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ENERGY FUTURE: JUST DESERTS?

The ingenious use of mirrors and DC electrical grid technology could provide a significant new source of power from desert sunlight. **GERRY WOLFF** explains

Every year, each square kilometre of hot desert receives solar energy equivalent to 1.5 million barrels of oil. Multiplied by the total area of deserts world-wide, this is nearly a thousand times the entire current energy consumption of the world.

Given our concerns about energy supplies and the need to cut CO_2 emissions, these rather startling statistics seem to be a cause for optimism. But, you may very reasonably ask: Can we tap into this enormous source of energy at a reasonable cost? Can we get it to where people are living? And, if those things are possible, what other snags or problems might there be? The purpose of this article is to describe some answers to those questions and suggest that one's initial sense of optimism may be something more than just a mirage.

The key technology for tapping into the solar energy of desert regions is 'concentrating solar power' (CSP). This is not some futuristic possibility like fusion nuclear power. It is the remarkably simple idea of using mirrors to concentrate direct sunlight to create heat and then using the heat to raise steam to drive turbines and generators, just like a conventional power station. However, in some variations, the heat is used to drive a Stirling engine that drives a generator.

A useful feature of CSP is that it is possible to store solar heat in melted salts (such as nitrates of sodium or potassium, or a mixture of the two) so that electricity generation may continue through the night or on cloudy days. This overcomes a common objection to solar power: that it is not available when there is no sun.

CSP is very different from the better-known photovoltaic panels and, with current prices for PV, it can deliver electricity more cheaply in situations where lots of direct sunlight is available. However, PV may become cheaper in the future and methods for storing PV electricity are likely to improve – so the balance of advantage may change. Just to confuse matters, CSP is sometimes used in conjunction with PV, to minimise the amount of PV that is required.

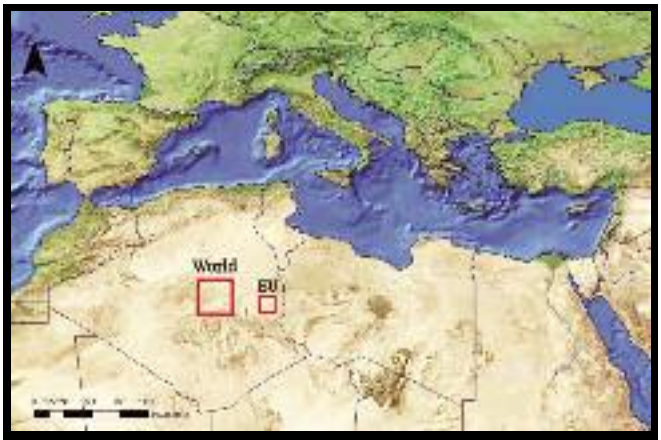
The relative merits of different technologies and different versions of CSP will, no doubt, be the subject of study and debate for years to come. The key point for present purposes is that the technology works, it is relatively mature and has been generating electricity successfully in California since 1985. Currently, about 100,000 Californian homes are powered by CSP plants, new plants came on stream recently in Arizona and Spain, and others are being planned or built in various parts of the world.

Getting the energy to where it is needed

Given that, with a few exceptions, desert regions are not places where many people choose to live, it is natural to ask how all this plentiful supply of energy is to be used. One possibility is to move energy-intensive industries such as aluminium smelting to desert areas. But even if all such industries were relocated, there would still be a need to transmit electricity to towns and cities elsewhere.

The high-voltage AC transmission lines with which we are all familiar work well over relatively short distances, but they become increasingly inefficient as distances increase. Fortunately, it is possible to transmit electricity efficiently over very long distances using high-voltage DC (HVDC) transmission lines, a technology that has been in use for over 50 years. With transmission losses of about 3% per 1,000 km, it would for example be possible to transmit solar electricity all the way from North Africa to London with only about 10% loss of power. When one considers that the 'fuel' is free, this level of loss compares very favourably with the 50% to 70% losses that have been accepted for many years from conventional coal-fired power stations, where the fuel is far from being free.

To meet the need for this kind of long-distance transmission of solar power, the 'TREC' group of scientists,



The larger red square on the map shows a 254 km × 254 km area of hot desert that, if covered with concentrating solar power plants, would provide electricity equivalent to the current electricity consumption of the whole world. The smaller square shows a 110 km × 110 km area that would meet the electricity demands of the European Union (25 countries).

engineers and politicians[1] propose the development of an HVDC transmission grid across all the countries of Europe, the Middle East and North Africa (EUMENA). Apart from long-distance transmission of solar power, there are other good reasons to build such a grid. For example, if there is a surplus of wind power or hydropower in one area, it is very useful to be able to transmit that electricity to places where there is a shortage. Without that facility, the surplus power is simply wasted! And although wind power may be quite variable in any one location, it is much less variable across a large region such as Europe or EUMENA. Large-scale grids are also needed to take advantage of large-scale but remote sources of renewable electricity such as offshore wind farms, wave farms, tidal lagoons and tidal stream generators.

