Energy Insight: Solar panels and Solar Roof Tiles

Highlights

The following Energy Insight provides an overview of the topic of solar technologies. It covers:

- Photovoltaic solar panels
- Solar thermal panels
- Solar tiles
- Global production of solar electricity
- BP and the solar market

Introduction

There are two types of solar panel that work by harnessing the sun's energy: photovoltaic and thermal. Photovoltaic solar panels convert sunlight into electricity which can be used to run appliances and lighting. These cells don't need direct sunlight and can generate some electricity even on a cloudy day. Solar thermal panels capture the heat from the sun which can be used directly or converted into mechanical energy then electricity.

Photovoltaic (PV) solar panels

Photovoltaic modules use light energy (photons) to generate electricity. They use water-based crystalline silicon cells or thin-film cells. The cells need to be protected from mechanical damage and damp. Most modules are rigid, but some, based on thin-film cells, are flexible and can be used in areas where movement is a problem. The cells are connected electrically in series, one to another. Most photovoltaic modules use MC4 connectors making weatherproof connections to the rest of the system.

A PV (photovoltaic) module is made up of PV cells. These modules make up the array of a PV electricity generating system that converts solar energy into electricity. These are to be found in both commercial and domestic use. The modules are rated by their DC output power. The modules are connected either in series to achieve a desired output voltage or in parallel to give the desired current.

A single solar module can produce only a limited amount of power, so most installations contain multiple modules. A typical PV system consists of an array of PV modules, an inverter to convert the output so it can be fed into the grid and battery storage for the output to be stored until needed.

The fact that an array of PV modules, occasionally called a solar farm, demands a large area to produce electricity on a commercial scale has led to criticism in that the array is using land that could be better used for other purposes. It has however been pointed out that sheep and free-range poultry graze quite contentedly under solar panels although cattle and pigs are too heavy and liable to damage the arrays.

In order to increase the efficiency of solar panels, some PV modules include concentrators which focus light through lenses or mirrors onto smaller cells. This allows the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-efficient way.

According to the Energy Saving Trust, a 4kWp solar system located in southern England can generate around 3,800 kilowatt hours of electricity. This is roughly how much a typical household consumes and will cut nearly two tonnes of carbon dioxide emissions every year. Further north the same system can generate about 3,200 kilowatt hours of electricity.

More recently, the heatwave in the UK in June and July 2018 has seen record highs for solar power generation.

Solar thermal panels

By NAVFAC - Solar Thermal Panels, CC BY 2.0,

Solar water heating (solar thermal) systems use the sun's energy to heat up water most commonly for domestic use.

- Panels, known as the solar collector, containing water absorb solar energy.
- The water in the panels heats up.
- This hot water is pumped through a coil in the hot water cylinder.
- The heat from the coil is transferred to the water in the cylinder.

Although the natural energy from the sun provides the heat, an electric pump is needed to pump the water through the panels and back into hot water cylinder.

Most panels are mounted on roofs, but they can also be mounted at ground level. Wherever they are situated, they need direct sunlight to work efficiently. For the best results the panels need to be at an angle between 20 and 50 degrees from the horizontal. This is generally the pitch of most roofs in Britain and Northern Europe.

The one disadvantage of roof mounting is that the installation of the panels can affect the integrity of the roof. Also, any work needed to be done on either the roof or the panels themselves can place an additional strain on either structure. Another option are solar tiles in which the panels are fitted flush with and replace some of the tiles on a roof.

The Energy Saving Trust has produced advice to users on how to control solar water heating systems especially in terms of volume of hot water use, timing of back-up heating and temperatures required.

Monitoring 88 homes in the UK and Ireland in 2010-2011, a survey run by the Energy Saving Trust "Here Comes the Sun: a field trial of solar water heating systems"found that solar water heating systems can work well in the UK and the Ireland but need to be installed by qualified fitters.

The Energy Saving Trust found a wide range of performance, with the best system producing 98% of a house's hot water while and the worst produced only 9%. The survey showed a median of 39%.

There are two types of solar thermal panel: flat plate panels and evacuated tubes.

