



Solar Thermal Foundation Project

Final report: project results

Lead organisation: Commonwealth Scientific Industrial Research Organisation

Project commencement date: July 2009

Completion date: October 2013

Date published: 24 June 2014

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Executive Summary

This project involving the CSIRO and Australian National University (ANU) aimed to establish state of the art research facilities for concentrated solar thermal research in Australia. This was achieved through the establishment of Australia’s largest solar thermal research hub incorporating a new solar thermal tower and thermal storage laboratories at the CSIRO National Solar Energy Centre in Newcastle, New South Wales in addition to improvements to ANU’s “big dish” parabolic dish concentrator in Canberra, Australian Capital Territory.

The new solar thermal research hub comprises a 30 metre high solar tower surrounded by a 4000 square metre field of 451 locally-manufactured custom-design mirrors (heliostats), capable of generating temperatures of up to 1500 degrees Celcius.



CSIRO National Solar Energy Centre, Newcastle, Australia

The hub provides a platform that allows Australia’s best researchers to develop, test and commercialise Concentrated Solar Power (CSP) technologies side by side with industry partners and research institutions around the world.

Project Overview

Project summary

The Solar Thermal Foundation Project established a state of the art research facility for ongoing development of enhanced CSP components, processes and products. This was achieved through the

construction of a new 1.2MWth concentrating solar thermal tower at the CSIRO's Newcastle Energy Centre.

The project has already generated strong industry interest with a number of subsequent projects utilising the capabilities of the facility. These projects have included:

- \$7M Advanced solar thermal energy storage technologies project in collaboration with Abengoa Solar (Spain)
- \$10.6M Solar Air Turbine Systems in collaboration with Mitsubishi Heavy Industries (Japan)
- \$6.24M Solar-driven supercritical CO₂ Brayton Cycle in collaboration with Sandia National Laboratories (United States), National Renewable Energy Laboratory (United States), University of Sydney, and Queensland University of Technology

CSIRO uses the facility to develop and test solar air turbines that generate electricity from air and sunshine alone. This is a new area of solar research and will provide cost effective and efficient energy solutions to remote arid towns and industry in Australia and around the world.



Australian National University SG4 “Big Dish”, Canberra, Australia

As part of the foundation project, the Australian National University also evaluated the solar air turbine technology used in the Solar Thermal Research Hub for use on solar parabolic dishes.

Project scope

This project was one of three foundation projects funded by ARENA (originally through the former Australian Solar Institute) and was primarily aimed at establishing state of the art research infrastructure for concentrated solar thermal research activities in Australia.

In 2008 the research needs of CSIRO's CSP program were extending beyond the technical capabilities of the existing facilities at CSIRO's National Solar Energy Centre in Newcastle. The next generation of

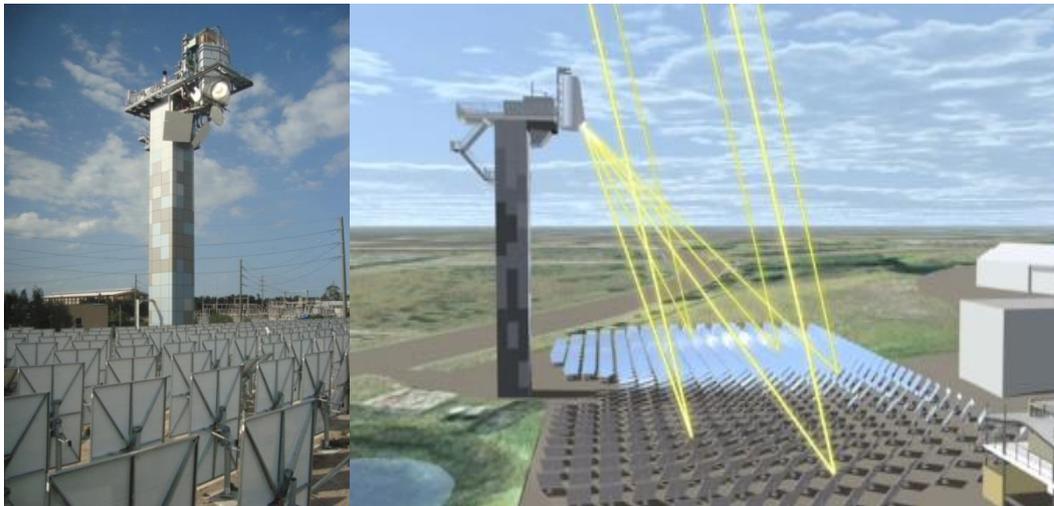
research and development required a facility able to achieve higher temperatures, higher solar flux¹, improved flux control, and higher temperature receiver development.

