RMIT

The 3000 m² demonstration solar pond at Pyramid Hill during filling, showing surface-wave suppression rings which prevent wind disturbing the important salinity gradients.

One golden pond

After turning white death into gold on saline land in northern Victoria, entrepreneurs have built an ingeniously simple solar pond that generates cheap heat energy and helps restore salt-laden pastures.

In collaboration with RMIT University's Energy Conservation and Renewable Energy group, and former environmental engineering company*, Geo-Eng Australia Pty Ltd, Pyramid Salt Ltd is involved in the demonstration and commercialisation of a salt water phenomenon that promises great economic and environmental benefits.

'Solar pond' technology, which uses shallow ponds of saline water to harness solar energy, is expected to replace some of the demand in rural areas for industrial process heat from the natural gas grid, traditionally drawn from fossil fuels. Proponents of the technology say this will lead to a reduction in greenhouse gas emissions, while the associated fall in fuel costs will offer flow-on benefits for local economic development and job creation. Solar ponds can be readily integrated with salinity mitigation schemes aimed at returning salt-affected land to productive use.

The technical and economic viability of solar ponds for generating process heat was recently demonstrated at the Pyramid Salt salt works, thanks to a $550 000 grant from the Australian Greenhouse Office's Renewable Energy Commercialisation Program. The money helped fund construction of a 3000m² demonstration pond, which is currently supplying Pyramid Salt with heat to dry its high-purity, gourmet flake salt, extracted from saline groundwater.

The project is the first Australian attempt to demonstrate and commercialise the technology, despite decades of experimentation, both nationally and internationally. This circumstance may in part be due to the need for a large area of cheap land, an even larger supply of salt water, and a nearby industry capable of using the heat. However, as fossil fuel costs and greenhouse gas emissions rise, and solar pond infrastructure costs fall, the technology is looking increasingly attractive. Australia is now in a position to offer solar pond technologies and systems, and associated services, to prospective clients on a commercial basis.

*In 2003 Geo-Eng Australia Pty Ltd merged with the global professional services consultancy, GHD.

Simply efficient technology

According to the Solar Pond Project Leader, RMIT University Professor Aliakbar Akbarzadeh, commercial-scale solar ponds are upwards of a hectare in area, about two metres deep, and filled with water that gets increasingly saline with depth. As sunlight penetrates the water, heat is stored in the lower, more saline layers.

'Solar ponds can store solar heat more efficiently than a body of freshwater, because the salinity gradient prevents convection currents,' Akbarzadeh says.

'The lower convective zone contains a heavy layer of concentrated brine, while the upper convective zone is flushed with low salinity water. Convection in the gradient zone is therefore suppressed, because water in the heavy lower layers cannot rise.'

At Pyramid Salt, the first pond in the series of 13 that are needed to evaporatively extract salt from groundwater is partly filled with a concentrated brine solution. This is produced by pumping groundwater into the pond and allowing the water to evaporate until a salt concentration of about 300 000 parts per million is achieved. Low salinity groundwater (30 000 parts per million) is then 'injected' over the top of this briny layer, in a manner Akbarzadeh says is akin to making a colourful multi-layered cocktail. A grid of plastic rings is also used to suppress any wind-driven wave action on the surface of the pond, which could cause mixing and disturb the salinity gradient.

Heat is extracted using a heat exchanger (a series of water-filled pipes) at the bottom of the pond. Heated water in the pipes then passes through another heat exchanger, warming cool air to temperatures of 60–80°C. This heat is available 24-hours a day.

The pond not only provides heat to dry Pyramid Salt's final product, replacing heat previously generated by electric heating elements, it has also lowered the water table around the salt works, regenerating pastures and crop land up to three kilometres away.

Long-term commercial viability

As part of their agreement with the Australian Greenhouse Office, the Solar Pond Project partners were required to evaluate the technical performance and economic viability of the technology for process heating, and assess its potential to reduce greenhouse gasses.

In terms of its technical performance, the average rate of heat delivery to the salt works was between 40–50 kW in the first year of operation (2001). Temperatures in the bottom layer of the pond were approaching 70°C in the summer of 2002, and the project team expects an annual average output of 60 kW will be achieved.

