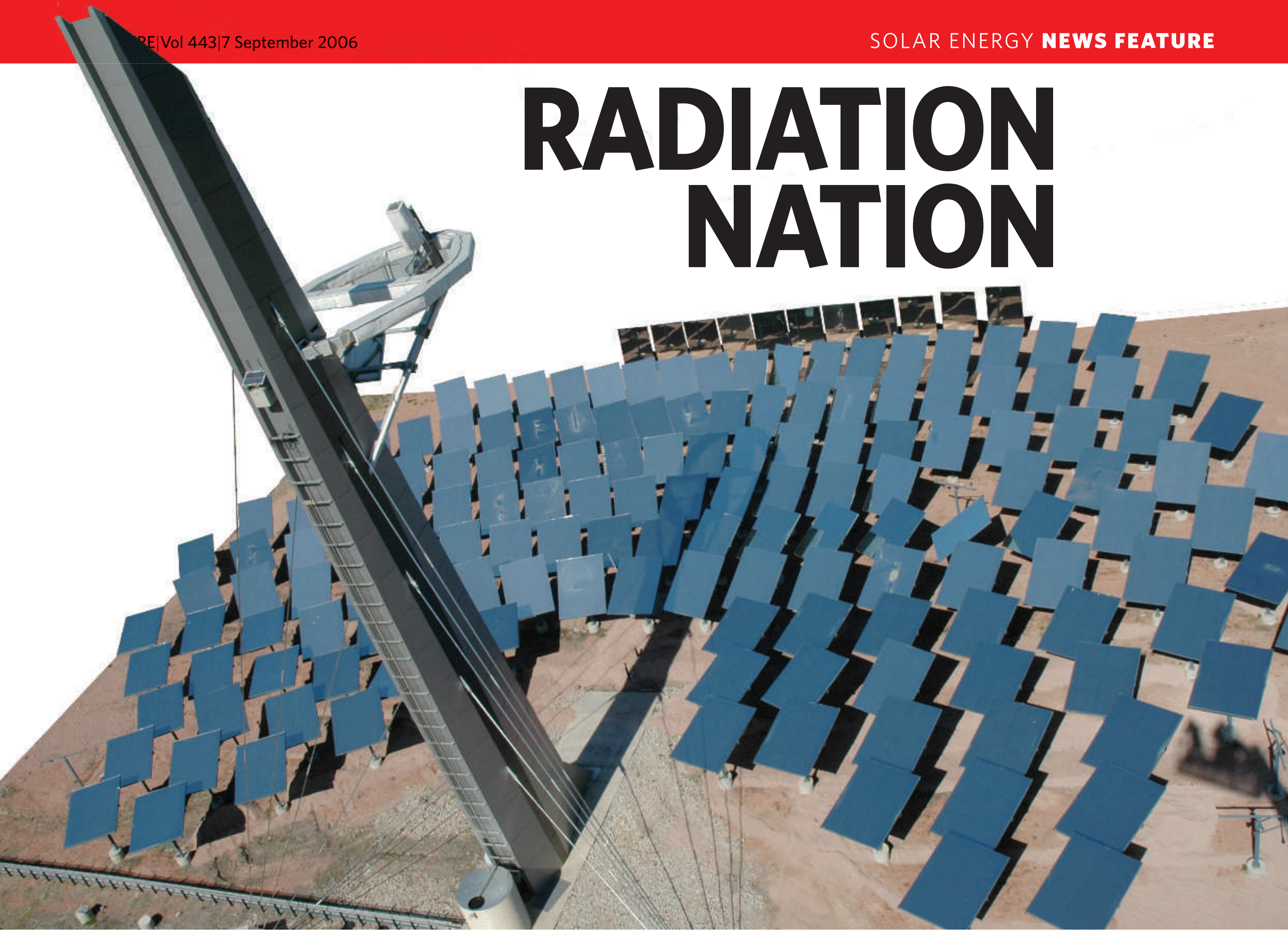
RADIATION NATION



These mirrors in the Australian landscape focus the Sun's rays to power the production of 'SolarGas'.