The Solar Thermal Foundation Project set out to achieve three primary outcomes:

- Outcome 1 - Establishment of a state of the art research facility suitable for ongoing development of enhanced CSP components, processes and products.
- Outcome 2 - A fully operational demonstration of a high temperature engine generator.
- Outcome 3 - Completion of a flagship project as the basis of a calibre to attract international research partners, and excite the growth of a strong Australian solar thermal capability.

Outcomes

The key outcome from the Solar Thermal Foundation Project was the establishment of a state of the art research facility for ongoing development of enhanced CSP components, processes and products. This outcome was achieved through the construction of a new 1.2MW_{th} concentrating solar thermal tower at the CSIRO's Newcastle Energy Centre.



CSIRO Newcastle Energy Centre, photo and diagram

This project has provided Australia with unique world class research capabilities that provide us with a competitive advantage for attracting key international researchers and organisations to undertake collaborative research with Australia institutions. The project has provided a research platform for projects within ARENA and a path to collaboration with solar component companies, Universities, and companies preparing to undertake commercial scale solar demonstration projects.

Key highlights of the project included:

- Construction and commissioning of a world class 1.2MW_{th} high flux solar thermal tower research facility.
- Successful demonstration of a solar air turbine system.

¹ Solar flux refers to the solar energy rate per unit area and is measured in W/m²

- Development of low cost high performance heliostat technology leading to world record performance of Mitsubishi Heavy Industries receiver.
- 4 patents related to heliostat technology.
- Successful engagement with Australian SME's for fabrication of facility in particular world class heliostat technology.
- Extensive media coverage and exposure: 75 print articles (combined circulation 2.08 million), 4 Television stories (372,000 viewers), 8 radio interviews, 55 online articles.
- Official opening of the facility by the Prime Minister of Australia, June 2011.

The foundation project has greatly accelerated the development of CSP technology in Australia. The \$5M investment in the Solar Thermal Foundation project by ARENA has to date leveraged over \$35M of additional research investment into CSP including research projects to develop advanced solar air turbine systems, high temperature steam and thermal storage, and advanced developments in solar driven supercritical CO2 turbine cycles.

