VAST SOLAR

Dr Kerry Schott AO
Independent Chair
Energy Security Board
Parliament House
Canberra ACT

By email: info@esb.org.au

8 June 2021

Dear Dr Schott and Board

Re: Response to P2025 Market Design Consultation Paper

Vast Solar is grateful for this opportunity to contribute to the ongoing consultative process into redesign of the National Energy Markets. We applaud the Energy Security Board's actions to ensure the continuous delivery of high-quality electricity during the transition of the grid from a reliance on coal generation to zero carbon alternatives.

We recognise the challenge faced by the Energy Security Board to plan effective reliability mechanisms for a system undergoing revolutionary changes with a rule-book formulated to manage steady-state operations. Additionally, the uncertainty over the expected form (physical, regulatory and commercial) of the grid at the conclusion of the transition and the risk of unintended consequences from security measures enacted now compound the difficulty.

In this submission we provide brief introduction to our company and experiences from the last 11 years of operation in Australia, present a vision for the role of concentrating solar thermal power (CSP) in the NEM and provide some perspectives that we request the Board consider when formulating its policy recommendations.

1. Vast Solar

Vast Solar is an Australian company that has developed world leading CSP technology, delivering less risky, less complex, cheaper and more efficient dispatchable electricity generation. CSP plants work by gathering sunlight during the day and storing it as heat until it is needed (e.g., night time), at which point it is converted to electricity by way of a steam turbine. The primary differentiator of Vast Solar's technology is modular solar arrays which offer cost, performance and reliability advantages over competing designs.

Vast Solar's technology has been refined, tested and proven in three successively larger projects, the latest of which is a world-first 1.1MW grid-connected pilot plant located at Jemalong, near Forbes in NSW. The pilot plant was successfully and safely operated from January 2018 until its scheduled decommissioning in October 2020. Vast Solar's significant contribution to the progress of CSP globally has been recognized by the international CSP community by the International Energy Agency's SolarPACES 2019 Technical Innovation Award.

Figure 1 Pilot Plant at Jemalong NSW

In addition to our technology focus Vast Solar has been active as a developer of projects in Australia. The company developed a 50MW PV plant at Jemalong NSW, which was sold as a shovel-ready project to Genex in 2018, and is working in partnership with Stanwell Corporation, Queensland's largest generation company, to develop the North West Queensland Hybrid Power Project (NWQHPP), a 50MW solar hybrid power plant located in Mount Isa.

The NWQHPP will deliver 50MW of continuous power and reduce emissions by ~85% below those of the current gas-fired generation that powers the Mount Isa mini-grid. In this project, the mining and minerals processing operations that are powered by the NWQHPP require around the clock, highly reliable, constant supply. The plant dispatches four technologies to meet customer requirements: CSP for night time generation; PV for day time generation; a small battery to assist PV performance; and gas reciprocating engines for firming during inclement weather. This solution delivers cheaper power than gas and substantial reduction in carbon emissions (note that greater emissions reductions are possible but are not cost effective in this project). Of relevance, the NWQHPP can be considered as a utility-scale demonstration of the way in which CSP can underpin and augment combinations of existing technologies to transform the NEM by replacing the roles currently played by coal and gas.

