The potential of power from 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 the energy content of 1.5 million barrels of oil[1]. When multiplied by the total area of deserts worldwide, this amounts to several hundred times the entire current energy consumption of the world[2].

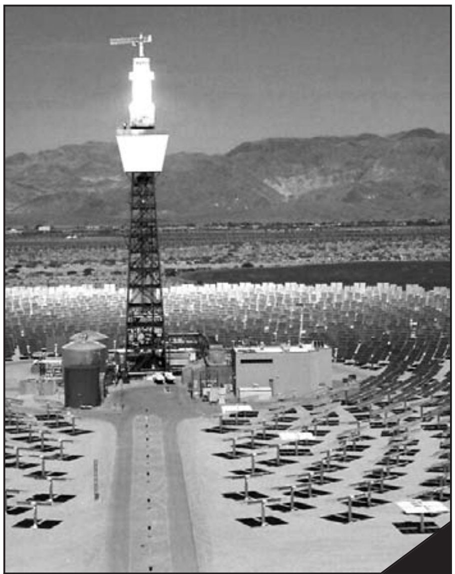
Given concerns about energy supplies and the need to cut CO_2 emissions, this startling statistic seems to be a cause for optimism. But, you may ask: can we tap into this enormous source of energy at a reasonable cost? Can we get it to where people are living? And, if those things are possible, what other problems might there be? The purpose of this article is to provide answers to those questions and suggest that any initial sense of optimism may well be more than 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 but is the remarkably simple idea of using mirrors to concentrate direct sunlight in order to create heat and then using the heat to raise steam, which drives turbines and generators, just like a conventional power station. (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)[3] 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. Of course, this technology is not specific to CSP but, in conjunction with CSP, it has proved effective for short-term storage of solar energy.

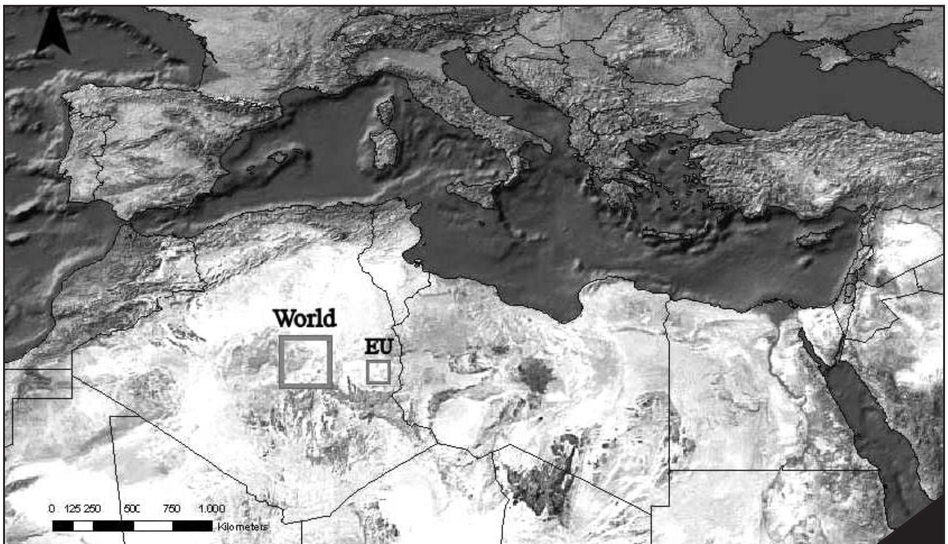
CSP is different from the better-known photovoltaic (PV) technology and, with current prices for PV, it can deliver electricity more cheaply in situations where lots of direct sunlight is available[4]. However, PV may become cheaper in the future and methods for storing PV electricity are likely to improve—so the balance of advantage may change. (Note that CSP is sometimes used in conjunction with PV.)

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 other parts of the world.



Credit: Sandia National Laboratories ©

The Solar Two 'power tower' type of CSP plant at Barstow, California.



Credit: http://www.trecers.org ©

The larger square on the left shows a 254 km x 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 x 110 km area that would meet electricity demands of the European Union (when it included 25 countries).

Getting the energy to where it is needed

Since not many people tend to live in desert regions, an obvious question is how to use this plentiful supply of energy. One possibility is to move energy-intensive industries such as aluminium smelting to desert areas. But even if this were possible, there would still be a need to transmit electricity to towns and cities elsewhere.

The high-voltage AC transmission lines, with which we are familiar, work well over relatively short distances but become increasingly inefficient as distances increase. 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 1000 km, it would for example be possible to transmit solar electricity from North Africa to London with only about 10% loss of power. Considering 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 free.

To meet the need for long-distance transmission of solar power, the 'TREC' group of scientists, engineers and politicians[5] propose the development of an HVDC transmission grid across all the countries of Europe,

A close up view of a parabolic trough solar mirror with a pipe at its focus containing heat-collecting fluid.

the Middle East and North Africa (EUMENA). There are other good reasons to build such a grid. For example, if there is a surplus of wind power or hydro-power in one area, it would be useful to be able to transmit that electricity to places where there is a shortage. And although wind power may be 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 such reasons, the wind energy company Airtricity has proposed a Europe-wide 'Supergrid' of HVDC transmission lines; others have proposed a worldwide HVDC transmission grid. Airtricity propose 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 (because they use 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, there will likely be a need for price support via direct subsidies or market mechanisms such as 'feed-in tariffs'. Then, according to the 'TRANS-CSP' report commissioned by the German government,[6] 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[7]. In a report in *Business Week*[8], 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

A fascinating aspect of CSP is its potential for producing other benefits besides plentiful supplies of pollution-free electricity. For example, waste heat from steam turbines (used in the production of electricity) may be used to desalinate sea water. This could be a major help in alleviating water shortages in drier areas, a problem that is likely to worsen with rising global temperatures. 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. And since it should still receive enough light for growing plants, it could transform previously infertile land into productive land. The water requirements for 'CSP horticulture' could, in theory, come from the desalination activity.