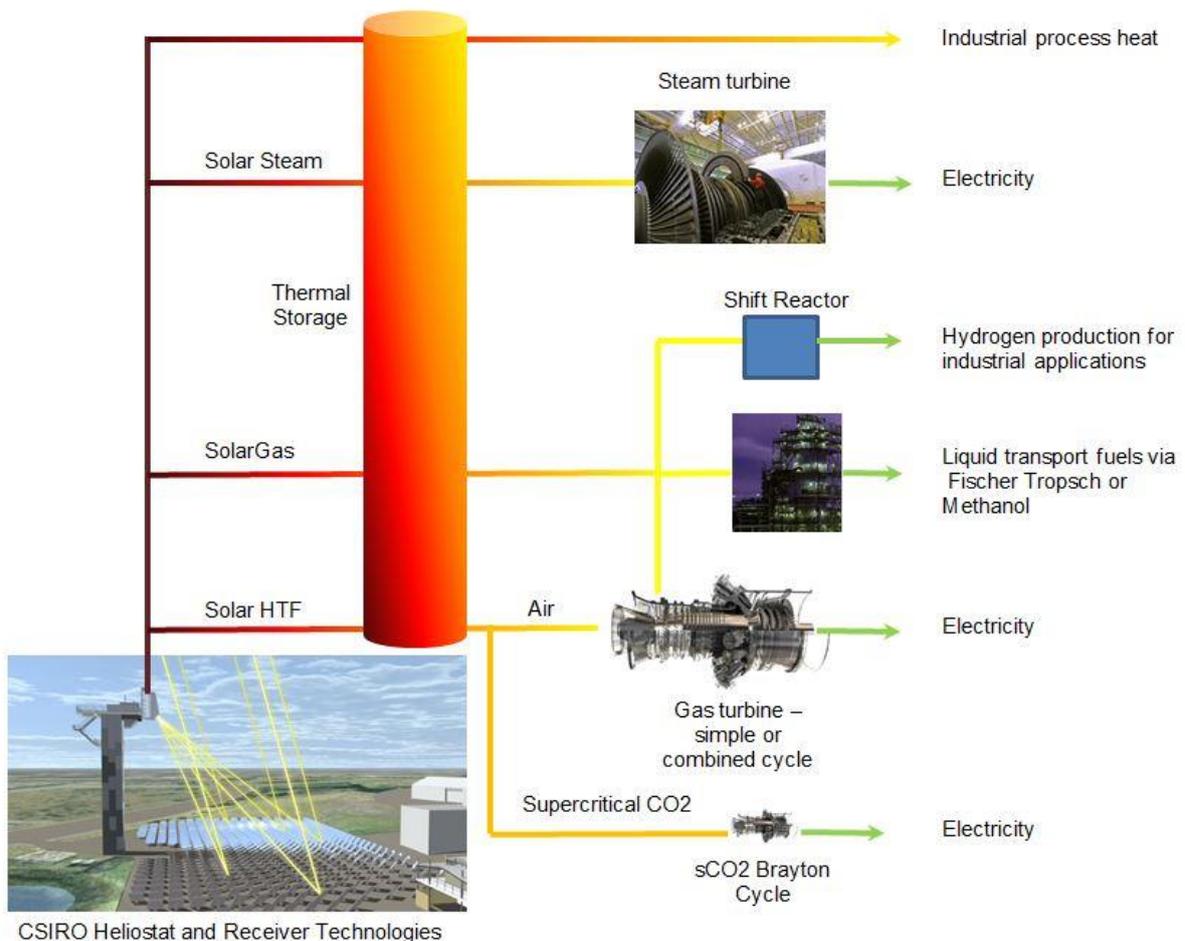


Transferability

This project highlighted the importance of large scale pilot facilities for the development of CSP technologies and confirmed the ability of these facilities to generating successful industry partnerships. The construction of this research infrastructure has attracted significant investment by major international companies including Mitsubishi Heavy Industries (Japan), Abengoa Solar (Spain), and General Electric (United States).

The Foundation project has also placed Australia at the forefront of CSP research and development by allowing for the development of technologies able to achieve higher temperature, higher solar concentration ratios, improved optical performance, higher receiver efficiency, and higher temperature thermal storage temperatures. These technological developments will ultimately drive cost reductions in the levelised cost of energy (LCOE) leading to lower cost renewable energy.