W. STEIN/CSIRO

Australia receives more solar radiation per square metre, on average, than any other continent. Although turning this radiation into electricity is one option, another is finding ways to make use of its heat. We spoke to Australian proponents of two very different solar-thermal systems, both rather confusingly known as solar towers: Roger Davey, executive chairman and chief executive of EnviroMission, based in Melbourne; and Wes Stein, from the Energy Technology Division of the Commonwealth Scientific and Industrial Research Organisation, based in Newcastle.

How does your solar-thermal project work?

Roger Davey: In our solar tower, solar radiation is used to heat the air captured under a large greenhouse. The roof of the greenhouse is sloped towards the centre, where there are turbines and a very tall tower that creates a chimney effect. Hot air rises up and out of the tower, rushing through turbines at the base of the tower to produce power.

Wes Stein: We have 200 small mirrors that track the Sun during the day and concentrate its rays onto a single point on the tower. This provides temperatures hot enough to drive a chemical 'reforming' reaction. Methane and steam go in, energy and a catalyst are added; the resulting gas [carbon monoxide and hydrogen] is called syngas in the industry — we call it SolarGas. This gas has 26% more energy per kilogram than methane — it is solar energy embedded in chemical bonds. So the plant improves the energy value of the gas, and provides a precursor for other energy products, such as liquid fuels. We could link this process with carbon burial so that the carbon dioxide from the fossil-fuel component was sequestered.

How big is your solar tower?

RD: The original concept design made it 1 kilometre high and 7 kilometres in diameter, but we have developed new technologies that will make it substantially smaller and more powerful. A 50-megawatt demonstration plant will be built at Tapio Station, about 22 kilometres northeast of Mildura in New South Wales. This is not necessarily the optimum size, but it is the optimum size to build in the first instance to show the robustness of the technology. The front-end engineering and design are currently under way, and it would be premature of me to talk heights and sizes now, and then alter them in a week's time.

WS: The tower reactor is 15 metres above the mirrors, and the tops of the mirrors are about 3 metres off the ground. The total ground area is 40 × 40 metres, but that is because of our site constraints — it doesn't necessarily represent the ideal module size. So I don't want to make a big deal of the specific dimensions. It will produce up to 250 kilowatts of electricity. However, this is a research-size system. We designed this tower to represent a single module that could be replicated again and again to make it up to any desired capacity.

How does your system fit into the existing energy infrastructure?

RD: It operates as a power plant and feeds into the normal electricity grid.

WS: The gas can be used in gas turbines to make electricity or we can turn it into liquid transport fuels. We are investigating the use of existing gas pipelines to transport SolarGas. One idea is to do the solar-reforming reaction out in the desert region, where many gas pipelines originate, putting the SolarGas into the pipeline and transporting it downstream. We can have all the convenience of gas but with all the benefits of solar energy.

SolarGas can make liquid transport fuels and also fertilizer. After power plants, transport

W. STEIN/CSIRO

"We can use SolarGas in a broad range of sectors, not just electricity." — Wes Stein

and agriculture are the biggest greenhouse-gas emitters in Australia, so it gives us an opportunity to target more than electricity.

How are you trying to improve the technology?

RD: We can now create far greater heat under the collector roof. It captures more heat and retains more heat — it's a bit like double-glazing.

We now also have a method of storing heat in brine ponds, so that on days of lower solar radiation we can bring in that stored heat to create the temperatures we need. That means we have a system that could operate 24 hours a day, 7 days a week, 365 days a year.

WS: We believe cost reductions will come from improving the efficiency of the reaction and reducing the cost of the mirror field through mass production. We have two areas of research we are working on. One is to reduce the reaction temperature to around 550 °C [from around 800 °C]. That greatly reduces the capital costs of the mirror field, because fewer mirrors are required. We are using a novel arrangement of membranes to allow a much lower reaction temperature. We are in the middle of a patent application, so that's all I can say at present.

The second concept uses carbon dioxide as the reforming agent rather than steam, so we would be using a waste stream. Coal-seam methane is a rapidly growing resource in Australia. Methane from coal seams comes out with a fair amount of CO_2. Normally, that CO_2 is stripped off before the gas goes into the downstream pipeline — so we would make use of that discarded CO_2. But we need to develop new catalysts for that reaction.

How much does it cost?

