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Solar energy factsheet

On a bright, sunny day, the sun shines approximately 1,000 watts of energy per square meter of the planet's surface; if all of this energy could be collected, it would provide the world with ample electricity. Most buildings have windows allowing the sun to provide natural light, while the heat from the sun will warm any building up to a degree. This use of natural solar energy can be enhanced by passive solar design (PSD), in which buildings are designed to maximize the energy and make additional energy savings.

So far only a very small proportion of the UK's building stock – a few thousand buildings – have been deliberately designed to exploit solar energy. It has been estimated that the benefit of deploying PSD in these specially designed buildings is equivalent to an energy saving of about 10 GWh/year (DUKES, 2012).

Solar radiation levels

For all latitudes outside of the tropics, the maximum solar intensity for a horizontal surface occurs at noon at the time of the summer solstice. The radiation that falls on vertical surfaces is often of more importance in building design (because of windows) than the radiation on a horizontal surface.

The orientation of a wall is an additional variable. As long as there is no shading where the panels are installed, then you should still see over 97% of the same efficiency if your panel is facing south east or south west as long as it is within 20 degrees of south facing (the ideal positioning). The European Commission provide an online PV power estimation calculator.

In the UK South-West England receives the highest level of solar radiation per square metre – the country’s first purpose-built solar farm was granted planning permission in Cornwall: four more have since been granted permission and several more applications are awaiting determination. In a typical UK location the sun shines during one third of daylight hours. On a cloudy day, solar photovoltaic panels do continue to convert some energy, but much less than on a sunny day. The power delivered by photovoltaic panels is almost exactly proportional to the intensity of the sunlight, although hotter panels (over about 25°C) deliver reduced power.

Solar photovoltaics overview

Photovoltaics (PV) is used to directly generate energy from the sun. A photovoltaic cell is a semi-conductor that converts photons of light into electricity. This is called the photovoltaic effect. The semi-conductor is generally made of silicon, although other materials can be used. Professor Michael Grätzel, the inventor of dye-sensitised (DSSC) solar cells, won Finland’s 2010 Millennium Technology Prize for the cells, which have an excellent price/performance ratio.

In silicon cells, rays of sunlight are absorbed by the silicon, causing electrons to be released from their atoms. These electrons flow through the silicon and produce an electric current. This type of electricity is common in low-drain devices like pocket calculators and wrist watches and more recently has been used for powering certain road signs and lights. Solar PV cells can be used in small panels for domestic households or in large arrays feeding power directly into the electricity grid.
Domestic PV

A domestic solar energy system typically costs around £3,000-£3,500 per kWp installed, with most domestic systems usually between 2-4 kWp. A 2.7kWp array can provide enough electricity to meet around half a household’s electricity needs. The Energy Saving Trust website in August 2012 estimated an average 3 kWp domestic system as costing around £7,700 inc VAT (based on a Department of Energy and Climate Change assessment of solar PV costs), almost half the average cost of around £13,000 in April 2010. Costs vary between companies, mainly according to the size of the system and the level of installation required, in particular whether the system will be ground or roof mounted.

UK domestic use of solar PV electricity has increased rapidly since the government introduced Feed-in-tariffs (FITs), in April 2010, a support system already used successfully by around 50 other countries. Anyone who installs a renewable energy system producing less than 5MW electricity is eligible to claim the tariffs. FITs pay a guaranteed payment for all the electricity you produce, even if you use it yourself, plus an above-market price for any excess electricity fed into the grid for a period of 20-25 years. The returns offered were originally close to 10%, but after enthusiastic take-up the government has substantially reduced the tariffs, so returns will be closer to 6% for most home owners putting in typically sized, well-sited installations after 31 March 2012.

Commercial PV

Internationally, large commercial PV parks include Andasol (Spain, 100 MW), Nevada Solar One (US, 64 MW), Olmedilla (Spain, 60 MW), Lieberose (Germany, 53 MW) and Puertollano (Spain, 50 MW). By the end of 2010 an estimated 5,000 utility-scale solar PV plants (larger than 200 kW) existed worldwide (Ren 21, Renewables Global Status Report, 2012). Currently PV panels are more expensive than mirrors or lenses, which are used in the commercial concentrating thermal solar power plants discussed below. However, PV panels are advantageous because they deliver more power - 20 W/m² on average, compared to a 15–20 W/m² average for concentrating solar power stations (David MacKay, Sustainable Energy – without the hot air, 2009). This is because the concentrating panel has to track the sun, so gaps have to be left between each panel, losing sunshine between the gaps as a result.