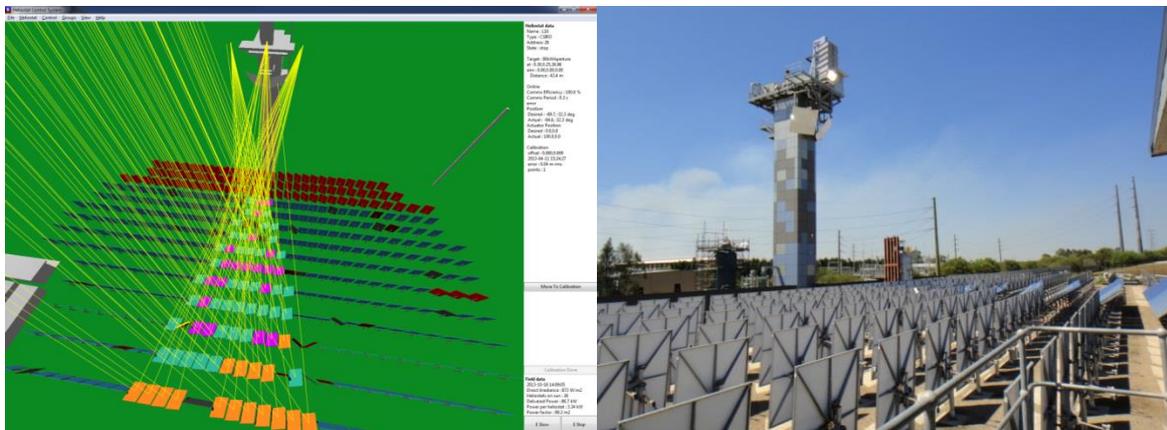
The project has also affirmed that CSP technologies are well suited to domestic manufacturing. Australia is typically an adopter of energy technologies with most of these technologies imported. Most of the technology demonstrated in this project has been Australian design and Australian manufactured providing a good case study for the potential of a domestic CSP industry.



The heliostat technology developed and implemented as a result of the Foundations project provides a number of advantages compared to existing technology:

- Improved design leading to lower construction costs and whole of life expenses;
- Shaped mirrors for precision concentration of solar radiation;
- Simple design to facilitate low cost, mass production manufacturing;
- Light weight prefabricated components that can be assembled rapidly on site by a two man team without the need for heavy lifting equipment;
- The flexibility to be installed on uneven ground, reducing site preparation costs;
- Simple plug and play field wiring reducing the need for skilled electrical trades during installation;

Modular design that utilises a novel actuation mechanism combined with a precision patented control system and superior field design capabilities allow for a closely packed field to minimise land use.



Heliostat System “On-sun” During Air Turbine Test October 2013

The project also allowed for a practical demonstration of Australia’s manufacturing sector capabilities in the construction of CSP technology. Almost the entire facility was built using Australian designs, materials and Australian companies to deliver the project under CSIRO’s management. The project was a model for successful engagement with Australian SME’s for the fabrication of the facility in particular the development of a world class heliostat technology.

The key technical challenge for the project related to the sourcing of the heat engine for the demonstration of the solar air turbine system. The lack of local manufacturing capability for small scale brayton cycle turbines meant that the heat engine had to be sourced from international suppliers. With the added technical challenge of modifying a standard turbine design to allow for the solar thermal input with no local technical support, many of the potential suppliers were unwilling to provide a one off custom turbine for the purposes of research and development activities. This difficulty led to delays in the completion of the solarised air turbine demonstration on the facility.

Conclusion and next steps

Since the establishment of the new solar tower as part of the Foundation project, CSIRO has been able to extend its CSP research program to demonstrate a range of market applications for CSP

technologies in Australia. Since commissioning the facility has been utilised for a range of projects including projects for high temperature air for operation of gas turbines and demonstration of next generation SolarGas™ technologies being developed by CSIRO.

The establishment of this facility, the enhancement of ANU's dish technology, and the associated follow on research programs has greatly raised Australia's profile in CSP and we now are at the forefront of this technology attracting major technology developers to invest in research and development in Australia and creating a commercialisation pathway for Australian developed technologies to be deployed globally.

The foundation project provided CSIRO with the opportunity to employ 10 years of experience and know-how in the development of central receiver systems resulting in 4 patents for the heliostat technology implemented on foundation project. Active commercial discussions for the licencing of this heliostat technology are currently ongoing in what we envisage will be the first of many Australian CSP technologies to be commercialised due to the investment by ARENA in CSP infrastructure in Australia.

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Other resources

<http://www.csiro.au/Outcomes/Energy/Renewables-and-Smart-Systems/Solar-Energy-Centre.aspx>

<http://csirosolarblog.com/>