For these kinds of reasons, the wind energy company Airtricity has proposed a Europe-wide 'Supergrid' of HVDC transmission lines and others have proposed a world-wide HVDC transmission grid. Interestingly, Airtricity proposes that all the HVDC transmission cables can be laid under the sea, thus simplifying construction and avoiding the visual intrusion of transmission lines over land.

How much will it cost?

While fossil fuels are artificially cheap (using the atmosphere as a free dumping ground for CO_2) and until CSP costs are reduced via economies of scale and refinements in the technology, it is likely that there will be a need for price support via direct subsidies or market mechanisms such as 'renewable obligation certificates'. Then, according to the 'TRANS-CSP' report commissioned by the German government,[2] CSP is likely to become one of the cheapest sources of electricity in Europe, including the cost of transmitting it.

Others take an even more positive view of costs. The legendary venture capitalist Vinod Khosla has suggested that CSP is poised for explosive growth, with or without public support.[3] In a report in *Business Week*,[4] the CEO of Solel is quoted as saying 'Our [CSP] technology is already competitive with electricity produced at natural-gas power plants in California.'

CSP bonuses

One of the most fascinating aspects of concentrating solar power is the potential that it has for producing other benefits besides plentiful supplies of pollution-free electricity.

Perhaps the most interesting possibility is that waste heat from steam turbines (used in the production of electricity) may be used to desalinate sea water. This could have a major impact in alleviating shortages of water in drier parts of the world, a problem that is likely to become increasingly severe with rising global temperatures – as has been highlighted by Sir David King, Chief Scientific Advisor to the UK government. Waste heat from electricity generation may also be used for air conditioning.

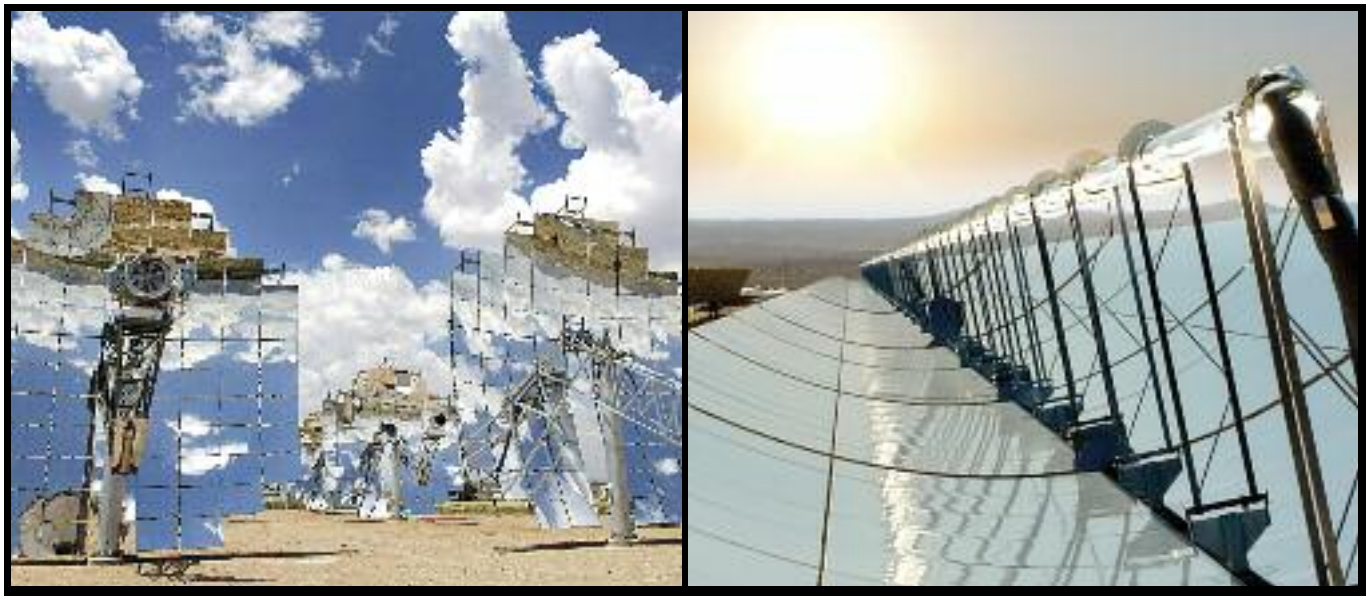
Another interesting side-effect of CSP is that the area under the mirrors of a solar plant is protected from the harshness of direct tropical sunlight. These shaded areas may be useful for many purposes including living space, stables for animals, car parks and so on. Although the area under solar collectors is in shadow, it should still receive quite a lot of light, quite sufficient for growing plants and without the damaging effect of direct tropical sunlight. Thus land that would otherwise be useless for any kind of cultivation could become very productive. An obvious problem is that plants need water and that is not plentiful in hot deserts. But desalination of sea water may provide the fresh water that would be needed for 'CSP horticulture'.