Because flat PV panels have traditionally been expensive, many companies have chosen to use thermal concentrating systems despite their relative inefficiency. Recently manufacturing cost per PV panel has tumbled to an average of around $1.75 per watt in 2010, due to a big increase in polysilicon production capacity – causing a surge in demand, although there is a risk of the market being oversupplied. A typical commercial solar panel has an efficiency of 15% - about one-sixth of the sunlight striking the cell generates electricity. Crystalline silicon cells, by far the most commonly used technology, have an efficiency range of around 14%-22%. Thin film technology cells use alternative semiconductors, making them cheaper to produce, although the downside is lower efficiency rates of between 2-12%, depending on the technology used (European PhotoVolatic Industry Association, Solar Generation 6, 2011, p25).

Generating costs vary depending on the number of sunshine hours in a location – for large ground-mounted systems in 2010, between 0.29 €/kWh in northern Europe and 0.15 €/kWh in southern Europe to just 0.12 €/kWh in the Middle East (European PhotoVolatic Industry Association, Solar Generation 6, 2011, p32). These costs are expected to fall significantly by 2020 to 0.07-0.17 €/kWh across Europe.

Financial incentives – solar PV

Many UK Solar PV companies were sorely disappointed by the Department of Energy & Climate Change (DECC)’s 2011 decision to slash the tariff paid by its Feed-in-tariffs (FITs) scheme by 39-49% for all PV installations above 50kW, from August 2011 onwards. This was followed by a November 2011 announcement proposing halved FIT tariffs for smaller schemes up to 4kW in size of 21p/kWh – down from 43.3p/kWh, plus reduced rates for schemes between 4kW and 250kW. An average household solar installation is around 2.5kW. Companies which previously offered free solar PV to customers in return for the income generated through FITs are likely to cease doing so.

DECC says it will not act retrospectively and the tariff changes will only affect new entrants into the FITs scheme. Greg Barker, Climate Change and Energy Minister, has explained the tariff reductions as being necessary following a recent surge in households installing solar PV, causing an urgent need to keep the FITs scheme budget under control and reflect the plummeting costs of the technology. As of November 2011, nearly three times as much solar PV as originally projected by DECC had so far been installed, with over 100,000 separate installations totalling over 400MW of capacity.
Solar thermal overview

One of the simplest ways in which we can harness the energy of the Sun directly is by using it to heat water. This is known as solar thermal power. There are many different types of solar thermal systems – also known as active solar water heating systems - ranging from those that help provide domestic hot water to systems that can heat water to over 150°C for industrial purposes. Domestic systems commonly use either flat plate or evacuated tube type solar panels, usually on the roof of a building, to absorb and store the sun’s heat. Water circulating through the units is heated and stored in a large tank.

Domestic thermal

There are millions of domestic solar thermal systems in use around the world. When visiting Mediterranean countries you will often see solar panels and tanks on the roofs of houses. Even in the UK’s climate, solar panels are efficient enough to provide hot water. The temperature of the water obviously depends on the amount of sunshine but even in cloudy conditions water can be warmed. Unfortunately the power produced is at the lowest in the winter months when the heat is required the most, but payback for the cost installation can still be only a few years and is very useful for summer cottages, swimming pools and trailer parks.

Solar water heating is currently more commonly used than solar photovoltaics in most domestic households in the UK, because it is cheaper to install and offers a quicker return on investment (the Renewable Energy Centre suggest 7-15 years for an average household). The Energy Saving Trust estimates that the capital cost for a typical domestic solar water heating system is around £4,800. A 3.4m squared panel should reduce the water heating bill in a 3 bed semi-detached British home by a modest amount of between £50 and £85 per year. It will also save up to 570kg of CO2 emissions, depending on what fuel is being replaced.

Commercial thermal

Commercial thermal systems placed in deserts, which use arrays of mirrors or lenses to focus sunlight, have great future potential. An organization called the DESERTEC Foundation is proposing to use concentrating solar power in sunny Middle East and North African countries, before transporting it to cloudier northern countries via high-voltage transmission lines. DESERTEC believe that in order to meet today’s global power demand of 18,000 TWh/year, it would suffice to equip about three thousandths of the world’s deserts (around 90,000 km2) with solar collectors for solar thermal power plants.

The Andasol solar power station in Spain, designed by FLAGSOL, is a good example of a functioning commercial thermal power plant. It uses parabolic trough technology to collect heat and a thermal storage system which absorbs excess heat produced during the day and stores it in a molten salt mixture of 60% sodium nitrate and 40% potassium nitrate. Electricity can then be produced using this heat in the evening or on cloudy days. See the diagram below for an explanation of how the system works.

Flagsol diagram showing the working principle of a solar electric generating system
Financial incentives – solar thermal

The UK government’s Low Carbon Buildings Programme (LCBP), which provided grants to homeowners to install small renewable microgeneration systems such as solar thermal, was closed during post 2010-election departmental spending cuts.

