CSP: bright future for linear fresnel technology?

PART 5: CONCENTRATED SOLAR POWER IS NOT NEW ON THE SCENE. SO THE QUESTION IS, DO LATECOMERS STILL HAVE A BRIGHT FUTURE AND CAN THEY DELIVER SOLAR POWER ON A GLOBAL SCALE, THAT WE CAN ALL AFFORD? CONTINUING A REVIEW SERIES OF CONCENTRATING SOLAR POWER (CSP) TECHNOLOGIES, **GRAHAM FORD** OF HELIODYNAMICS LOOKS AT LINEAR FRESNEL CSP.

Concentrating Solar Power recent articles:

- Part one – **CSP concentrates the mind**, Jan/Feb, pages 42-47;
- Part two – **Parabolic troughs: CSP's quiet achiever**, Mar/Apr, pages 46-50;
- Part three – **Hot stuff: CSP and the Power Tower**, May/Jun pages 51-54;
- Part four – **Dish projects inch forward**, Jul/Aug pages 52-54;
- Part five – below, pages 49 and 51.

Until recently, Linear Fresnel CSP technology was not even acknowledged as a CSP technology, as it is the only one that was not built experimentally during the oil crises of the 1970s.

Linear Fresnel CSP technology derives its name from a type of optical system that uses a multiplicity of small flat optical faces, invented by the French engineer Augustin-Jean Fresnel who, while Commissioner for Lighthouses, invented the segmented lighthouse lens.

Presented as mirrors, these flat or slightly curved optical surfaces are arranged in long parallel lines, and are positioned to reflect direct sunlight into a long target, or receiver, with one surface having a Linear Fresnel concentrator.

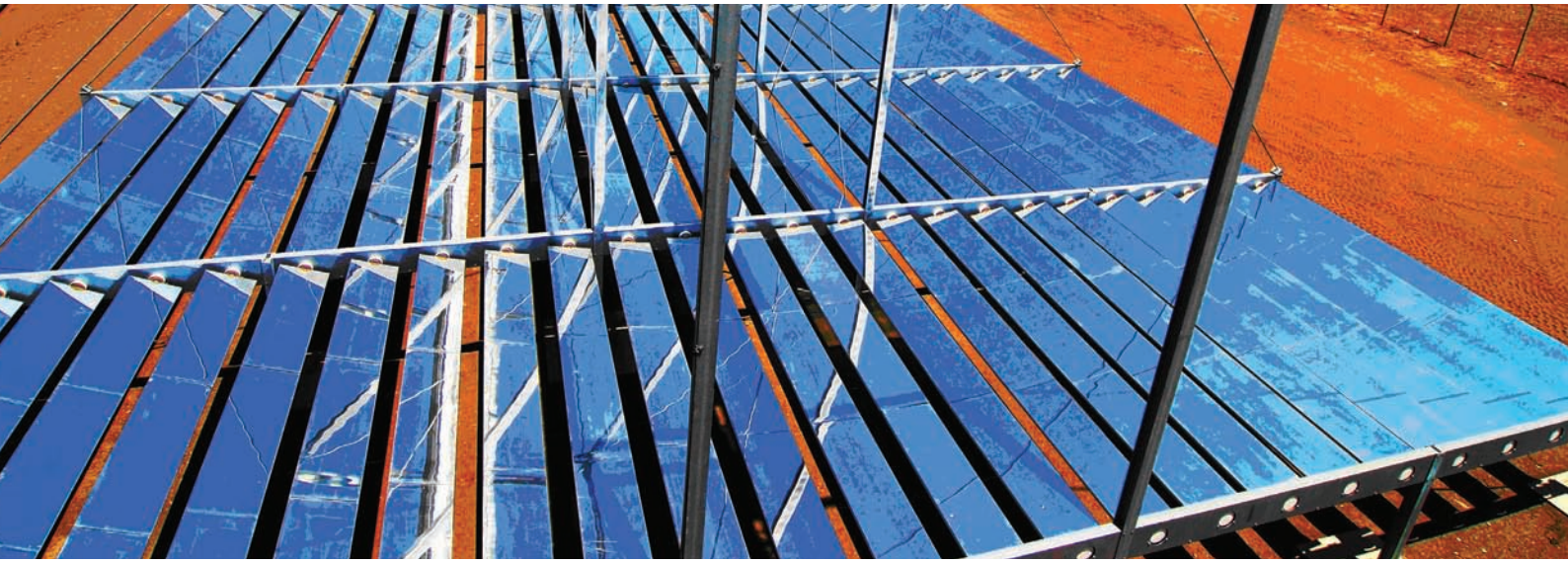
Dr David Mills, a member of the University of Sydney's department of Applied Physics, has been a pioneer in the development of Linear Fresnel CSP. His then company, Solar Heat and Power, built a 1 MW thermal steam generator near a coal fired power station in Australia, to supply medium pressure steam to the turbine genset during the day. This technology attracted Vinod Khosla of Khosla Ventures and Kleiner Perkins Caufield and Byers – the well known Silicon Valley venture capital firm – to invest heavily, transforming Mills' company into US-based **Ausra Inc**.

