Tower of power

Concentrated solar power (CSP) has had a difficult past, but it remains in the conversation as a renewable energy alternative. **RACHEL WILLIAMSON** examines CSP's history – and possible future.

The crop growing from the reddish Victorian dirt was more *War of the Worlds* than Clarkson's Farm: a field of 300 giant 4 x 5 metre mirrors, gently tilting on individual axles, were harvesting sunlight.

The solar bounty was concentrated into a beam that can melt steel, then aimed at what looked like an enormous 4m² theatre light, mounted at the top of a steel tower.

"Don't look at the collector," reminds John Lasich. The panel of miniature made-for-space solar photovoltaic (PV) cells topping the tower can withstand the laser-like brightness; the human eye cannot.

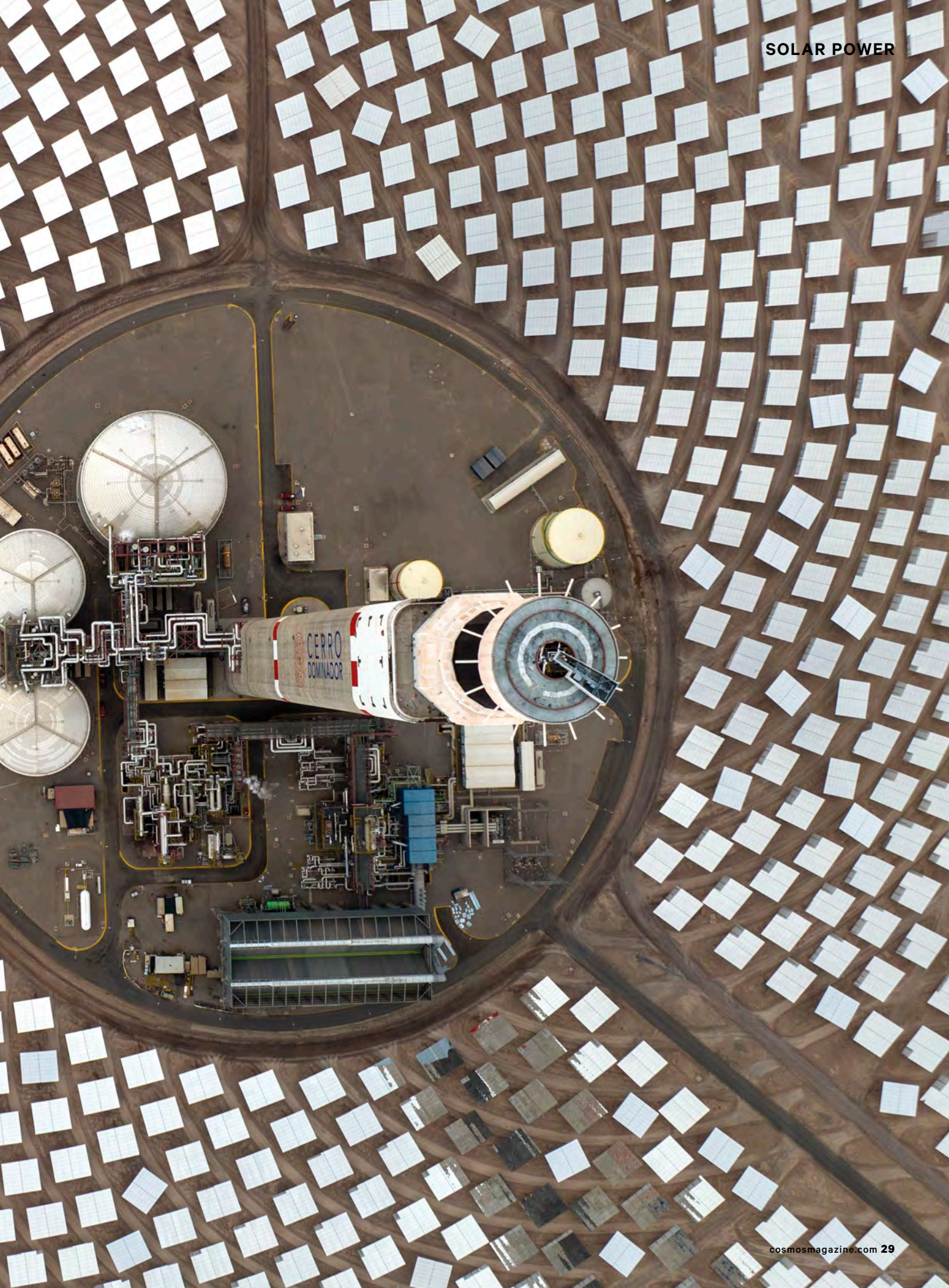
I am standing with Lasich, inventor of this solar thermal power plant and founder of RayGen, beside one of four fields of heliostats – mirrors – at RayGen's under-construction concentrated solar and energy storage pilot in Carwarp, a farming community in the north of Victoria. The forbidding glow of the towers looms over us as we tour the crusty-dirt worksite.

