SOLAR SOLUTIONS

CONCENTRATING SOLAR POWER HAS VAST POTENTIAL WAITING TO BE REALISED. RICHARD PRIESTLEY LOOKS AT THE LATEST DEVELOPMENTS AND WHERE THE TECHNOLOGY IS HEADING.

Will we look back on the decade 2007-17 as the time of transition from the 'Fossil Fuel Age' to 'The Solar Age'? The potential of solar power is vast. Every year each square kilometre of hot desert receives energy equivalent to 1.5mbbl of oil. Less than one per cent of the planet's hot dry deserts, if covered with solar collectors would generate as much electricity as the world is now using. Desert generated solar electricity could be a major source of power for many people across the globe. Using a low-loss high-voltage direct-current (HVDC) transmission grid to bring the power from desert regions in the Middle East or North Africa, it could be a significant source of power for Europe. This is all possible with existing technology.

At present, concentrating solar power (CSP) appears to be somewhat expensive

"Solar power will not run out, is comparatively pollution free, cost effective and can be built relatively quickly compared with nuclear power plants."

but that is in comparison with commonly-quoted prices for coal-fired or nuclear electricity that are artificially cheap. When environmental and hidden costs are factored in, electricity from CSP is cheaper than that from nuclear power and 'clean' coal. And the cost of CSP is falling while the cost of electricity from fossil fuels and nuclear power is on a rising trend.

Climate change requires that we radically reduce carbon emissions. The Kyoto Protocol demanded 60 per cent reductions by 2050, the EU is looking to cuts its emissions by 80 per cent by 2050, but the latest science now requires 100 per cent and as soon as possible. Urgent action is required. Carbon emitting fuels and technologies will have to be restricted, rationed and taxed to protect the planet.

A global economy based on renewable sources of energy could be as, or even significantly more, prosperous than the current fossil-fuelled economy. Solar power will not run out, is comparatively pollution-free, cost-effective and can be built relatively quickly compared with nuclear power plants. With a choice of heat storage media such as molten salt or graphite blocks, or using gas in hybrid solar systems, CSP can deliver any combination of base load power, intermediate load or peaking power, although of course, like any other power plant, there may be outages for maintenance or unscheduled breakdowns.

Surplus power, particularly in the Saharan summer might be used to produce huge quantities of hydrogen. Some high energy requiring industries such as aluminium smelting may be relocated to desert areas. CSP plants can also be used to desalinate sea water thus producing supplies of fresh water that would be particularly welcome in the arid regions where CSP works best. With large-scale solar projects there will be many advantages, many win-win situations. There is now a race to be market leader, to innovate and improve on existing designs and to scale-up.

There are many different ways to utilise solar power. Domestic rooftop solar water heating systems and domestic scale rooftop photovoltaic systems are the best-known examples. However, it is the other, less well-known technologies that offer far greater rewards both economically and environmentally. By using mirrors and lenses sunlight can be concentrated onto receivers of several types to generate electricity (or heat and steam for any other use) and these are all generically referred to as Concentrating Solar Power or CSP.

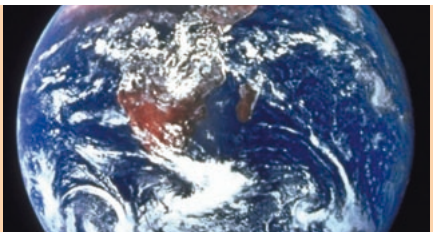
Concentrating solar power: a short history

CSP has a long history. Archimedes, defending the Greek colony of Syracuse, is said to have used mirrors to concentrate the sun's rays, igniting the besieging Roman ships, and Leonardo da Vinci proposed the industrial scale use of CSP. However, it is really with the inventions of Augustine Mouchot in the 1860s that CSP was born. He focused sunlight using mirrored dishes onto boilers to produce steam and so drive engines. Frank Shuman used parabolic trough technology to drive steam pumps in Egypt in 1912, and plans to utilise the Sahara Desert to supply Europe with electricity date from this time. Sadly, the First World War and the subsequent era of cheap oil meant that these useful technologies were largely ignored until the oil shocks of the 1970s. This prompted a worldwide wave of interesting R&D. Kramer Junction, California, was the only utility scale, grid-connected commercial solar power station built at this time, and it still produces 354MW of clean electricity.