Ausra's vision is simple and straightforward: to cover desert areas with square miles of mirrors. These mirrors shine light up to steam-generation receivers, store that heat in high-temperature concrete heat stores, superheat that steam with fuel and ultimately drive steam turbines.

It is said that when coal power plant engineers meet, they talk in gigawatts, while solar engineers talk in megawatts. That is definitely not Ausra's problem, with good reason.

Cost savings

The key element of a Linear Fresnel CSP system is the mirror, made of thin 1-2 mm thick ribbons



of mirrored float glass, available from any number of mirror manufacturers worldwide, and now available with low-iron glass for extra efficiency. Unlike parabolic trough makers, who must go to some length to secure expensive plant capacity to make precision bent glass reflectors, Fresnel mirror is available at little more than €7 per square (sq.) metre. It weighs as little as 3 kg per sq. metre, a third of the weight of the parabolic trough mirror.

This is only the start of the cost savings. The simple structures that make up the mirrors lend themselves to high volume automated manufacture, and are considerably lighter than the structures required by the heliostats in competitive technologies such as Power Towers, Dish Stirling and Parabolic Trough. This lightness is achieved very simply, as the Linear Fresnel CSP packs its mirrors close together so that they shield each other from the wind. When not in use, the mirrors can turn upside down for further protection from the wind, as well as sand storms or even hail. Lower wind loads permit lighter structures, and therefore less cost per unit area.

Ausra's engineers fully expect to become the leading CSP producer on the basis of their compact plants and low construction costs. One factory opened in Las Vegas earlier this year and a second plant is in preparation.

Further into the desert

Ausra are matched in their determination by **MAN Ferrostall Power Industry GmbH**, which is pursuing a similar ambition to turn pieces of worthless desert into power plants of the future.

With extensive experience in power plant development worldwide, MAN Ferrostaal is now erecting its first demonstrator thermal solar power station. It is collaborating with the **Solar Power Group (SPG)**, the **German Centre for Aerospace** and the **Fraunhofer Institut für Solar Energiesysteme**. Its 1 MWe demonstration plant is being constructed in Almeria in Spain, with a planned output of 1MW. It is expected to start operation later this year.

How to attract investors

Despite the advantages, Linear Fresnel CSP technology suffers from a lack of reference plants already built, as well as up and running. It is necessary, therefore, to persuade investors and project financiers that the cost savings will translate into profits once in operation. Naturally, all the usual project questions must be addressed, including reliability, longevity, efficiency, and O&M costs – with the assurance that no technical gremlins are left lurking in the design.

HelioDynamics: a gradual approach

More is needed than designs on paper to answer these questions – investors want to see a track record.

This perhaps explains why another Linear Fresnel CSP company, UK, Cambridge-based **HelioDynamics Ltd**, is taking a more gradual approach, starting with small thermal systems, and refining its technology experience further with smaller scale projects to build a good foundation before scaling up.