RayGen's system borrows heavily from concentrated solar power (CSP), specifically the type known as the power tower. Twelve years ago it was supposed to be Australia's path to a solar energy future. Today, it's an also-ran, damned by failure and overtaken by cheaper, faster solar PV and wind.

And yet Lasich says the time has come – not for CSP, but for *his* version, which incorporates some CSP elements with other tech to solve the increasingly urgent problem of solar and wind upsetting the stability of the electricity grid.

But we're discussing energy in Australia, where no two people think the same.

RayGen's former overseer at ARENA, Dominic Zaal, says Lasich's design actually solves a small-scale power problem similar to those faced by remote mine sites.


CERRO
DOMINADOR

RayGen competitor, Vast Solar, says *it* is solving the grid problem with new-and-improved traditional CSP.

BloombergNEF (new energy finance) analyst Jenny Chase says the grid problem is already being solved with lithium-ion batteries; CSP, she says, is for men with an engine "fetish".

Energy expert Tristan Edis denies grid stability is a problem at all.

The day may be arriving when CSP technology can claim its place in Australia's factionalised renewable energy tableau, but it must first prove one thing: that it can work.

CSP's chequered past

There are several forms of CSP, but the one deemed most suitable for Australia is the power tower. Sunlight is concentrated onto a tower-top receiver, heating molten salt to 560°C. That salt flows back through pipes to a heat exchanger, which boils water into steam to turn the same kind of turbine used in coal power plants. The "battery" element is a hot tank that can feed super-hot molten salt to the heat exchanger over a period of many hours, and a cold (290°C) tank that feeds the heat-sapped liquid back to the tower.



RayGen's Carwarp site has 300 mirrors that swivel to maximise sunlight for delivery to its "power towers."

In Australia, only Vast Solar's 1.1 megawatt (MW) demo at Jemalong, NSW, has succeeded, and only with an eye-popping price tag of $US14,919/kilowatt (kW), according to data from the US National Renewable Energy Laboratory (NREL). Globally, only six gigawatts (GW) of CSP has been installed commercially – and only 1.3GW of that is power tower, NREL data shows.

Technical problems have plagued the technology: including molten salt busting tanks open, and cloud-induced dips in sunlight wreaking havoc. But the idea is rising again. RayGen's Carwarp sun farm is already sending 4MW of PV power into the local grid as it finishes the 8MW turbine-and-thermal-storage backend and tests the computerised controls that will bring the whole complex machine together.

And it *is* complicated: the mini PV panels (100 times more expensive – but 1000 times more powerful – than a regular PV panel) generate normal solar power for the grid, but also heat. Water that flows behind the collector to keep it cool is heated to 90°C and piped back to a 16,000m^3 'hot' pit. It can then be used at will to boil ammonia (which has a boiling point under 90°C) to turn a turbine to generate as much as 17 hours of non-solar power. The cool water is held in a cold pit, ready to be "charged" again.

Vast Solar is yet to turn a sod on its newly acquired Port Augusta site in South Australia, but is confident this time it will be the winner, using new salt storage technology and software to maintain the 100% accuracy required from its heliostat targeting system.

CSP is not the only frontier energy storage idea Australia is having a go at. A massive compressed-air system is pencilled in for Broken Hill, in western NSW; Swiss whizzes want to build a gravity battery in Townsville, Queensland; and the Mars factory in Wodonga, northern Victoria, has signed up to a graphite battery. But CSP is the best cautionary tale to date for what can happen if the new technologies fail to live up to their promise.

Australia's first flirtations with power towers were in Queensland in 2011, when a French company pitched a $1.2 billion, 250MW project called Solar Dawn, and a demo plant separately launched at the Kogan Creek power station, near Chinchilla. Solar Dawn was scuttled the following year after failing to raise enough money, and Kogan Creek in 2016 after years of technical problems.

Around the same time, researchers at thinktank Beyond Zero Emissions analysed Australia's alternatives to coal and gas power and landed on CSP. The starting place for their campaign was Port Augusta.