With increasing concerns over carbon emissions and the recent run-up in oil and gas prices there has been renewed interest in solar over the past few years. There are now many ways of concentrating the sun's rays and using them to generate power. CSP divides into two categories: concentrating solar thermal (CST) and concentrating photovoltaics. Both of them are poised to become a huge boom industry with an almost certain role as a major power source in the future.

CST utilises four main designs of mirrors and lenses: dishes, parabolic troughs, power towers with heliostat fields and compact linear Fresnel reflectors. Three such projects have come on-stream recently; each on a different continent, each using different forms of CST technology but all demonstrating the economic and environmental sustainability of this as a major power source.

In March 2007 the 11MW ps10 power tower opened near Seville, Spain. A total of 624 heliostats, or solar tracking mirrors, focus the solar energy up onto a receiver atop a tower 40 stories high. Experimental solar power tower technology has been around for about 30 years, but ps10 is the



first grid-connected commercially operating example. Abengoa, who built ps10, is already building another power tower twice the size, ps20. Other solar power towers are planned, notably at Cloncurry in remote NW Queensland where graphite blocks will act as heat stores to allow solar electricity generation of 10MW from 54 mini power towers at night time as well as during the day, and the Solar Tres Power Tower at Ecija in Andalusia, Spain, where molten salt will be used as a heat storage medium. Advocates of power towers claim greater efficiencies than other forms of CSP: these advantages remain theoretical and only time will tell if they can outperform their rivals.

In June 2007 Nevada Solar One came on-stream utilising parabolic trough technology to produce a maximum capacity 75MW. This plant was built by Acciona, but many other companies are also building similar designs closely resembling those at Kramer Junction that have been operating successfully for approximately 25 years. These are not very different from those developed by Frank Shuman at Meadi in Egypt around 1912. Parabolic trough technology is perhaps the most tried and tested form of CSP, but with the Nevada project the technology has been improved to greater levels of efficiency. By the time this article is read, Andasol 1 should have opened, with Andasol 2 opening next year and Andasol 3 sometime after that, each utilising salt as a heat store and each producing 50MW for much of the 24-hour day, all at Guadix near Granada, Spain. The German company Solar Millennium are one of the partners behind Andasol, and they

Rooftop solar water heaters are one of the most well known ways in which sunlight can be harnessed for residential applications.

have a number of other exciting projects under development, particularly the Ordos project in the Inner Mongolia region of China where they and local partners are building a solar parabolic trough power station, the first phase of which is due to open soon, and when completed in 2020 will have a capacity of 1000MW. Parabolic trough technology is well established and set to grow rapidly in the coming decade.

Current developments

The latest news is the opening on October 23, 2008 of the Kimberlina power station near Bakersfield, California. It is only 5MW, but is just the first phase and demonstration plant for the 177MW San Luis Obispo plant due to open in 2010. These plants use a Compact Linear Fresnel Reflector (CLFR) system like that commissioned to pre-heat steam at the Liddell coal power station in the Hunter Valley, New South Wales, Australia, in 2004. Dr David Mills had spent many years researching solar power at Sydney University and developing the CLFR technology. In 2006, he and Vinod Khosla founded Ausra, based in California but with global ambitions. The Liddell, and now also Kimberlina project, demonstrated the potential of CLFR technology. Ausra opened a factory to mass-produce solar components on June 30, 2008 in Las Vegas and they have many other projects in the pipeline. Now the goal is to build gigawatt-sized power stations.

CLFR technology has several advantages over its competitors: its power output to land requirement ratio is twice as good as that of most of the competition and by using simple flat plate reflectors it is faster and cheaper to construct. Ausra's CLFR technology is one of the main contenders to be solar market leader.