The company's combination of high efficiency cells and the low concentrator costs of the Linear Fresnel concentrators are seen to have the potential to lower the cost of solar power even further. In June 2008, HelioDynamics' small scale concentrators, and gallium arsenide

Unlike parabolic trough makers, who must go to some lengths to secure expensive plant capacity to make precision bent glass reflectors, Fresnel mirror is available at little more than €7 per square metre. It weighs as little as 3 kg per sq metre, 30% of the weight of the parabolic trough mirror.

PV receivers were acquired by **EnergyMixx AG** of Switzerland.

Whereas Ausra's Linear Fresnel has been designed to be implemented at large scale – in plant sizes of megawatt to gigawatt scales – HelioDynamics will provide solar air-conditioning systems for a single office or shopping mall, or provide a factory with process steam from the sun falling on the roof.

Having gone through four generations of development over a 7 year period, HD is manufacturing its solar thermal Linear Fresnel Concentrator and selling it commercially, and it has achieved safety certification for its solar concentrator.

Making steam for food companies makes thermodynamic sense, saving natural gas on customer sites (given that it only takes two units of gas to make a unit of electricity in a standard CCGT plant). So, a typical 1 MW-thermal installation will actually release the fuel to generate 500 kWe of power elsewhere in the energy system, for a pre-installation hardware price of €0.6/W-thermal.

HD ultimately plans to use the same product to boil steam in combination with a waste biofuel superheater – and to drive steam turbines. This approach offers power generation costs of the order of €1.50/We (without storage), nearly on a par with onshore wind.

But steam is not the only power plant one can hook onto a Linear Fresnel concentrator, nor its near cousin Organic Rankine Cycle – a low temperature version using carbon-based working fluids. There is a unique aspect of a well engineered Linear Fresnel concentrator that should not be overlooked – an evenly illuminated receiver.

Well controlled illumination of a receiver, without bright spots or dark spots, is essential if the receiver is to be combined with high efficiency PV cells, such as gallium arsenide cells which are now approaching 40% efficiency, and have the potential to achieve 50%.

By concentrating sunlight in both axes up to 500 suns, these tiny cells have the ability to produce a kilowatt of power from only 20 cm^2 of PV wafer.

All the main pioneers of Linear Fresnel CSP have designed their systems. They are now in manufacture and undertaking demonstration projects.

Advantages for utility companies

First and foremost, a relatively small amount of capital is required to build an assembly plant. Also important, the product technology lends itself to manufacturing simplicity, requiring little more than well-established engineering materials and processes. As a result, these plants can be assembled and commissioned in months, rather than years.

This makes this technology rapidly scalable. and, unlike Power Towers and wind generators, it has a low visual footprint, and can therefore be sited near residential areas.

If the political will is there, growth rates well above 100% could be sustained until the industry can exceed tens of GW of capacity per year.

Right now, the bottleneck is in medium sized steam turbines, with three years as the typical lead time. However, with joint planning, clear purchasing policies and a clear lead from Governments, the turbine makers could build a standardised product, and thus boost capacity rapidly.

New jobs

For every GW/y of capacity built, around 20,000 jobs will be created by the main contractors and their supply chain.

Therefore, with European electricity demand running at an average of around 400 GW, and a need to change most of that to renewables by 2050, a European Linear Fresnel CSP industry could deliver 200,000 jobs. It will also consume around two million tonnes of steel or aluminium metal per year. On this scale, the cost of solar power will be less than the current cost of natural gas fired power plants. And what applies to Europe could equally apply to the USA, Brazil, India, China, the Middle East and Africa.

Utility companies will choose which technology of power plants they want to invest in. Of course, they must avoid investing in assets that become stranded due to excessively high marginal operating costs, and they must factor in the cost of carbon, which is likely to be substantial and possibly punitive. I will be surprised if utilities don't take a long hard look at Linear Fresnel CSP, and then go for it.

About the author:

Graham Ford is ceo of HelioDynamics Ltd.