Coal had been good to Port Augusta, but left a terrible legacy. From 1954, three power plants employed generations of workers, but in early 2012 Playford B, the country's dirtiest coal plant, was mothballed. Its neighbour, Northern Power Station, ran for three more years and took hundreds of jobs when it closed. In March 2015, Beyond Zero Emissions director Mark Ogge was called in to present to a sceptical Port Augusta council.

PREVIOUS SPREAD: JOHN MOORE / GETTY IMAGES. ABOVE:



The sun-collecting, curved heliostats range in size from the large to the huge. Typically more than 20m², some in development are reaching the 150m² mark.

"We finished the briefing and there was this stony silence," he says. "One councillor said, 'what about the cost of this?' And [mayor] Joy Baluch goes, 'well, what about the bloody cost of people in hospital with lung cancer, councillor?' And at that moment I realised we had a powerful ally."

Baluch's husband died of lung cancer, which she attributed to his job at the power plant; she died in May 2013 from breast cancer. Official statistics from 2010 showed Port Augustans had a lung cancer rate double the SA average. A "cancer atlas" produced in 2012 by the University of Adelaide for the SA Cancer Council shows lung cancer rates in Port Augusta remained at above average levels for years.

Between 2012 and 2017, a grassroots lobby called Repower Port Augusta Alliance campaigned to bring a CSP project to the town. Chair Gary Rowbottom, who worked in the power stations, believed it would provide the jobs "the normal mechanical sods among us" would need when coal-fired generators closed. Their champion? US company SolarReserve, introduced to Port Augusta by Ogge's team, which in 2017 proposed to build a copy of their $US1 billion, 150MW Nevada plant, to be christened Aurora.

But to get even that far SolarReserve had already made compromises that would prove fatal. To get the project off the ground, the company won a tender to sell power to the SA government. But it was forced to undercut bidders with cheaper alternatives, such as solar PV, with a maximum $78/MWh price.

According to BloombergNEF's Jenny Chase, 2022 prices for low-cost solar PV backed by a four-hour battery in Australia start around $60/MWh; the global CSP light-on-the-hill, the Cerro Dominador project in the Atacama desert in Chile, sells power for $US114/MW.

SolarReserve had also secured $110 million in low-interest loans from the federal government, but private investors couldn't be convinced to back it. Not only were they sceptical of SolarReserve's ability to make the low-low price turn a profit, but the company's Nevada plant was struggling with a crucial problem: engineers couldn't figure out how to stop the 560°C molten salt from melting the hot tank.

Other assumptions behind the Aussie plant didn't add up. It was supposed to produce almost three times as much power as the Nevada plant for less than half the cost, but from a less favourable location and with two hours less storage, wrote Alberto Boretti, a former RMIT scientist and now dean at Prince Mohammad Bin Fahd University in Saudi Arabia, in a paper last year.

"To expect [this performance]... was contemptibly optimistic. No investor, therefore, decided to risk [sic] on this project."

By 2019 the Aurora dream was over. SolarReserve went bankrupt the following year.

Now, VastSolar is relaunching Aurora and plans to build a 30MW CSP plant on the site, using that federal government funding. It's still looking for the final $70 million to cover its $180 million cost.

The current position

Sunny countries around the world are increasingly littered with fields of mirrors glinting at towers, parabolic troughs and linear fresnel systems.

The US has two operational CSP plants – the 377MW Ivanpah in the Mojave Desert, California, and SolarReserve's Crescent Dunes in Nevada, which reopened after it solved the leaking molten salt problem with new types of welds for the holding tanks. More recently plants have been built in Morocco, the UAE, Chile and China.

Chile is the bright shining light of the industry. The 110MW Cerro Dominador project is a hybrid of CSP and 100 MW of solar PV; its molten salt storage can provide a whopping 17.5 hours of power.

The project cost $US1 billion to build. Last year the company entered Chile's energy action with a second project, a three-tower CSP site in the north with a record low sub-$US34/MWh price.

Yet because Chile, like Australia, does not yet place a special value on dispatchable power – the ability to send 'firm' power into the grid at any time other than when it's made – it lost that tender.