The fourth type of solar collector is the dish. It is the longest established form of collector, dating back to the inventions of Augustine Mouchot in the 1860s. There are now a bewildering range of companies

"Cool Earth Solar... have developed an 8ft-diameter inflated plastic film balloon with a high specification photovoltaic receiver in the middle."

utilising dishes to collect solar energy either as concentrating solar thermal energy via steam, or directly producing electricity by placing a Stirling engine or a high specification photovoltaic receiver at the focal point.

There are many small schemes and prototype projects up and running, but no large-scale commercial grid-connected systems yet operating, as far as I am aware in this fast changing environment. There are many exciting projects in the planning and construction stages. One example is Stirling Energy Systems who have developed the "Suncatcher", a 38ft-diameter dish with a Stirling engine providing 25kW per dish. They plan two projects, both in the Californian desert, which when fully developed would use 70,000 dishes in total to generate 1750MW.

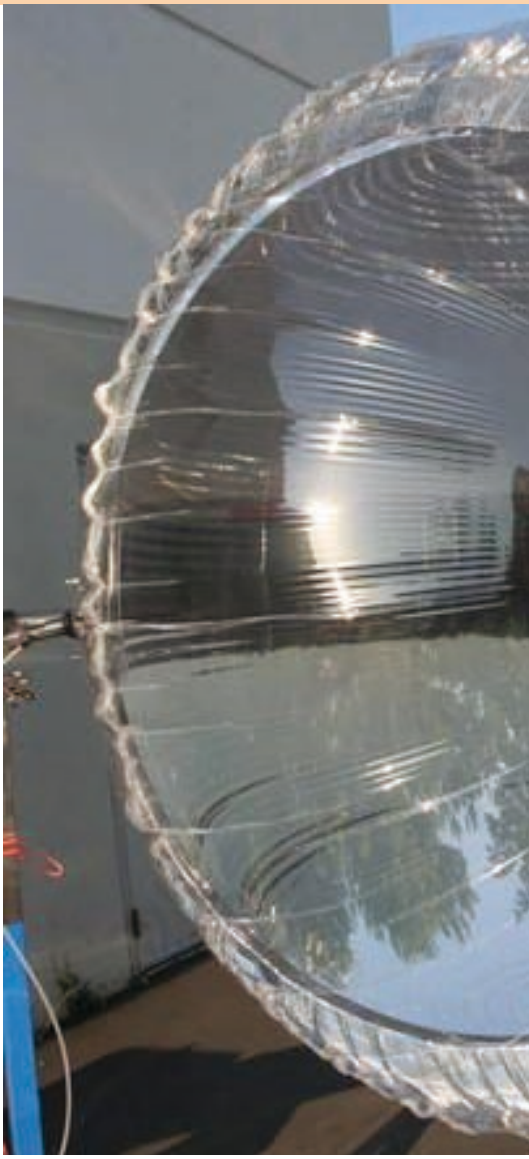
Concentrating photovoltaics

Another form of solar power which has enormous potential is concentrating photovoltaics (CPV). Many new companies have started-up in the last three or four years, mainly based in the USA and especially in California. One of these is Cool Earth Solar who have developed an 8ft-diameter inflated plastic film balloon with a high-specification photovoltaic receiver in the middle. The company claims that given an equal area of sunlight hitting the earth, their concentrator can produce the same amount of electricity using 300 to 400 times less solar cell material. It is cheap to produce, very robust and as it does not cause any environmental damage is perfect for fallow farmland. There are many other such interesting innovations currently at the prototype stage that may be hugely significant in the very near future.

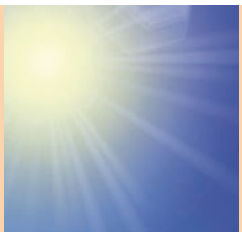
The Australian company Solar Systems has built a number of small CPV power stations for remote communities in the Australian outback, such as the dish system at Umuwa in South Australia. At Mildura in Northwest Victoria, Australia, they plan a 154MW CPV system utilising a power tower design, which they claim will be the world's largest CPV plant when it is fully operating in 2013.

