carbon emissions, PV avoids more carbon emissions as it displaces grid electricity, which is three times more carbon intensive than gas.

Myth 15: The UK does not receive sufficient sun to make PV

8. Energy Savings Trust: <http://www.est.org.uk/uploads/documents/myhome/Solar%20pv%20Factsheet%204%20final.pdf>

9. Photon Magazine September 2006

10. <http://www.dti.gov.uk/files/file16813.pdf>

11. <http://www.cat.org.uk/information/catinfo.tmpl?command=search&db=catinfo.db&eqSKUdataq=20020503154933>

worthwhile

Electricity is produced with daylight, not intense sunlight. Although most effective in sunny climates, the UK is still a suitable market. UK irradiance levels currently stand at 1000W/m²/year for London, with a range of 800W/m²/year to 1000W/m²/year across the UK. There is little difference between solar irradiation in the Scotland and the south coast of England. In fact, solar electric (PV) panels are routinely used in the polar regions to supply power for test equipment. The UK has similar irradiance levels to Germany and the Netherlands.¹²

Myth 16: **It's hard to get planning permission for PV in the UK**

Local government has recently taken the initiative to encourage the use of renewable energy. In June 2006 Yvette Cooper, Minister for Housing and Planning said, *"It is patently absurd that you should be able to put a satellite dish up on your house but should have to wrestle with the planning process for small scale microgeneration which is no more obtrusive. We want far more microgeneration to be treated as permitted development."*

She added *"We need to seize on new development as an opportunity not a threat. It is time to rethink the way we build. It is time to rethink the way we design our homes and communities, if we are to build communities for the future that are truly sustainable. Our long term ambition should be zero carbon development and we believe the Thames Gateway offers a fantastic opportunity to lead the way in environmental improvements for new developments. We do not know yet how fast we can get there, but the development industry should be clear about our aims and should start planning now for new investment and innovation to meet our goals."*

Solarcentury has installed PV in the UK on listed buildings and in areas of outstanding natural beauty. Previous restrictions can be overcome with technologies such as the new, discrete solarcentury **CompleteSolarRoof™**. This consists of solar PV and solar thermal tiles that sit flush on your roof, blending seamlessly into the natural roof line.

Myth 17: **PV is not a viable option for the developing world**

Two billion people on earth have no electricity. Typically their energy comes from candles, kerosene and batteries. Often these monthly costs are greater than the cost of borrowing to pay for a quality solar-home-system. PV, however, can provide electricity in remote areas. It provides power when you need it, where you need it. Caravaners, campers, backpackers, climbers and outdoor enthusiasts now have solar PV power packs that fit in a rucksack, provide power for laptops, GPS devices, music, light at night, and a charging point for mobile phones.

Solarcentury has set up a new charity to provide power in the developing world called Solar-Aid¹³. This uses off cuts from the PV industry, and is currently working to establish business skills and self sufficiency in Malawi.

12. The European Commission Joint Research Centre (<http://re.jrc.ec.eu.int/pvgis/pv/index.htm>).

13. www.solar-aid.org.

Myth 18: Installing PV is pointless if developing markets such as China increase their CO₂ emissions

Developed markets must lead the way in the fight against global warming. Unless we, and other of the worst CO₂ emitters, commit to a low carbon future others are unlikely to follow. The developing world is most at risk from the effects of global warming, such as rising sea levels, salinisation, desertification and erratic weather patterns, so we have a responsibility to lead the way.

Much development in industrialising nations such as China is in fact green. Dongtan in Shanghai is a current low carbon project three quarters of the size of Manhattan.¹⁴ With the help of Arup, this eco-city is setting an example of how rapidly industrialising nations can embrace low carbon living and potentially leap-frog carbon intensive industries

About Solarcentury

Solarcentury is the UK's leading solar energy company, specialising in the design and supply of building integrated photovoltaics. Solarcentury was established in 1998 to provide innovation and consultancy for low carbon building. Solarcentury is in business for a purpose: to help create a cleaner world and a sustainable future.

Alarmed by the threat of climate change to our global society and economy, founder and CEO Jeremy Leggett saw the need for a renewable energy company that understood not only the need for the reduction of CO₂ emissions, but a new type of built environment. The aim is to revolutionise the global energy market to provide economical and innovative micro generation; to make the 21st century the solar century.

Solarcentury envisages solar systems on the roof of every building, backed up by a family of other micro renewables, supplying clean power and achieving deep cuts in carbon emissions. The company offers support and guidance throughout the entire micro renewable planning and development process, from land appraisal through to design, installation and marketing.

www.solarcentury.com

Measurements

kWp (kiloWatt peak) – maximum PV output, this figure is used to size a system. It is calculated under standard test conditions (STC), the output of the solar PV module or tile is measured when a set amount of light energy is flashed at it in laboratory conditions.

kWh (kiloWatt hours) - units of electrical energy (power over time). These are the units your electricity bill is calculated in. An average efficiency 1kWp PV system will produce 810 kWh of electrical energy every year.

The average UK home consumes 3300 kWh per year*; a 2kWp PV system will produce approximately half of this. An energy efficient home however, will have a significantly lower energy requirement and subsequently a 2kWp PV system could provide a much higher proportion of the home's energy.

*source: Energy Saving Trust

Useful links

RIBA Solarcentury online cpd:	http://onlinecpd.ribaenterprises.com
Centre for Alternative Technology:	www.cat.org.uk
The Climate Clinic:	www.climateclinic.org.uk
The Energy Saving Trust:	www.est.org.uk
The National Energy Foundation:	www.greenenergy.org.uk
The Stern Review on the Economics of Climate Change:	www.hm-treasury.gov.uk
World Alliance for Decentralised Energy (WADE):	www.localpower.org
Renewable Energy Association:	www.r-p-a.org.uk
The Merton Rule	www.themertonrule.org
New Economics Foundation:	www.neweconomics.org
The Solar Village:	www.thesolarvillage.com
The Town and Country Planning Association:	www.tcpa.org.uk
Walt Patterson on Energy:	www.waltpatterson.org