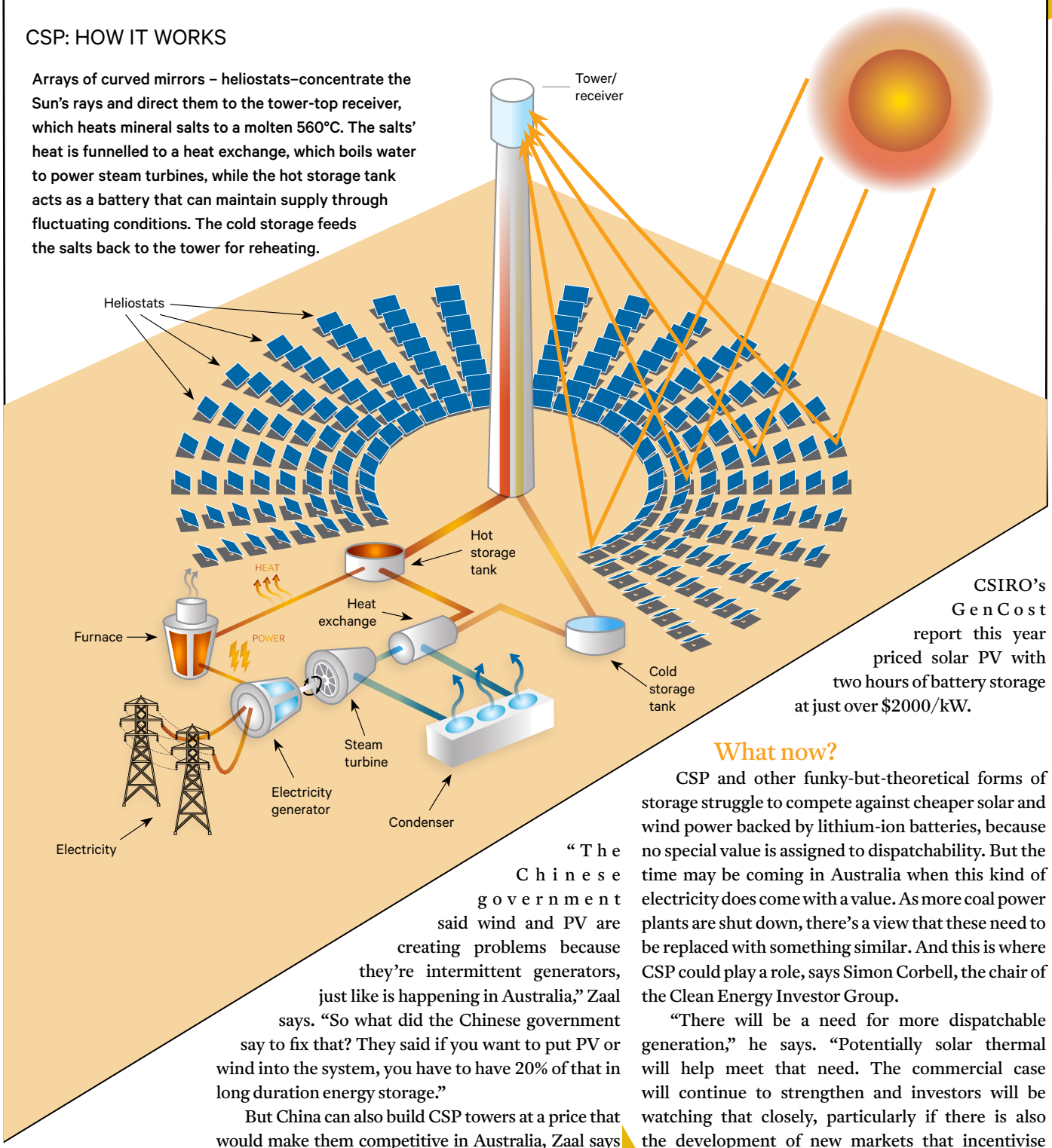
China is the one to watch, says Dominic Zaal, the director of the Australian Solar Thermal Research Institute (ASTRI). It has 28 CSP projects pencilled for launch in 2023 and 2024. Currently NREL data shows eight operational power tower projects in China, but the country has also consistently undershot its own five-year-plan goals for installed CSP, something it rarely does in any other field.

China is the one to watch ... It has 28 CSP projects pencilled for launch in 2023 and 2024.

VAST SOLAR

CSP: HOW IT WORKS

Arrays of curved mirrors – heliostats–concentrate the Sun's rays and direct them to the tower-top receiver, which heats mineral salts to a molten 560°C. The salts' heat is funnelled to a heat exchange, which boils water to power steam turbines, while the hot storage tank acts as a battery that can maintain supply through fluctuating conditions. The cold storage feeds the salts back to the tower for reheating.



"The Chinese government said wind and PV are creating problems because they're intermittent generators, just like is happening in Australia," Zaal says. "So what did the Chinese government say to fix that? They said if you want to put PV or wind into the system, you have to have 20% of that in long duration energy storage."

