Australian Government
Australian Renewable Energy Agency

Roof-Mounted Hybrid CST System for Distributed Generation of Heating, Cooling and Electricity

2010 2-A017

Project results and lessons learnt

Lead organisation:	Australian National University		
Project commencement date:	01/08/2011	**Completion date:**	30/4/15
Date published:	30/4/15		
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Project overview

This project was a partnership between the Australian national University, the University of New South Wales, RMIT University, CSIRO, NEP Solar and Chromasun.

The aim of the project is to develop an improved roof-mounted hybrid solar concentrator for the cost-effective delivery of heating, cooling and electricity that is suitable for installation on buildings. The key innovation of the project is the use of spectral splitting of sunlight to improve the overall efficiency. Only the part of the solar spectrum most suitable for photovoltaic (PV) conversion by the solar cells is directed to silicon solar cells. The balance is directed to a thermal absorber to heat a circulating thermal fluid to 120-150ºC. In addition, novel cooling technology that takes advantage of the 120-150ºC thermal output of the system was developed by CSIRO.

Chromasun solar micro concentrator

Project Outcomes

In order to develop a hybrid solar concentrator, a range of modelling, materials and subsystems were studied and developed. These included:

- Adapting one-sun solar cells (commercially available in vast quantities) for use under concentrated sunlight. Efficiencies under concentration of greater than 20% were realised, despite the large resistive losses involved in operating one-sun solar cells at 30 suns.
- Development of a suitable substrate for mounting of the solar cells that meet requirements relating to electrical connection, heat sinking, thermal expansion mismatch and survivability.

- Development of encapsulation methods for the solar cell assembly that meet requirements for survivability in accelerated failure testing.
- Optical modelling of beam splitting so that the best fraction of sunlight is directed to the solar cells, with the rest being directed to a thermal absorber to create heat.
- Identification of suitable thermal fluids for the glass channel that meet cost, technical and safety requirements
- Fabrication of PV receivers and absorbing thermal receivers, integration into a complete package, and mounting at the focus of a Chromasun micro-concentrator at ANU and at the focus of an NEP parabolic trough at UNSW.
- Measurement of performance of completed systems
- Economic and performance analysis of hybrid systems in comparison with alternatives including gas, grid electricity and electricity from roof-mounted conventional PV systems.
- Use of super-heated steam to regenerate a conventional high temperature desiccant wheel to assist with demonstrating solar cooling in buildings.
- Analysis of the potential for solar cooling to compete with alternative methods.

NEP system

Commercial prospects

The recent (and continuing) rapid price reduction in photovoltaics systems was foreseen by few people, and is causing widespread energy market disruption, possibly on a scale not seen since the introduction of oil a century ago.

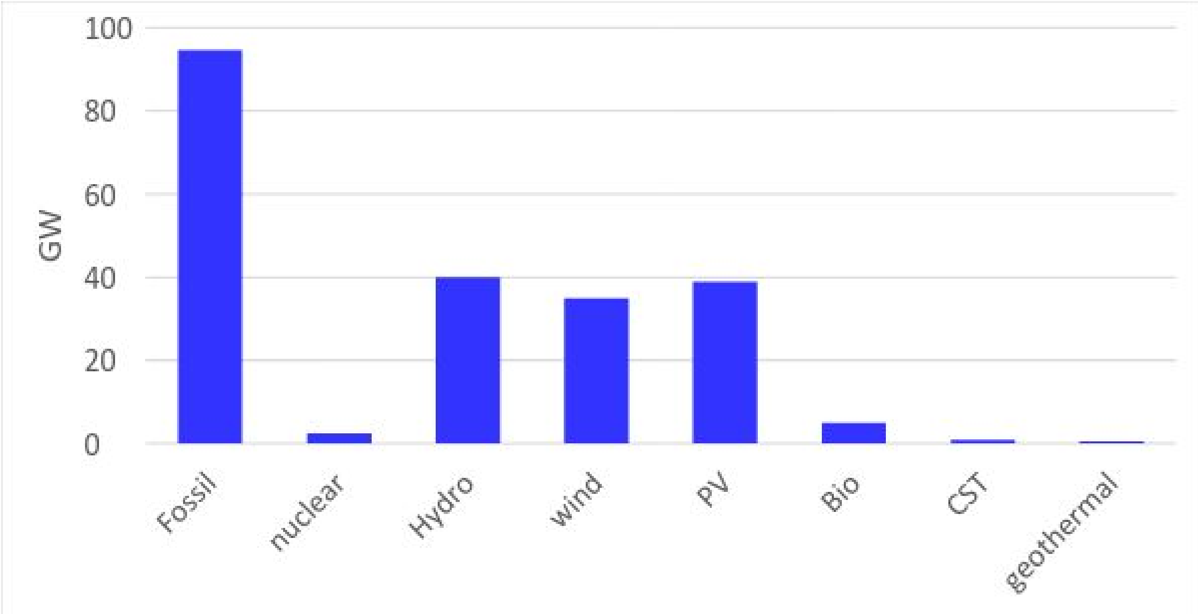
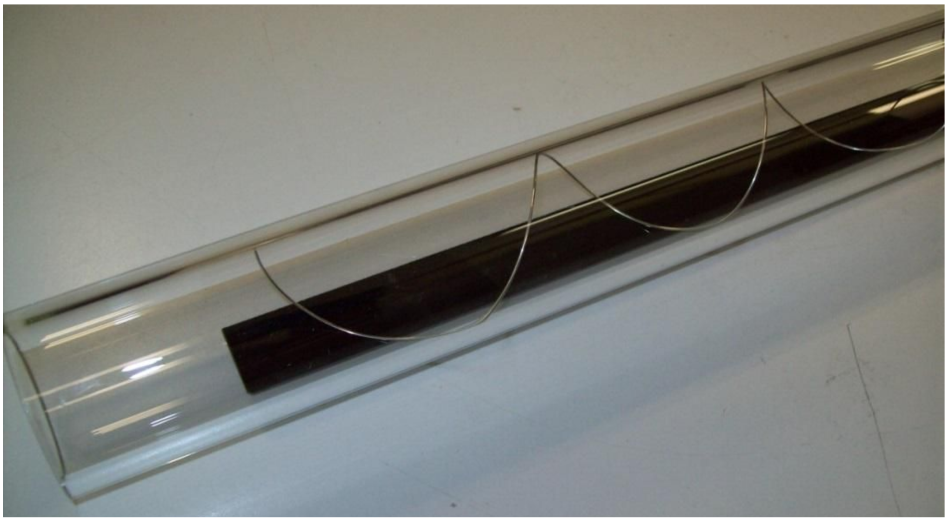