CSP has the potential to become a large new industry in the world with many benefits in terms of jobs and earnings. Many of the world's hot deserts are in countries that are relatively poor so we may suppose that concentrating solar power could be a particularly welcome new source of income via taxes or earnings from the sale of electricity.

Plentiful and inexpensive supplies of electricity from CSP would open up many interesting possibilities for taking fossil carbon out of transport by road and rail. For example, the latest generation of plug-in hybrid electric vehicles (PHEVs) – with relatively large batteries – can, for many journeys, be run largely on renewable electricity from the mains. Batteries may also be topped up from photovoltaic panels on each vehicle's roof. Railways can be electrified and run on renewable electricity. CSP also provides a means of avoiding the many disadvantages of nuclear power (see www.mng.org.uk/green_house/no_nukes.htm).

More generally, CSP can alleviate shortages of energy, water, food and land and reduce the risk of conflict over those resources (a risk that is likely to increase as climate change takes hold, as highlighted in a speech to the UN by Margaret Beckett when she was UK Foreign Secretary). And the development of a CSP collaboration among the countries of EUMENA is a positive way of building good relations between different groups of people, with potential advantages over the more aggressive policies that have been pursued in recent years.

1 'TREC' stands for the Trans-Mediterranean Renewable Energy Cooperation (www.trecers.net).
2 See www.trec-uk.org.uk/reports.htm or www.dlr.de/tt/trans-csp. Also relevant is the earlier MED-CSP report (see www.trec-uk.org.uk/reports.htm or www.dlr.de/tt/med-csp).
3 You may listen to his talk at the Solar Power 2006 conference in California via links from www.trec-uk.org.uk/resources.htm.
4 'Israeli Solar Startup Shines' by Neal Sandler, *Business Week*, 2006-02-14.



Left: Sun-tracking parabolic dish reflectors, each with a Stirling engine and electricity generator at its focal point.

Right: Close-up view of a parabolic trough solar mirror with a pipe at its focus containing heat-collecting fluid.

Possible problems

It is rare for any technology to be totally positive in its effects, without any offsetting disadvantages. That said, I believe that there are good answers to most of the queries or doubts that may be raised about CSP.

Security of supply

If Europe, for example, were to derive a large proportion of its energy from CSP, people would naturally wonder whether supplies might be suddenly cut off by the action of terrorists or unfriendly foreign governments.

In the scenario up to 2050 described in the TRANS-CSP report, there would be an overall reduction in imports of energy, an increase in the diversity of sources of energy, and a corresponding increase in the resilience and security of energy supplies. Imports of solar electricity would be an exception to the rule of reduced imports and would, in any case, be not more than 15% of European energy supplies.

Compared with sources of supply for oil and gas, there is a relatively large number of locations that have hot deserts. So in principle no country need be overly dependent on any one source of CSP. HVDC transmission grids can be designed to be robust in the face of attack, in much the same way that the internet was designed to carry on working even if part of it is damaged. Transmission cables can be buried underground or laid under the sea where they would be relatively safe from terrorist attack.

Isn't this just another smash and grab by rich countries upon the poor?

One may wonder whether CSP might become another case where rich countries take what they need from poorer countries leaving little for local people, except pollution.

There are reasons to think otherwise because several of the benefits of CSP are purely local and cannot easily be exported or expropriated. These include local jobs and earnings, local availability of inexpensive pollution-free electricity, desalination of sea water, and the creation of shaded areas with the kinds of uses mentioned above.

The ecology of deserts

From at least as far back as Walt Disney's *The Living Desert*, wildlife films have made us aware that hot deserts have their own vibrant ecology. If the world's hot deserts were all to be covered with CSP plants, there would indeed be cause for concern about the animals and plants that live there. But less than 1% of the world's deserts would meet current world demands for electricity and even in pessimistic scenarios, it seems unlikely that more than 5% would ever be needed in the future. It should be possible for CSP plants and wildlife to co-exist.

Conclusions

There is no doubt that planet Earth's ability to support humanity is being put at risk by a combination of inappropriate technologies, huge and increasing material demands, and the sheer weight of population. CSP is not a panacea but it can be a useful plank in the new ways of living that will be needed if we are to survive and prosper in the future.

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