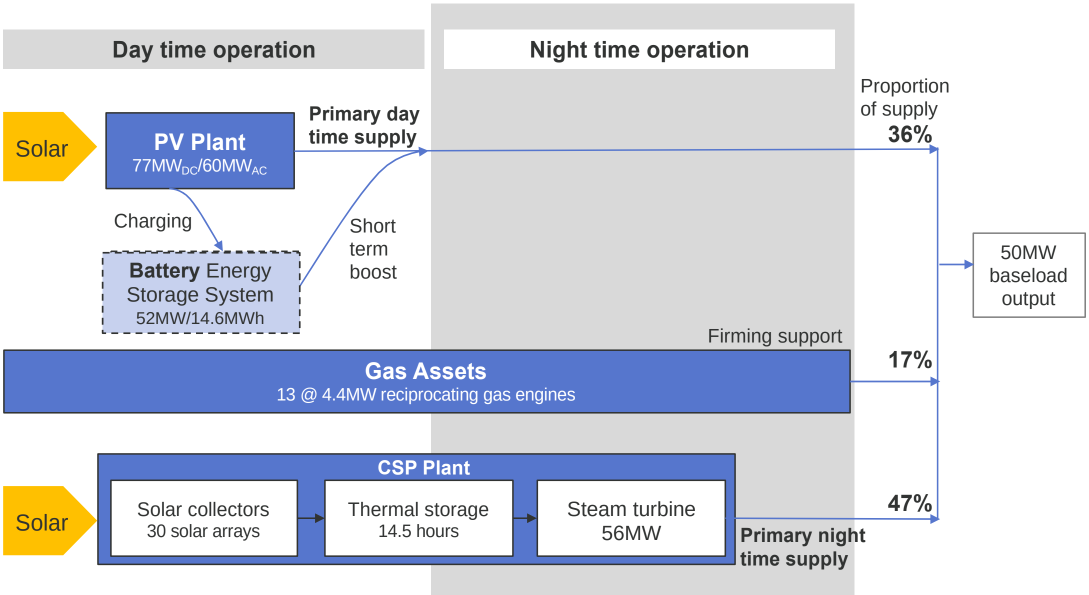

Figure 2 Configuration of NWQHPP hybrid plant

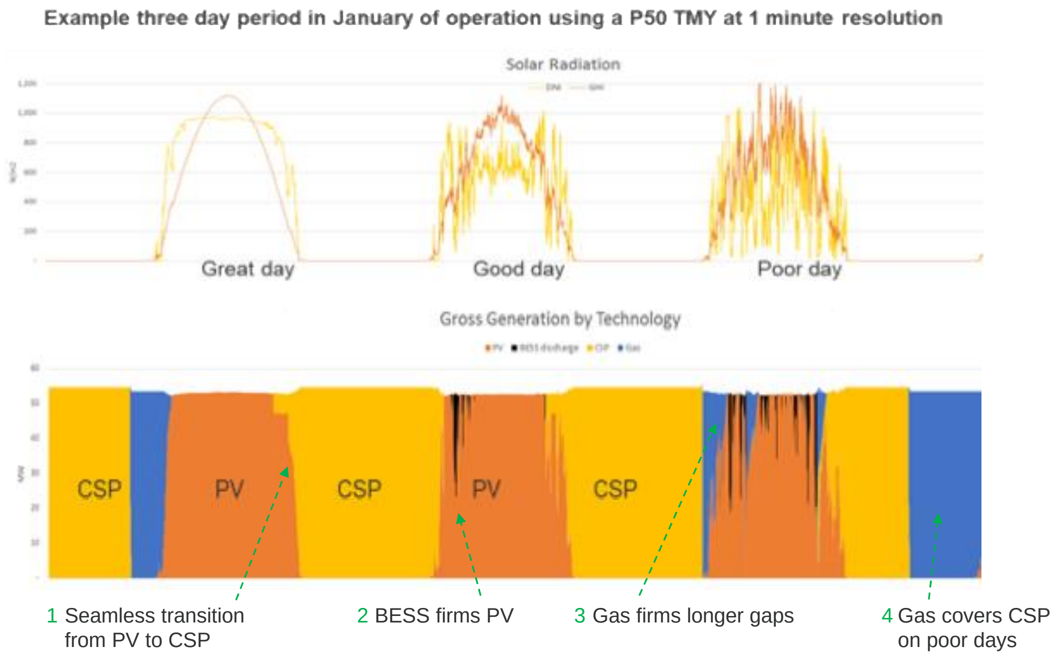

Figure 3 Example of hybrid plant operation

2. The Role for CSP

Our vision is for an Australian grid full of intermittent renewables built on a foundational base of CSP plants. A scaffold of strategically-located CSP plants delivering dispatchable turbine-based generation and long-duration storage will provide the lowest-cost, most reliable base to support the largest volume of cheaper intermittent generation. Other technologies will have a role to play (e.g., batteries for short-duration storage and frequency control; pumped hydro where it's available and economic; etc.) but CSP is the ideal technology for Australia's sunny, dry climate. We see CSP playing the same role as hydro in the Norwegian grid, enabling the integration of wind and PV with high reliability and security for zero emissions electricity.

In this section of the paper we present the benefits of generic CSP technologies to support our vision for CSP as the backbone of the Australian generation portfolio. These factors are not unique to Vast Solar's design, although we believe that our technology is superior to traditional designs on reliability, flexibility, cost and performance.

Concentrating solar thermal power plants can be constructed with or without storage. The earliest plants developed in the 80's in the US and from 2007 in Spain had very short storage durations, while recent plants generally have 6 to 10 hours of storage. For the purposes of this paper, we will be discussing the benefits of CSP plants with thermal storage of between 4 and 12 hours.

