Submission by the
ANU Solar Thermal Group

to the Federal Senate Select Committee into the
Resilence of Electricity Infrastructure in an Warming World

Concentrating Solar-Thermal Power (CSP)

John Pye, Joe Coventry and Wojciech Lipinski
3 Feb 2017

Background

The terms of reference of this committee include:

(a) to investigate the *role of storage technologies and localised, distributed generation* to provide Australia's electricity networks with the *resilience to withstand the increasing severity and frequency of extreme weather events driven by global warming*;
(b) to recommend measures that should be taken by federal, state and local governments to *hasten the rollout of such technologies* in order to: (i) create jobs in installation, manufacture and research of storage and distribution technologies, (ii) stimulate household and business demand for storage technologies, (iii) anticipate the rapid deployment of localised distributed generation through changes to market rules, (iv) drive the reduction in technology costs through economies of scale, and (v) seize on the opportunities to be a global leader in deploying storage technologies because of Australia's high fixed electricity tariffs and significant penetration of rooftop solar.

Overview of CSP

Concentrating solar-thermal power (CSP) involves the use of a large array of mirrors to concentrate sunlight onto a 'receiver' where the energy is collected by heating a fluid; the fluid can be stored and then later, when needed, used to make steam and run a turbine to produce electricity[1].

The particular benefit of CSP is that its configuration allows energy storage as an easily and cost-effectively integrated part of the system. Systems with as much as 15 h of storage capacity have been installed (eg *Gemasolar*, Spain and *Crescent Dunes*, USA), achieving commercial supply of 24-h solar energy for the first time[2]. The cost of similar amounts of energy storage using batteries (often referred to as the only important storage technology, eg in the recent ENA/CSIRO *Network Transformation Roadmap*[3]) would be far more costly and cannot yet achieve this level of dispatchability in a commercial context.

CSP systems can also be hybridised with small amounts fossil or biomass fuels, for higher levels of reliability with minimal redundant equipment, a configuration which may assistant in a reliable migration towards 100% renewables in coming years. CSP systems can also be beneficially hybridised with other renewables such as PV[4,5].

1 K Lovegrove and W Stein, 2012. *Concentrating Solar Power Technology*, Woodhead, ISBN 9781845697693.
2 E Fitzpatrick, Oct 2013. 'Solar storage plant Gemasolar sets 36-day record for 24/7 output', *RenewEconomy* https://is.gd/AwJ2Zd (accessed 29 Jan 2017).
3 Energy Networks Australia, Dec 2016, 'Electricity Network Transformation Roadmap 2017–2027: Key Concepts Report' https://is.gd/wUQF1k (accessed 29 Jan 2017).
4 SolarReserve, *Hybrid CSP+PV Solutions* https://is.gd/g4gBvG (accessed 29 Jan 2017).
5 Green et al, 2015. *Energy Procedia* **69**:2049–2059. doi:10.1016/j.egypro.2015.03.218.

Australia has been investing significantly to build up a world-class capacity in research and development of CSP through program funding from ARENA, and is perfectly positioned to play a major role in this global industry. Research hubs for CSP work include CSIRO (Newcastle), ANU (ACT), Univ of Adelaide, UniSA and Flinders Universities (SA), University of Queensland and QUT (South Australia), UNSW (NSW) and RMIT (Vic).

Our industry sector here in Australia has recently developed a (1) world-first CSP-powered greenhouse in 2016 which provides desalinated seawater to grow tomatoes to Coles supermarkets (Sundrop Farms[6], Port Augusta, SA), as well as (2) a world-first modular CSP tower system in 2017 with liquid sodium as its heating fluid (Vast Solar[7], Forbes, NSW). Leading international companies such as Solar Reserve are also active here and seeking to develop a range of projects.

Major attributes of CSP

- **Minimal carbon footprint.** Emissions due to CSP are 96–98% lower than emissions from conventional coal generation and 92–96% lower than emissions from natural gas generation[8]. Even compared to carbon capture and storage (CCS), CSP has much lower emissions[9]
- **Able to withstand changing climatic conditions.** A risk analysis by Patt et al[10] found that risks posed by climate change to CSP, such as occasion high winds, hotter ambient temperatures, dust and soiling and variations in cloud frequency and type were surmountable and were not present a major for the technology. There exist full-scale CSP systems which have been running successfully and continuously in hot, dusty, windy locations in California for more than 30 years[11].
- **Deployment is growing strongly.** CSP is a technology which is achieving growing deployment at a rate similar to that of other renewables, and looks set to play a major role in the future energy mix. Since passing the point of its first 1 GW of total global deployment (which happened for CSP some time in 2011), CSP has grown at a rate of 37% p.a. This compares with PV also at 37% (from 1998) and with wind at 23% (from 1990)[12]. This strong growth in CSP only started recently, however, and total deployment is still quite small. *This very rapid growth rate has been accompanied by very strong growth of companies and specialist expertise, not least in Australia, but has not yet widely recognised.*
- **Integrated with storage, for solar electricity on demand.** CSP systems are distinct from other renewable energy technologies in that, in most cases, they can incorporate storage cost-effectively as an integral part of the plant, and because when storage is added within a CSP system, the annualised cost of the electricity from that system *decreases* rather than increasing as is the case with all other renewable energy generation[13]. Having said this, CSP is currently more expensive than PV and wind, and major focus of R&D is to improve efficiency and reduce cost, while also maximising the value that the integrated storage can provide.
- **CSP is appropriate technology for Australia.** CSP is highly appropriate to the dry, sunny Australian environment – the continent with the highest average levels of direct (focussable)