As pond efficiency can be marred by the growth of algae, which reduce the ability of sunlight to penetrate

CSIRO Land and Water

Solar ponds could provide a welcome and profitable means of returning the viability of salt-affected areas in Australia.

and heat the water, the team developed an innovative solution: brine shrimp.

'You can control algae using chemicals to change the pH, but brine shrimp offer a cheaper, low maintenance way of maintaining reasonable water clarity,' Akbarzadeh says.

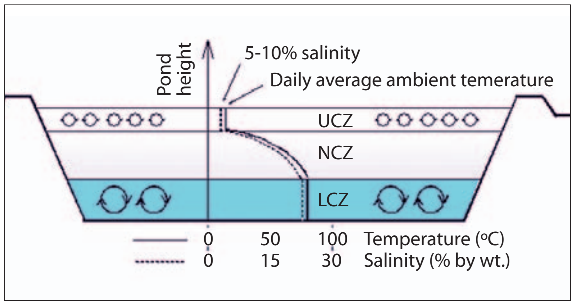
'The shrimp also provide a profitable sideline for Pyramid Salt, which sells them to the aquarium industry and fish farms.'

In terms of the technology's economic viability, project manager Dr John Andrews, also of RMIT University, says solar ponds in suitable locations can be economically competitive over 10 years, compared to LPG and electricity.

'We estimate the unit cost of heat delivered by a solar pond system to be about $23/GJ,' Andrews says.

'This is under half that typical for electric heating, and just under that for LPG at $24/GJ. So the corresponding simple payback periods are just over three years against electricity and just over seven years against gas. Further savings are expected as commercialisation of the technology proceeds, and as the cost of electricity and gas rise.'

As the outlay to construct a solar pond will vary from site to site due to differences in the soil type, terrain, availability of salt water, and the distances between the pond and heating application, Andrews says site-specific economic evaluations will be necessary.



From Burston and Akbarzadeh (1995)

In a salt-gradient non-convective solar pond, the lower convective zone (LCZ) contains concentrated brine. Salinity decreases progressively with height through the non-convective zone (NCZ). The upper convective zone (UCZ) is flushed with low salinity water. Convection in the NCZ is suppressed so that solar heat is stored in the LCZ.

Greenhouse savings

The project partners' 3000m² solar pond has been calculated to reduce greenhouse gas emissions from electricity generation by some 874 tonnes per year, and by around 17 500 tonnes over 20 years.

'On the conservative assumption that the annual rate of installation of solar pond heating systems in Australia rises linearly to 0.1 km²/yr, the annual greenhouse savings in 2008 would be around 87 000 tonnes per year, and the cumulative savings over five years would be some 0.2 megatonnes,' Andrews says.

Further work is now needed to evaluate the market potential and hence the greenhouse gas reduction potential of solar pond heating systems in Australia. Andrews says process heat from solar ponds will be useful for a range of rural industries, including dairy product manufacture, food processing, and fruit and grain drying, especially in salt-affected areas.

'There are many such industries in the Murray - Darling Basin, and other areas with high salinity levels in Australia,' Andrews says.

'Commercialised solar pond technology therefore has the potential to reduce greenhouse gas emissions and fuel costs in a wide range of rural industries.'

Powering on

The project partners are now planning stage two of the project; an evaluation of the commercial potential of the solar pond for electricity generation and combined heat and power. This could be achieved by incorporating a gas-driven turbine into the equation.

'Hot water from the solar pond could be used to evaporate a low boiling point chemical, such as a hydrocarbon liquid, to form a high pressure gas which could drive a turbine and produce electricity,' Akbarzadeh says.

He says energy from the ponds could also be used to desalinate water.

'We could use hot brine from the bottom of the pond as a working fluid in a power-generating cycle, which would produce electricity and freshwater.'

Concentrated salt water produced as a by-product of this process could then be used to top up the briny layer in the solar pond.

Power production and desalination have been proven in other countries, including America and Israel. It is only a matter of time before Australia makes them a reality too.

● **Wendy Pyper**

Contacts: Dr John Andrews: (03) 9925 6085, andrews.john@rmit.edu.au
Professor Aliakbar Akbarzadeh: (03) 9925 6079, aliakbar.akbarzadeh@rmit.edu.au
www.mm.rmit.edu.au/research/energygp.htm