Flat plate panels consist of an absorber plate in an insulated metal box. The glass or plastic top of the box allows solar energy through and the insulation in the box keeps heat loss to a minimum. A large number of tubes carry water through the absorber to heat it up as it passes through.

Evacuated tube collectors have glass tubes containing metal absorber tubes Instead of a plate. Water is pumped through the tubes and heated by the sun. Each tube is a vacuum thereby cutting heat loss.

The Energy Saving Trust field trial found little difference in performance between the two. However, much depends on the installation and quality of the collectors: research shows that the best performing collectors are more than twice as efficient as the worst ones. This same research also showed that there is little difference in energy yield between systems using flat-plate solar collectors and those using evacuated-tube solar collectors.

Since any system depends on performance of the water pumps, the survey looked at the way pumps run by mains electricity performed compared with pumps run by a small PV panel; purists arguing that a solar system should not depend on electricity from another source. The trial found that energy consumption from the mains was minimal when the total amount of heat produced by the system was taken into consideration. Again, the efficiency of the whole system was also a factor and has to be monitored.

Some systems failed to perform at their designed capacity due to heat loss from pipes and cylinders being poorly insulated and the EST has recommended industry standards for all types of heating system.

The field trial found that a well-installed and properly used solar water heating system should give both energy and carbon savings with the energy savings been shown in lower energy bills for both domestic and commercial users.

Solar Tiles

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Solar tiles are photovoltaic modules which convert sunlight into electricity in the same way as solar panels. These tiles fit flush with the existing roofing tiles or slates and are therefore less obtrusive and less likely to have an adverse effect on the integrity of the roof on installation or when being repaired or maintained.

Different types of tiles need to be installed differently. Some can be installed directly onto roofing battens in the same way as are regular roofing tiles or slates and mixed with regular tiles. Others need to be installation according to the manufacturers practices.

Some manufacturers use solar thin-film technologies, such as CIGS to produce electricity. Other manufacturers use the industry-standard monocrystalline or polycrystalline silicon solar cells for their solar tiles. Solar tiled roofs are purplish-blue or black in colour and so match slate or dark tiled roofs in most situations. More recent manufacturing methods now produce tiles in colours to match almost any natural roof tile colouring. Thus, not only are the tiles almost invisible amongst traditional tiles but also avoid having large panels on roofs. Recent manufacturing methods have also produced solar tiles that are able to resist high speed impact damage from hail-stones, birds or wind-born objects. These are particularly relevant in areas where the weather is likely to have an adverse effect on structures, especially roofs.