Figure 9.1: new generation capacity added worldwide in 2013 by technology type. PV and wind constitute nearly 100% of new generation capacity installed in Australia each year, and will soon exceed half of new capacity installed annually worldwide

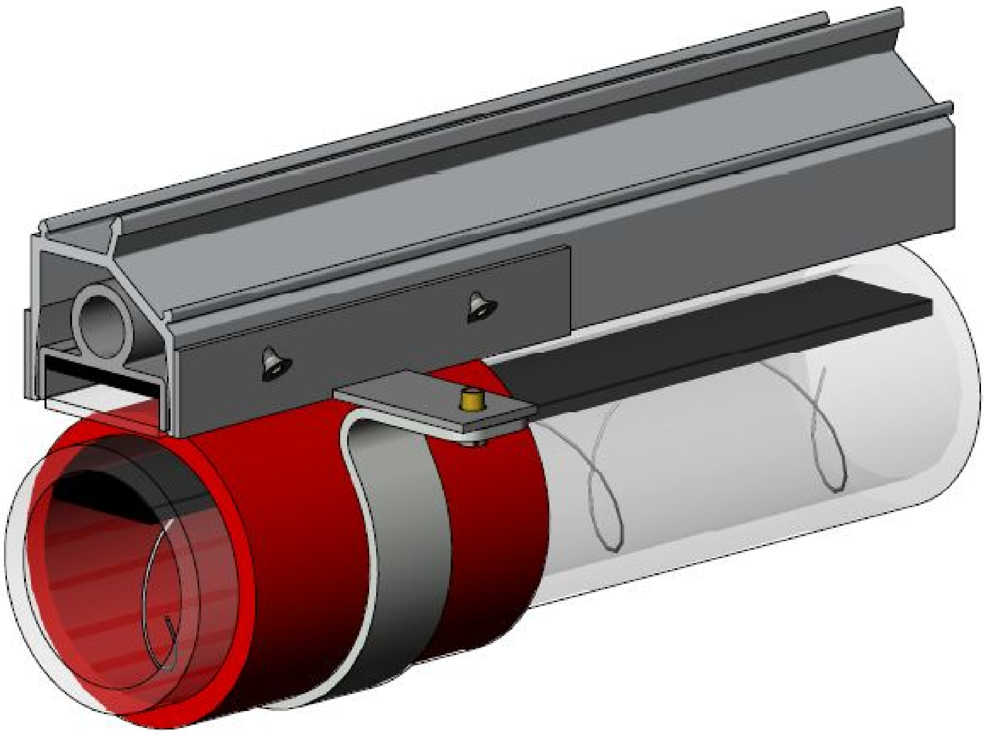
The cost of installed roof-mounted silicon PV systems in Australia has declined by nearly a factor of 3 since this project was approved. Energy from roof mounted PV systems, alone or in conjunction with heat pumps (which use electricity to move heat from one place to another), is now cheaper, often substantially cheaper, than domestic and commercial gas, off-peak and on-peak electricity, and alternative solar collectors, for supply of electricity, space heating and cooling, hot water, and medium temperature steam.

This remarkable phenomenon impacts on the commercial prospects of all competing solar systems. Concentrating solar thermal, concentrating PV, solar water heaters and all non-standard PV technologies, are being driven into niches or obscurity by the silicon juggernaut. Large investments in renewable energy technology are being written down, and enormous investments in gas and conventional electricity assets are also at risk.

PV receiver showing the solar cells



Absorber plate in place within the thermal channel glass tube



Schematic of the competed and mounted PV-thermal hybrid receiver

Transferability

The project was a technical success. At an earlier time it would have been relatively straightforward to carry on development of the hybrid PV-thermal receiver in collaboration with commercial partners who are actively engaged in commercialising and selling thermal-only roof mounted solar systems – Chromasun and NEP. However, a largely unforeseen event has overtaken the project, namely the strongly declining cost of PV electricity from roof-mounted systems, and of PV and wind electricity from ground mounted systems. This is putting pressure on all non-standard solar technology, as well as conventional gas and electricity businesses. Commercial prospects require careful consideration in this environment.

Information about the methods and systems developed during the project have been widely disseminated via visits of people to our facilities, outreach activities in the media, publications in journals and presentations at conferences.

Conclusion and next steps

Although the route to successful commercialisation of the technology developed during this project in the near future is unclear, the project was still worth undertaking. A large amount of information has been generated which is now available to others interested in hybrid energy systems. The question of whether a hybrid system can be successfully commercialised can now be answered with substantially certainty. The skills that have been developed by students and staff in terms of modelling, characterisation, analysis, and knowledge of solar systems in general, are available to other solar projects.