Instead a similar scheme for heat generating micro-renewables, the Renewable Heat Incentive, (RHI) will replace it. The RHI is believed to be a world first in incentivising the generation of renewable heat. However, the RHI for domestic residential installations has been delayed from October 2012 to summer 2013 and domestic tariffs are yet to be announced. Until then, the government has provided a limited ‘Renewable Heat Premium Payment’ (RHPP) £15m fund for household renewable heat installations, originally running from 1 August 2011 – 31 March 2012 and now extended with an additional £25m funding until March 2013. This will provide a fixed one-off payment towards the cost of domestic installations. The one-off payment amount varies depending on the technology, with the highest payment given to ground source heat pumps - £1,250 - and the lowest to solar thermal - £300 – a relatively small incentive considering the Energy Saving Trust's 2012 estimate of £4,800 costs for a typical solar water heating system.

Renewable Heat Incentive support for industry, commercial and public sector (non-residential) installations has begun much earlier, from November 2011 (delayed from Sept 2011). A tariff rate of 8.5 pence/kWh will be paid over the next 20 years to non-residential solar thermal projects less than 200 kWth in size which have been installed since 15 July 2009. The Department of Energy and Climate Change (DECC) has said that once a project is approved to enter the scheme the tariff level it receives will be fixed and adjusted annually with inflation. However, the tariff levels available for new entrants to the RHI scheme are likely to be decreased by the government over time, as DECC expects renewables equipment and installation costs to reduce.

Businesses are also still eligible for grants for installing thermal solar systems. The Carbon Trust manage the Energy Technology List (ETL), a list of products, such as thermal solar equipment, that may be eligible for 100% tax relief under the Enhanced Capital Allowance (ECA) scheme for energy saving technologies. The ECA scheme provides businesses with 100% first year tax relief on their qualifying capital expenditure, meaning that businesses can write off the cost of the equipment against taxable profits in the year of purchase. The aim is to provide an incentive to invest in renewable technology and energy saving equipment.

UK solar capacity & production

- PV installed capacity in the UK reached an estimated 975.8 MW in 2011, a steep increase from an estimated 10.9 MW in 2005 (DECC Digest of UK Energy Statistics, 2012)
- In the UK during 2010 solar PV officially generated a very small amount of electricity – 33 GWh compared to 7,137 GWh from onshore wind (DECC Digest of UK Energy Statistics, 2011).
- Solar thermal heating in the UK produced an estimated 122 GWh for domestic hot water generation and for swimming pools an estimated 640 GWh (DECC Digest of UK Energy Statistics, 2011).
- Renewable energy sources as a whole generated 6.8% of the UK’s electricity in 2010. Only 2% of the UK’s renewable energy came from renewable sources other than biomass, wind and large-scale hydro. The other sources included solar, small-scale hydro and geothermal aquifers.
- In 2010 only 3.6% of the UK’s total primary energy requirements came from renewable sources (mostly biomass, hydro and wind), which has been predicted to rise to 5% by 2020 under current government policies (The UK Renewable Energy Strategy Consultation, 2008).

However, the European Commission has proposed that the UK should use renewable sources for around 15% of its energy by 2020, to help contribute to the ambitious overall EU target to source 20% of the EU’s total energy use by 2020. Urgent action and policy changes will therefore need to be taken if the UK is to meet this target.
Global solar capacity & production

- Globally solar PV continues to be the fastest growing power-generation technology in the world. During 2010 an estimated 17 GW of new PV capacity was added worldwide, bringing global installed capacity to about 40 GW by the end of 2010 (Ren 21, Renewables Global Status Report, 2011).

- The countries with the greatest existing grid-connected PV capacity at the end of 2010 were Germany (44%), Spain (10%), Japan (9%), Italy (9%) and the US (6%) (Ren 21, Renewables Global Status Report, 2011). Despite Feed-in Tariff scheme cuts there, Germany added more PV (7.4 GW) in 2010 than the entire world did in 2009, ending 2010 with 17.3 GW total capacity.

- During 2009 global solar PV production increased from 6.9 GW in 2008 to 11 GW in 2009 (Ren 21, Renewables Global Status Report, 2010).

- Crystalline Silicon cell technology forms about 80% of solar cell demand. The balance comes from thin film technologies, which made up 19% of the global market for cells and 22% of the global market for modules in 2009 (Ren 21, Renewables Global Status Report, 2010).