The benefits of concentrating solar thermal power that make it ideal as the foundation for the Australian grid include stable predicable output, synchronous generation, responsiveness to changing conditions, flexibility of operation over their lifetime and straightforward integration with other technologies.

Guaranteed output
One of the most important aspects of CSP when compared to PV or wind generation is the consistency of its output. As depicted in the diagram below, the thermal storage in a CSP system provides two services:

a) Time-shifting of energy collected during the day for conversion to electricity at night; and
b) A buffer that guarantees generation output over several hours regardless of variability in sunlight intensity (for daytime operation).

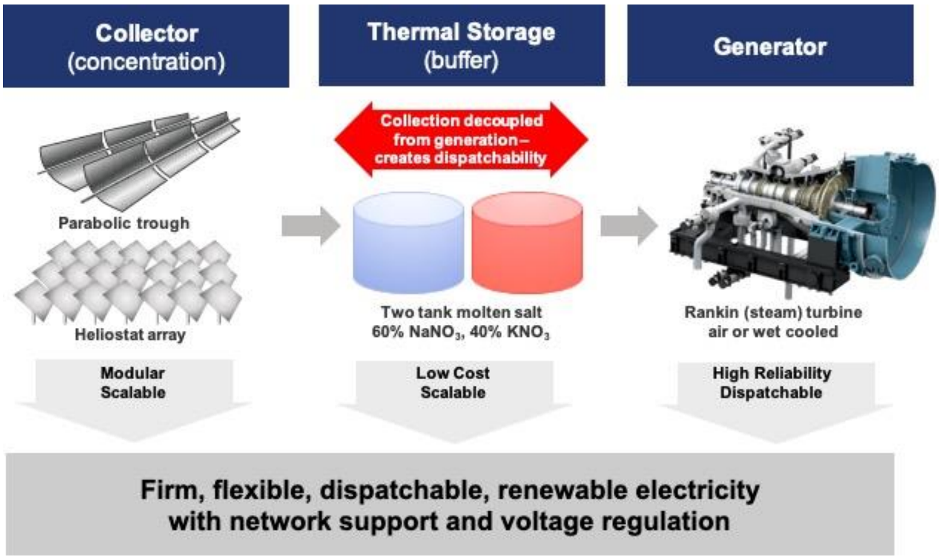

Figure 4 Components of a CSP system

Once the steam turbine is running, the plant operator can choose the production level and assure the system operator that this output will be maintained for a number of hours until a predetermined time. This is possible because the amount of energy contained in the hot salt in the tank is know precisely at all times. This attribute can be thought of as equivalent to a hydro plant being able to guarantee output because of the water that is above the intake of the dam, and it contrasts with wind and PV plants where output can fall by 80% or more over five minutes as conditions change.

Synchronous generation
The steam turbine driven generators in CSP plants are almost identical (with the benefit exceptions described later) in operational characteristics to those run today's NEM-connected coal plants. This means CSP plants can deliver to the grid most of the services that coal plants provide today including those that have not yet been explicitly priced in the past, such as inertia.

Responsiveness
One of the fundamental requirements of CSP plant designs is the need to start and stop the steam generator and turbine daily. Conversely, traditional coal plants are designed with an expectation of months of operation between shutdowns which limits their flexibility to respond to reductions in demand and/or increases maintenance costs and shortens asset lives if regular cycling is required. This daily cycle means CSP plants can provide additional flexibility at a grid portfolio level. For example, a fleet of CSP plants could be scheduled to start and ramp progressively to support peak demand, and to ramp down or stop to respond to minimum load conditions.

Lifetime flexibility
The ratio of solar collector area to storage in a CSP plant is determined by the solar conditions at the site and the expected use case for the plant, and it is carefully optimised to maximise investor return. However, once a plant has been constructed, the plant operator can respond to changed market conditions by altering the operating plan. For example, the operator can choose the start/stop time, the generator set point, they can ramp generation up and down to meet demand profiles, and/or supply ancillary services. This is not possible with wind or PV plants in which the only control option is curtailment.

Plays nicely with others
Our work on the Mount Isa hybrid plant has given us a detailed understanding of the interactions between a CSP plant and variable renewable energy generators in a system. The CSP plant is straightforward to integrate as it is dispatchable and predictable, with only a small quantity of fast acting bridging technology (such as batteries) required to ensure seamless integration due to mechanical lags. It should be noted that the Mount Isa requirement for a completely flat output profile from a variable energy source (sunlight) is an extreme case and that integrating CSP into a portfolio of other generators with a shaped demand profile will require far less interim firming.