CSP has the potential to become a large new industry with obvious economic benefits. Many of the world's hot deserts are in countries that are relatively poor; CSP could be a 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 interesting possibilities for taking fossil carbon out of road and rail transport. 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 provides the means of avoiding the many disadvantages of nuclear power[9].

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 recent speech to the UN by Margaret Beckett, UK Foreign Secretary). And the development of a CSP collaboration amongst the countries of EUMENA is a positive way of building good relations among different groups of people.

Possible problems

It is rare for any technology to be totally positive in its effects. That said, I believe that there are good answers to most of the 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, a reasonable concern would be whether supplies might be vulnerable to the actions of terrorists or unfriendly foreign governments.

In the scenario up to 2050 described in the TRANS-CSP report[10], 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, a relatively large number of places 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.

Inequity

It would be fair to ask 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. 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 for uses mentioned above.

Desert ecology

We know 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[11]. Even in pessimistic scenarios, it seems unlikely that more than 5% would 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 the human tribe is being put at risk by a combination of inappropriate technologies, huge and increasing material demands, and the sheer weight of human numbers. CSP is not a panacea but it could be a useful plank in the new ways of living that will be needed if we are to survive and prosper.

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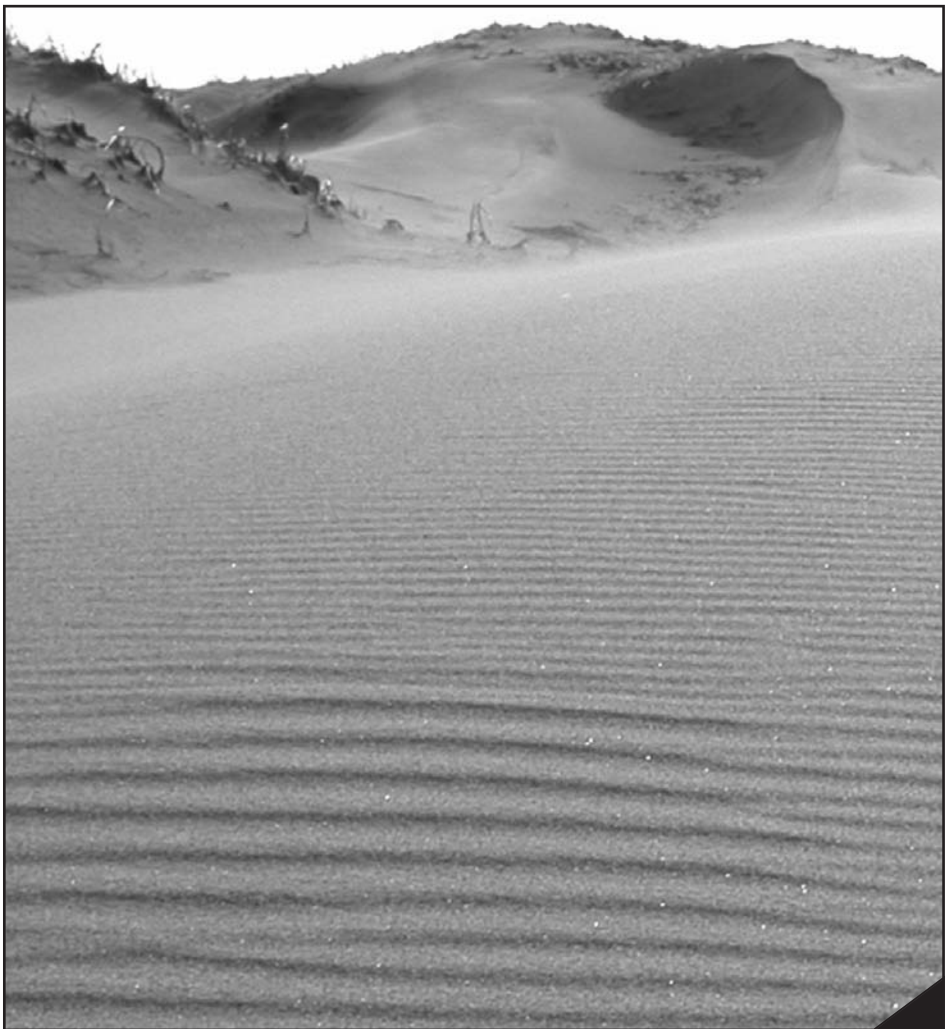

Will hot deserts host a new generation of renewable energy technologies?

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11. Dr Franz Trieb, personal communication, May 2007. "Multiplying an irradiance of 2400 GWh/km^2/y by 10% CSP efficiency and 35 million km^2 yields 8,400,000 TWh/y which is 466 times the present electricity demand of 18,000 TWh/y. That means 0.2% of the deserts would cover the present electricity demand."