Global energy industry

- Geothermal, solar/PV and wind grouped together ranked as the world’s eighth largest primary energy source in 2009, accounting for 1,179 Quadrillion Btu of the world’s 72,970 QBtu total primary energy production. Source: US Energy Information Administration (EIA)

- Concentrating solar power (CSP) plants are projected to increase in installed capacity to over 90 GW and produce 340 TWh of electricity in 2035 (from less than 1 TWh in 2008) by the International Energy Agency. Source: World Energy Outlook 2010, IEA

- 2011 World production/consumption of primary energy  
  Source: US Energy Information Administration (EIA)

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<thead>
<tr>
<th>2011 World production (Quadrillion Btu)</th>
<th>2011 World consumption (Quadrillion Btu)</th>
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<tbody>
<tr>
<td>Biomass 4.511</td>
<td>Biomass 4.411</td>
</tr>
<tr>
<td>Crude oil 11.986</td>
<td>Coal 19.643</td>
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<tr>
<td>Coal 22.181</td>
<td>Natural Gas 24.843</td>
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<tr>
<td>Dry Natural Gas 23.506</td>
<td>Non-combustible renewable energy, inc hydro, geothermal, solar and wind:</td>
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<tr>
<td>Geothermal .226</td>
<td>Captured energy 1.785</td>
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<tr>
<td>Hydroelectric 3.171</td>
<td>Adjustment for Fossil Fuel Equivalence 2.939</td>
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<tr>
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<td>Nuclear electric 8.259</td>
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<tr>
<td>Natural Gas Plant Liquids 2.928</td>
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<td>Solar/PV 158</td>
<td>Coal coke net imports .011</td>
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<tr>
<td>Wind 1.168</td>
<td>Electricity net imports .127</td>
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<tr>
<td>Total: 78.096</td>
<td>Total: 97.301</td>
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Most figures are EIA estimates. Consumption of petroleum products includes natural gas plant liquids and crude oil burned as fuel. Does not include biofuels that have been blended with petroleum, which are included in the Biomass category.
Solar energy material in the Energy Institute library

This is only a small selection from the titles we have, please search our catalogues to see all our stock. Books can be borrowed by EI members, either in person or via postal loan.

- **Planning and installing solar thermal systems: A guide for installers, architects and engineers:**

  Solar thermal systems available today offer efficiency and reliability. They can be applied in different conditions to meet space- and water-heating requirements in the residential, commercial, and industrial building sectors. The potential for this technology and the associated environmental benefits are significant. This book offers clear guidance on planning and installing a solar thermal system, crucial to the successful uptake of this technology.


  A fully illustrated, easy-to-follow guide showing how the different types of system work, this book is a comprehensive introduction to all aspects of solar domestic water heating systems, the most environmentally-friendly way of heating water.


  Review or publishers details: There is a vast interest in renewable energy but the role various technologies will play in the transition to a low-carbon future are in the main uncertain. This book sets out the facts: how the technologies work, where and to what extent they are currently employed and where the greatest potential lies. It covers all major fields - solar electricity, solar thermal, solar architecture, bioenergy, wind, geothermal, hydropower, as well as new energy technologies and also includes sections on how best to promote the uptake of renewables and answers to common questions and opposition. The authors provide a number of German-sourced, internationally relevant examples and strategies which have become significant in promoting renewable energy. An essential source for understanding and promoting renewable energy.


  Review or publishers details: Solar energy is free and sustainable with many methods of harnessing it. This guide is an essential introduction to the subject and explains how the technologies work, how they can be employed and the costs of using them. It provides detailed yet accessible coverage of: passive solar building solar water heating solar space heating other solar thermal applications (such as cooling and desalination) grid-connected photovoltaics stand-alone photovoltaics. It also introduces the reader to larger scale applications such as concentrating solar power.
Further information

Useful websites

Enhanced Capital Allowance - (ECA) Scheme set up by the UK government to support businesses with investing in renewable technologies such as solar thermal systems

The Renewable Energy Centre - a useful overview of the solar power industry in the UK and a directory of the companies involved

See the Met Office’s website for details of sunshine levels in the UK

Feed-in Tariffs - the information site for the new guaranteed payments for renewable electricity in the UK

Renewable Heat Incentive – sister government scheme to the FITs to encourage renewable heat in the UK

Solar Trade Association – promoting solar thermal technology in the UK

General information


Planning database map - Department of Energy & Climate Change (DECC) – shows locations of planned UK renewable installations, including PV projects

Solar Warrior.com – Photos of a residential photovoltaic system in California, a 2,880 square foot array with a theoretical output of 30.5kW. The system generates enough electricity to power the home, including a pool, hot tub, air conditioning and four electric cars.

Solar energy publications

Carbon Trust, Renewables energy sources: Opportunities for businesses

David MacKay, Sustainable Energy: Without the Hot Air (2009)

DESERTEC Foundation, Clean Power from Deserts (2009)

Department of Energy and Climate Change (DECC), Review of the generation costs and deployment potential of renewable electricity technologies in the UK (2011)

European Photovoltaic Industry Association, Global Market Outlook for Photovoltaics until 2016 (2012)

European Photovoltaic Industry Association, Solar Generation 6 (2011)
