Prospects of future concentrated solar thermal markets in Australia and beyond

Meeting summary by Wojciech Lipiński, Gabriele Sartori and Kenneth Baldwin
Canberra, 22 July 2016

Participants

National and international representatives from research, industry and governmental and non-governmental bodies participated in the summit.

- Kenneth Baldwin, ***Roundtable Chair***, Director of the Energy Change Institute, The Australian National University, Australia
- Gabriele Sartori, Australian Renewable Energy Agency, Australia
- Louise Vickery, Australian Renewable Energy Agency, Australia
- Rhonda Dickson, Department of Environment, Australia
- James Minto, Department of Industry, Innovation and Science, Australia
- Stuart Richardson, Department of Industry, Innovation and Science, Australia
- Joe Coventry, The Australian National University, Australia
- Wojciech Lipiński, The Australian National University, Australia
- John Pye, The Australian National University, Australia
- Graham Nathan, The University of Adelaide, Australia
- Wes Stein, ***Roundtable Discussion Moderator***, CSIRO, Australia
- James Fisher, Vast Solar, Australia
- Michael Ison, Cement Industry Federation, Australia
- Keith Lovegrove, IT Power, Australia
- Sid Marris, Minerals Council of Australia, Australia
- Daniel Thompson, SolarReserve, Australia
- Jens Sondergaard, Aalborg CSP, Denmark
- Cedric Philibert, International Energy Agency, France
- Christian Sattler, German Aerospace Center (DLR), Germany
- Ayako Matsumoto, Mitsui Global Strategic Studies Institute, Japan
- Bill Gould, SolarReserve, USA
- Ellen Stechel, Arizona State University, USA
- Joseph Stekli, US Department of Energy, USA

Organisation

A *roundtable discussion summit*, co-organised by the ANU Energy Change Institute (ECI) and the Australian Renewable Energy Agency (ARENA), was held at The Australian National University on Friday, 6 May 2016, 14:00–16:30.The discussion was followed by a tour of the ANU Solar Thermal Laboratories.

Purpose

The purpose of the *roundtable discussion summit* was to bring together research, industry and government to discuss the state of the art in CST technologies, identify benefits of their development for the Australian society and economy, discuss the role of research in technology development and commercialization, and explore the market potential in the national and international context.

Discussion outcomes

At present, energy-related greenhouse gas emissions are produced mainly by combustion of fossil fuels in three main areas, the electricity generation in power plants, heat generation for industrial processes, and land, sea and air transportation. In the Post COP 21 Era, emissions in all three areas need to be significantly reduced to achieve the 2°C goal and meet the national pledges. As penetration of intermittent renewables in the electricity sector increases, there is a greater need for dispatchable renewable energy, inertia and frequency control. Concentrated solar thermal technology is one viable alternative to address this challenge.

The technology is able to supply energy at times when the price for electricity in the wholesale market is high and consumers are ready to pay supply premiums—usually during diurnal peak demand in the late

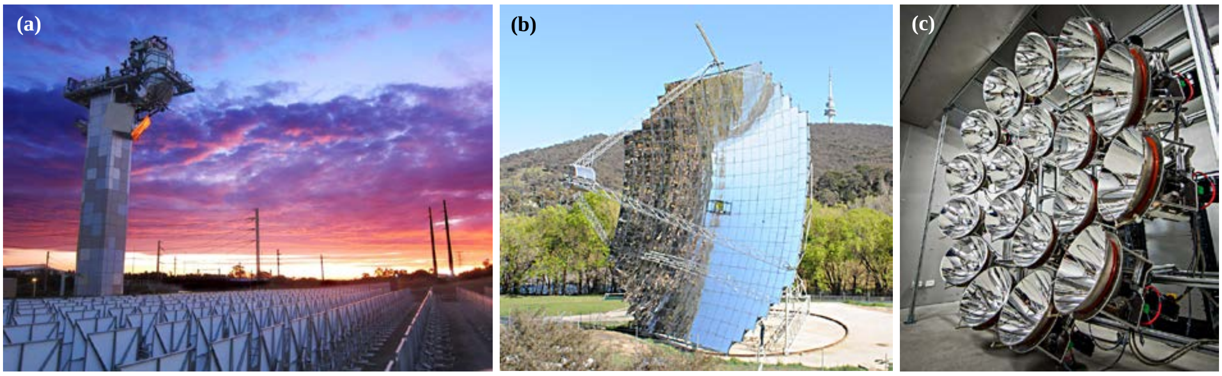

Figure 1. Flagship Australian CST research facilities: (a) 1MW$_{th}$ solar tower at CSIRO, (b) 0.5 MW$_{th}$ Big Dish at ANU, and (c) 45 kW$_{e}$ high-flux solar simulator at ANU.

afternoon and evening. CST R&D activities aim at substantial cost reductions towards near-term technology commercialisation. In particular, the electricity price target currently set within the Australian Solar Thermal Research Initiative (ASTRI) is 0.12 AU$/kWh.

CST is a technology most suitable for high direct normal irradiance (DNI), dry locations with minimum cloud coverage. The main demonstration and commercialisation developments with CST technologies are observed on all continents, with the United States, Spain, Morocco, South Africa, Middle East, China and Chile taking the international leadership. Australia has outstanding natural conditions for development of CST for domestic and global uses and has been building its technical capabilities for this application. With the specific Australian geographical and demographic conditions, scalable, modular and low cost solutions—in particular for fringe-of-grid and off-grid areas—should be considered along the traditional medium- and large-scale systems in the initial phase of CST deployment in Australia.