Many reports have been written over the last few years by a number of organisations highlighting the enormous potential benefits of the widespread adoption of CSP. One organisation stands out for the breadth of its vision and the depth of its research and that is the Trans-Mediterranean Renewable Energy Cooperation or TREC. It seeks to form an alliance between all of the countries throughout North Africa, the Middle East and the European Union as a community for energy, climate and water security, and these plans have been greatly facilitated by Nicolas Sarkozy and the recent formation of the Union for the Mediterranean. The TREC plan, called "DESERTEC", is to gradually replace much of the coal, oil, gas and nuclear generation capacity throughout the whole region with a portfolio of renewable forms of energy, with CSP playing a central role.

The countries of North Africa and the Middle East would benefit both by having additional electricity for themselves and revenue from electricity sales to Europe. At the same time, useful quantities of fresh water could be produced by desalination of sea water utilising the waste heat from the CSP plants. This would of course be very useful in the sunny regions where CSP works best.



Clean electricity may be transmitted throughout the region using the existing transmission grid. As the quantities of electricity increase, transmission capacity may be increased by removing bottlenecks, by installing smart electronics to enable the grid to work more efficiently, by converting



existing high-voltage alternating-current (HVAC) transmission lines to low-loss high-voltage direct-current (HVDC) lines, and by installing new HVDC lines (some of which may be laid under the sea).

This is not, as some commentators seem to think, some project for the distant future. CSP plants can be built relatively quickly and capacities may be ramped up fast. With the right political impetus, CSP could be making a substantial contribution within relatively short timescales.

Apart from developments in Spain, new CSP plants are already being constructed in Morocco and in Egypt. Algeria is interested in the possibility of exporting as much as 6GW of electricity to Europe from hybrid gas/solar power plants. Other countries throughout North Africa and the Middle East are becoming interested in the possibilities. Jordan is planning the Ma'an Development Area featuring solar power and Abu Dhabi has a CPV plant up and running as part of the Masdar project.

In Australia, WorleyParsons, the country's largest engineering company, announced on August 12 plans to build 34 solar power stations by 2020, each one with a peak output of 250MW. The first one will probably be built in Pilbara, Western Australia. Power there would go mainly to mining operations, with later stations supplying urban centres.

Melbourne-based company Acquasol with partners Solar Millennium and Hatch is planning a development at Point Paterson, near Port Augusta in South Australia. They plan for a capacity of 200MW in the form of a 150MW combined cycle gas turbine and a 50MW parabolic trough solar thermal system. What makes this project so interesting is the combination of electricity production with large scale desalination, initially of 5.5 gigalitres of water, with possible expansion to 45 gigalitres, or enough for a city of 250,000 people. Solar evaporation will then convert the brine from the desalination process into commercially significant salt. This project is an example of multiple benefits: brine, often a pollutant at desalination plants becomes saleable salt, solar and gas replace existing brown coal facilities, so reducing carbon emissions and the desalinated water relieves pressure on the over-exploited Murray River.

Start of a revolution?

US venture capitalist Vinod Khosla, speaking about CSP, recently said: "We are poised for breakaway growth – for explosive growth – not because we are cleaner [than 'clean' coal-fired electricity] but because we are cheaper. We happen to be cleaner incidentally." The opening of ps10 plant in Spain in March 2007 and the Nevada Solar One in June 2007 may prove to be a watershed in the development of CSP, marking that year as the start of something significant. 'The Solar Age' may just have begun. Barack Obama's election to the White House coupled with Harry Reid (a strong advocate of solar power) as democratic leader in the Senate may mean that the political moment is right for rapid growth in the solar power industry in the key American market. With luck, we may well look back on the decade 2007-17 as the 'Decade of Transition' from the 'Fossil Fuel Age" to 'The Solar Age'. ■

Feature information

Richard Priestley is an independent writer and speaker currently working on a book and series of talks titled "Global Problems : Global Solutions", on the positive opportunities that combating climate change offers. Moving from the "Fossil Fuel Age" to "The Solar Age" is necessary, possible and desirable.

The author can be contacted at:
richardjpriestley@hotmail.com