Global production of solar electricity

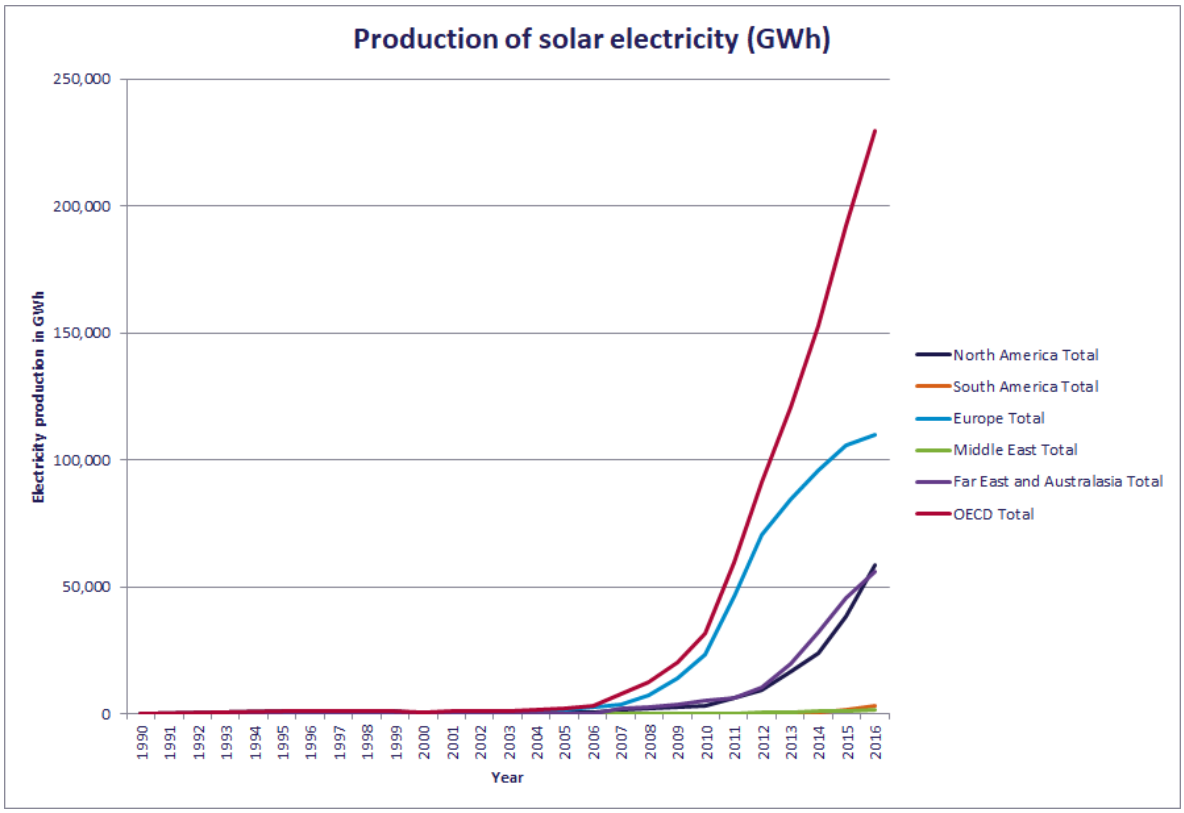

Figure 1.

Between 1990 and 2016 electricity from solar photovoltaics and solar thermal increased from 19GWh to 229,340 GWh, and solar photovoltaics was the fastest growing of all renewable electricity technologies.

Of the total OECD solar electricity production, 11.0TWh was produced from solar thermal technologies in Australia, Spain and the USA.

In 2016 the USA produced the most solar electricity followed by Japan, Germany and the Italy. Between 2000 and 2016 the strongest growth was seen in the European Union.

Solar technologies have been so successful because they are becoming increasingly affordable, efficient and reliable. There is also generally strong policy support and deployment around the world.

Case study: BP and the solar market

In 2000, BP, to diversify from hydrocarbons, moved into renewable energy, one area of which was solar. In this, the company entered into the manufacture of solar panels. This venture, coming up against low-cost manufacturing in the far-east, failed to produce the hoped-for results and the company withdrew to concentrate on other renewable projects.

In a more recent venture at the end of 2017, by taking a £130 million stake in Lightsource - Europe's biggest solar operator - BP has returned to the solar power market. This current return to renewables will concentrate on developing and managing large solar projects rather than on producing solar panels.

By using the oil company's global position and energy trading experience, the new company, to be renamed Lightsource BP plans to develop solar projects around the world especially in the US, India and the Middle East.

Lightsource BP will become part of BP's alternative energy business together with its investments in wind energy and biofuels and biopower as part of BP's shift towards lower carbon energy.

BP's annual "Statistical Review of World Energy" shows that global installed solar generating capacity has more than tripled in the four years 2014-2017, and grew by over 30pc in 2016 alone. BP's research suggest solar power is likely to generate around a third of the world's total renewable power and up to 10pc of total global power by 2035.

For Lightsource the BP deal is its latest major link-up after it helped set up Sunplug with EDF early in 2018. Sunplug is a battery storage solar energy system that generates the power through the day and uses the electricity when it is needed without the cost of installing or maintaining the panels. Sunplug is hoping to be rolled out across a million British homes by 2020.

Further reading and information

Landowner Partnerships. Lightsource BP

Harnessing the sun's energy, Chevron

Renewable energy, Chevron

Current status of concentrator photovoltaic (CPV) technology Fraunhofer Institute of Solar Energy Systems ISE and National Renewable Energy Laboratory, April 2017

Solar Sheep and Voltaic Veggies: Uniting Solar Power and Agriculture. Mow, Benjamin, June 06, 2018

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