But China can also build CSP towers at a price that would make them competitive in Australia, Zaal says – $US3000 per kilowatt – and make money selling power for $US70/MWh. NREL historical data shows construction costs in the $US3000–5000/kW range.

Wood says Vast Solar's iteration of Aurora will cost $6000/kW – a considerable saving on the $22,000/kW NREL cites for its Jemalong plant. RayGen's Carwarp site will cost $30 million, but commercial manager Dr Kira Rundel says they don't have a breakdown of what that cost looks like at a per kilowatt level. However, she says the next project, a 300MW solar/150MW thermal storage plant in Yadnarie on the Eyre Peninsula, will cost $1400/kW for the solar farm and $2000/kW for the 24-hour thermal storage.

CSIRO's GenCost report this year priced solar PV with two hours of battery storage at just over $2000/kW.

What now?

CSP and other funky-but-theoretical forms of storage struggle to compete against cheaper solar and wind power backed by lithium-ion batteries, because no special value is assigned to dispatchability. But the time may be coming in Australia when this kind of electricity does come with a value. As more coal power plants are shut down, there's a view that these need to be replaced with something similar. And this is where CSP could play a role, says Simon Corbell, the chair of the Clean Energy Investor Group.

"There will be a need for more dispatchable generation," he says. "Potentially solar thermal will help meet that need. The commercial case will continue to strengthen and investors will be watching that closely, particularly if there is also the development of new markets that incentivise dispatchable energy, such as some kind of capacity mechanism in the National Energy Market."

That could mean a kind of Renewable Energy Target for stored energy, the subsidy that allowed wind and solar to take off from 2001.

Right now, companies like RayGen are positioning themselves in the witheringly dubbed "rhombus of regret", the area around Mildura where a lot of intermittent wind and solar is packed close to an electricity grid that isn't set up to transport it all. That's led to massive curtailment – when the energy market operator stops wind and solar farms from selling their energy because the infrastructure can't handle it.

GREG BARTON



Vast Solar's concentrated solar thermal power modules are made up of 700 mirrors.

Batteries are sneered at as a solution, because even the large-scale ones are designed to hold only up to about four hours of power. Yet, Price says, this is how the US is solving its grid+solar+wind problem.

Experts in Australia are cautious.

"Every time I've looked into CSP the point I've got to is there is a charismatic and persuasive and very dedicated engineer who's invested considerable time and effort in this and really believes in it," says energy economist Bruce Mountain, inaugural Director of the Victoria Energy Policy Centre.

"In an environment where governments are really keen to dedicate funding to new projects, they've obtained funding, and then they've struggled. But it's great we can afford to try these things so we really shouldn't stop. The benefit of the doubt should be given to those who have an idea that has some promise."

Climate Council senior researcher Carl Tidemann says despite its troubled history, CSP is promising. "It's been misunderstood as to what its role is. It's been compared directly with solar [PV], which has won the cost race for generating electricity, as have batteries in some ways," he says.

"If we hope to get off gas and coal completely we need longer-term storage. You can install as many batteries as you like, but they're not going to provide enough hours of storage to really start to displace coal and gas power."

"If we hope to get off gas and coal completely we need longer-term storage."

But what if Australia doesn't need long duration storage? What if, as Price says, the solution is just add another battery? Supply chains for lithium-ion components are broadening and cleaning out undesirable metals, and the large-scale market for them is growing faster than anyone expected.

A simulation from global renewable energy developer Windlab that scales up wind and solar and pumped hydro in the NEM suggests Australia can get away with just five hours of storage for all but a few weeks of the year.

"The case for long-duration storage has been that a bunch of people desperately want to believe that we will need it," says Green Energy Markets director Tristan Edis. "We don't need a lot of it. It's quite conceivable it could well be a bunch of biofuels sitting in storage tanks next to a gas turbine. CSP is not cheap per megawatt. What you want is cheap capex [capital expenditure]; and spend a lot on the fuel because you don't use it very often."

Concentrated solar power may still be the white elephant. And yet, without enthusiasts willing to keep niggling at the problems, we'll never have the chance to see if it could work in Australia.

As Repower's Gary Rowbottom put it: "It's safe to say 'it'll never happen' and be sceptical, because if it doesn't you can sit there smugly and say 'I told you so'. But it takes a bit of guts to advocate for something that's a little difficult." ◉

RACHEL WILLIAMSON is based in Melbourne. Her last story, on chronology, appeared in Issue 91.

VAST SOLAR