RD: The original-concept 200-megawatt plant would have cost around Aus$800 million (US$610 million). The 50-megawatt plant will be substantially less, owing to a reduction in the structural dimensions, with final costings anticipated at the completion of the front-end engineering and design. We are working on the engineering of the optimally sized power plant with the optimum output, incorporating the new technologies. I could guess, but it's better to be sure than to mislead.

WS: This solar tower has cost us Aus$1.5 million to build. But we think that if we apply the same learning curve that turbines have experienced over the past 15–20 years, this same system would cost us around Aus$300,000 to build in the future.

What are your advantages over rival solar technologies?

RD: We can guarantee output to meet the demand, just like coal-fired plants.

WS: The advantages are that we can use SolarGas in a broader range of sectors, not just electricity; the very-low-cost potential; and the fact that it overcomes the transport and storage issues of solar energy.

Solar thermal has been around for a while — why has it not caught on?

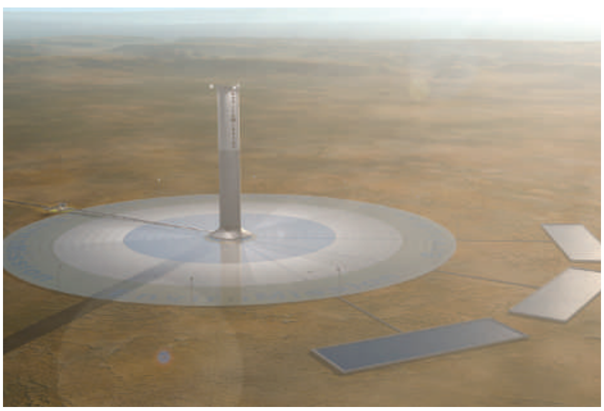
RD: I think it has caught on. That's why we're here.

WS: One of the difficulties it has had is the concept that it has to be built large for cost reductions to occur. It's one thing to build a system at the small demonstration level and enthuse everyone with that, and then say 'now I need to build 100,000 of these to be cost-effective in a 50-megawatt system'. I think the jump from that small to large scale has been too much for investors to handle, even though the modelling and calculations have always shown that it would be cost-effective.

Worldwide, investment in solar-thermal research is fairly low; why do you think that is?

RD: If you take the solar tower as an example, the original design had to be big to produce enough power to make enough money to pay for the capital costs. But with the additional technology we have added, we have created far more power out of a smaller plant.

WS: It is because of the difficulty investors have in biting off big chunks compared with the easier task of biting off small chunks. Photovoltaics are very sexy — they don't move, they don't make any noise sitting on top of a roof, and they can be made to look good on buildings. They are still very expensive, but they come in small chunks. It is much easier for investors to go with that concept than with a one-off, large, solar-thermal power station. It's only now, as a result of initiatives and incentives around the world, that solar-thermal technology is starting to take off globally.



ENVIROMISSION

Artist's impression of EnviroMission's solar tower, which will harness the Sun's heat to generate electricity.

J. SMITH/AAP IMAGE

"We have a system that could operate 24 hours a day, 7 days a week, 365 days a year." — Roger Davey

What stops power companies from making big investments in solar thermal?

RD: Power companies have investments in other assets, don't they?

WS: Purely cost. At the end of the day, it comes down to cost of the technology.

How much of Australia's electricity needs could solar thermal provide in 20 years — or in 50?

RD: We plan to develop approximately 2,100 megawatts of installed capacity by 2020. By 2030, we plan to have installed in excess of 6,500 megawatts of power, which would be the equivalent of the electricity usage of about 10 million households based on current energy use.

WS: I see no reason why, by 2050, solar energy couldn't be supplying at least 25% of Australia's energy mix.

Is your technology really only suitable for countries with big, empty deserts?

RD: No. Our solar tower operates on temperature differentiation — the creation of an environment with strong differentiation to ambient temperature will regulate where development is able to occur. Unfortunately, big, empty deserts do not serve electricity grids and have inherent supply-chain issues.

WS: Sensibly, yes. Technically, there is no reason why you can't do it in lower solar regions but the cost will be higher. I'm not advocating solar being a single solution for all Australia's energy needs. Theoretically it could be, but practically I don't think that will happen. ■

Carina Dennis is *Nature*'s Australasian correspondent.