Australia has developed world-class CST research capabilities to advance the science and engineering, and reduce the cost. Figure 1 shows the flagship Australian concentrating solar research facilities: the 1 MW$_{th}$ solar tower at CSIRO, the 0.5 MW$_{th}$ Big Dish at ANU, and the 45kW$_{e}$ high-flux solar simulator at ANU. Significant research is supported by the $80M national R&D programme Australian Solar Research Initiative (ASTRI) funded by the Australian Renewable Energy Agency (ARENA) as well as other research and development grants directly awarded through ARENA to academia and industry. The Australian Research Council (ARC) provides grant funding to academia for more fundamentally-oriented investigations. Industry sponsors research and development projects either directly or by making contributions to federally-sponsored projects such as those of the ARC Linkage Programme. In this context, the promising research areas discussed in the roundtable are the development of modular solar receivers using liquid metals as heat transfer fluids, particle receivers, supercritical CO_2 turbines, low-cost optical fields, high-temperature and high-capacity thermal energy storage systems, as well as technologies for production of solar fuels and material commodities.

The roundtable discussion identified the main barriers to the development of the CST industry and the end-user market in Australia. As a country with its economy still largely based on trading vast amounts of low-value mineral resources including fossil fuels and other commodities such as iron ore, few incentives effectively exist to promote transformation towards a sophisticated technological and economic environment for research, development, domestic commercialization and global export of novel energy technologies. Australia, as a developed, high-tax, high labour cost country, has relied on foreign manufacturing and imports of high-value products including those produced from exported Australian low-value minerals. A transformative development of the renewable energy sector in Australia, in particular CST, necessitates development and sustained implementation of an orchestrated plan, in which technical, economic, educational, environmental and societal targets are synchronized. This summit has identified the following areas recommended for consideration by technology developers, industry, users and policy makers.

CST opportunities in Australia

State-of-the-art solar concentrators allow for achieving temperatures in the range 100–1500°C, and provide concentrated radiative power in the range from few kW to hundreds of MW. These technical parameters meet compatibility requirements for a broad range of industrial applications with electricity production and thermal and thermochemical processing. The applications span from large-scale electricity production in centralized configurations including high-value storage capacity to smaller, fringe-of-grid and decentralized electricity production, from low- and mid-temperature agricultural and industrial feedstock preprocessing and product upgrade to advanced high-temperature processes for production of transportation fuels and energy-intensive material commodities, from solar-only processes to hybrid solar–fossil processes.

Three special applications have been identified as vectors for future CST developments: efficient generation of **dispatchable electricity, solar production of fuels (as energy storage or for transport), and thermal and thermochemical industrial processing including metals processing.** It is predicted that CST will become cost competitive for dispatchable electricity production in the foreseeable future, mainly due to cheaper demand-matching thermal storage technologies, as compared to photovoltaics or wind turbines combined with batteries.

Solar production of fuels, in particular aviation fuels, is predicted to play an important role for Australia and the world, as the need for emissions-reduced aviation and maritime fuels is increasing. In the Australian context, domestic production of solar kerosene and diesel (partially using biomass as feedstock) will address the national energy and transportation security.

Australia's uniquely collocated mineral and solar resources enable solar thermal and thermochemical processing for production of material commodities. High-temperature solar production of cement, metals, ceramics, fertilisers (ammonia) and processing of hazardous waste streams are the example opportunities. High-temperature solar thermal and thermochemical processing may greatly benefit from development of high-capacity, high-temperature thermal storage technologies to enable continuous processing resulting in higher-quality metal products. Low-temperature CST processing, mature from the R&D perspective in Australia, has deployment potential in agricultural and food & beverage sectors such as dairy processing, greenhouse crops, as well as desalination.

CST as the Australian-led energy technology

Creation of a robust CST R&D&C environment in Australia with global leadership ambition is feasible, as stressed by international roundtable participants. While the national research capabilities are being set up, it is crucial to simultaneously create sustained industry that implements the research outcomes in form of domestically deployed solar plants and exportable high-value products, from technology intellectual property to CST-products such as electricity, fuels and material commodities. The development of CST research and industrial capabilities is inherently linked with expanding the Australian higher-education capabilities in Science, Technology, Engineering and Mathematics (STEM) as well as economics subjects.

CST for Australian economic, environmental and social benefits

The geographical placement of Australia in close proximity to the Asian markets enables straightforward exports of renewable fuels, metals, ammonia and other goods. In particular, countries like Japan are planning on switching from fossil fuels to renewable hydrogen at latest by 2040. As outlined before, a major shift from fossil fuels to renewables is required globally to meet the goals of the Post COP 21 Era. Dispatchable electricity, process heat and transportation are of primary interest for CST. The Australian CST research and development sector will capitalise on the strengths of the Australian educational sector.

Enabling CST market development in Australia

To develop a robust CST industry and encourage further R&D in Australia, a financial incentive scheme like the Renewable Energy Target (RET) is necessary. The current RET includes electricity generation only with Large Scale Credits (LGCs) trading at $85 on the spot market. Including solar thermal heat generation under the RET would change the financial viability of CST projects substantially and also incentivizes further R&D developments.

Sustained R&D funding as well as national support for large-scale pilot power and chemical plants are required. ARENA's R&D&C programme and Clean Energy Finance Corporation (CEFC) in Australia, the US Department of Energy's Sunshot Initiative and Renewable Energy Tax Credits in the United States, as well as the European Union's R&D programmes are examples of CST R&D funding. R&D&C projects such as Public Private Partnerships (PPPs) in Europe are a good guideline for Australian policy makers. Bipartisan, continuing support that is independent of political change is the key to successfully transform Australia from a fossil-fuel to a modern, renewable economy.