6 *Sundrop Farms, 2017*. http://www.sundropfarms.com/ (accesssed 29 Jan 2017).
7 *Vast Solar,* 2017. http://www.vastsolar.com/ (accessed 29 Jan 2017)
8 P Viebahn et al, 2010. *'RECCS plus-Comparison of Renewable Energy Technologies (RE) with Carbon Dioxide Capture and Storage (CCS): Update and Expansion'*. Wuppertal Institute. https://is.gd/TPPhID.
9 ibid.
10 Patt et al, 2013. *Climatic Change* **121**:93–102. doi:10.1007/s10584-013-0887-0.
11 NREL, 2013. *Solar Electric Generatic System II*, https://is.gd/8G8V5X (accessed 29 Jan 2017)
12 Data: REN21, https://is.gd/dIwFT3.
13 IT Power/Australian Solar Institute, 2012 *Realising the Potential of Concentrating Solar Power in Australia,* https://is.gd/sfuyri (accessed 29 Jan 2017)

sunlight in the world[14]. It does not require significant amounts of water. A single plant in an inland/regional location can provide a good match of supply to demand, reducing the dependency on other forms of backup capacity.

- **Good for jobs and industry.** CSP has a higher fraction of local content than some other renewables. Systems installed in Spain achieved up to 70% or more of local content in their project budgets[15]
- **Cheaper than batteries, cheaper than pumped hydro.** Energy storage implemented within a CSP plant is currently significantly cheaper on a per-energy-stored basis than battery storage, and is expected to remain so for some time, even despite the big cost reductions anticipated by Tesla. The most recent comparative studies on the costs of CSP versus pumped hydro and batter storage are the studies from Lazard[16],[17]. These studies show that solar thermal energy with storage (including the cost of generation) may be as low as 119 USD/MWhe while the cheapest energy storage (excluding the cost of generation) is transmission-scale storage (with compressed air) at 116 USD/MWhe. Thus CSP is highly competitive as a source of dispatchable power, cheaper than any alternatives when the cost of generation is also included. Of course, this analysis is based on the US context, and Australia is different. *However this is compelling information that has not been sufficiently considered in the national debate.*

Recommended measures

- **Build on our strong position in CSP research**. At the recent SolarPACES 2016 conference in Abu Dhabi, Australia was one of the top three countries for research on central tower CSP systems[18]. We are well positioned to take a central role in development of next-generation technologies in this field. In the recent review of solar energy research in Australia under the ASTRI program, conducted by ARENA, leading policy and research experts in CSP from both USA and Germany expressed their agreement with this view[19].
- **Unbiased incentives enabling a range of storage technologies to thrive.** Incentives for deployment of energy storage should be carefully considered so that Australia doesn't end up only deploying small-scale behind-the-meter battery systems, at the risk of failing to conduct a proper evaluation of other compelling alternatives such as CSP with storage as outlined above. Grid-level benefits and impacts should be considered alongside short-term returns. An example of a good incentive is the South African feed-in-tariff for CSP, which recognises the higher value of power delivered during peak periods with a 2.7× uplift factor.
- **Revisit or review previous studies** which showed that future renewable-energy-dominated grids should be take as much as 12–22% or more of their supplied energy from CSP systems[20,21], in order to achieve a lowest-cost operational portfolio. This is a fast-moving topic and needs to carefully monitored.
- **Examine current electricity network rules** to ensure that all participants, as far as possibly, are suitably rewarded for doing their part to facilitate the migration towards a high-renewables grid configuration which will meet our emissions reduction targets. For example, assess whether the currently very high transmission/distribution costs are resulting

14 ABC News, 2015 *'Fact check: Is Australia the sunniest continent on Earth?'* https://is.gd/wrol0Z (accessed 29 Jan 2016).
15 K Lovegrove, 30 Jan 2014. 'Solar thermal and storage could offer best value for money', *RenewEconomy* https://is.gd/xob9pf (accessed 29 Jan 2017).
16 Lazard, 2016 *Levelized Cost of Energy Analysis 10.0*, https://is.gd/6vv39U (accessed 3 Feb 2017)
17 Lazard, 2016 *Levelised Cost of Storage Analysis 2.0*, https://is.gd/mF06ud (accessed 3 Feb 2017)
18 Paul Gauché, 2016. *Trends in Central Tower Systems*, Closing plenary at SolarPACES 2016, Abu Dhabi, Oct.
19 This point can be confirmed by referring to the CSP program leader at ARENA.
20 AEMO, 2013. *100 per cent renewable study - modelling outcomes.* https://is.gd/tYYMa1 (accessed 29 Jan 2017)
21 Elliston et al, 2013. *Energy Policy* **59**:270-282. doi:10.1016/j.enpol.2013.03.038.

in a market failure in the provision of centralised renewables and storage, and whether this effect might need to be corrected.

- **Consider the possibility of local content provisions for CSP and related projects**, to help the Australian CSP industry move further towards large-scale commercial viability, and to create jobs and increase manufacturing (as requested in the terms of reference).
- Consider incentives which might allow households and businesses **to contribute to or invest in centralised (rather than only distributed) storage systems**, which may require other changes to electricity market rules.
- Work with experience members of the CSP industry to **install a full-scale CSP system in Australia** with large amounts of storage – which will help to drive down costs and increase understanding of this major energy storage technology. Learn from and avoid the problems experienced under the past Solar Flagships program and ensure that project completion is assured.
- **Avoid prescriptive actions** such as that implied by the final item in the terms of reference, which suggests that we should charge ahead only with domestic battery storage.