The above list of beneficial characteristics is why we believe that CSP should play a foundational role in the Australian grid. However, no utility scale CSP plant has been built in Australia to date despite multiple attempts by local and international organisations. The primary reasons for the failure of previous projects is that i) dispatchable electricity is more expensive than variable generation due to both higher capital and ongoing operational costs, and ii) dispatchable renewable energy and the services provided by steam turbines have not been valued by the market. Instead, the market has favoured variable renewable energy, with the RET providing additional impetus, and dispatchability has been provided by gas peaking plants (open cycle turbines and reciprocating engines) rather than renewable alternatives.

3. Perspectives and Concerns

Over the last 11 years we have learnt much about the challenges of delivering CSP and PV plants in Australia, having investigated many projects located in the NEM, in Western Australia's SWIS and in remote locations. In this section we share some perspectives on the transition challenge faced by the NEM and our concerns regarding future market designs.

As mentioned previously, CSP is not cheap and the beneficial services that it offers have not historically been valued. In addition, CSP deployment has been impeded by the stringy nature of the Australian grid and dispatchable renewable technologies have not been incentivised. More broadly, the structure of the market and its rules favour incremental change, but optimal decisions made in series do not necessarily guarantee an optimal overall outcome, particularly in circumstances where fundamental change in grid infrastructure is both required and inevitable. Frustratingly, we are running out of time to implement thoughtful long term solutions to ensure sufficient dispatchable renewable generation is in place before coal-fired generation leaves the NEM. The consequential price spikes will benefit market participants to the detriment of energy consumers and necessitate further rounds of short term emergency measures.

Decarbonization must be baked into all frameworks
As the Market Design Options paper points out, although there is no explicit Commonwealth target or roadmap to decarbonization of the electricity network, the patchwork of international conventions and state and local government declarations essentially says the grid is transitioning to zero carbon. This goal should be central to and specifically articulated in energy regulations. During the transition and beyond there may be a role for fossil fuels – net zero does not mean zero consumption – but continued dependence on fossil fuel alternatives must be penalised so it does not become the easy out.

Solar resource is not uniformly distributed
Just as coal deposits in Australia are concentrated in specific locations, so too are the best renewable resources. This can easily be seen by looking at a map of wind projects in Australia and their clustering in areas of high wind speed such as the west coast of Tasmania and South Australia. For CSP plants, the key determinant of output is the quality DNI (Direct Normal Insolation = undisturbed sunlight) which is typically better further from coastal areas. In theory CSP plants can be placed almost anywhere; in reality, because of their size and cost, high DNI locations are preferred to drive down the cost of energy delivered and to increase capacity factors and reliability.

The grid today does not reach the areas of best solar resource and, while an improvement, the planned Renewable Energy Zones are not sufficiently inland to maximise output and minimize cost. As the graphics below show, there is ample scope for daytime PV generation across Australia, but if we want DNI for dispatchable generation (to fill the new transmission lines for the other 50% of the time) then the best resources lie farther from the coast.

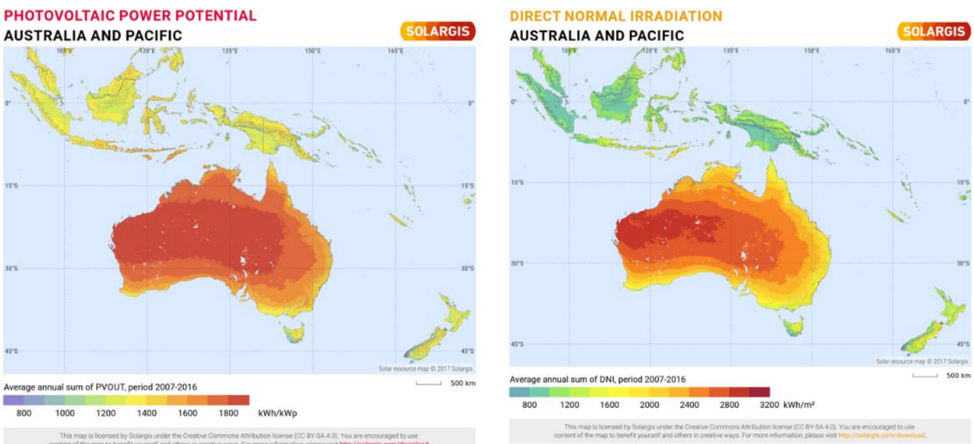

Figure 5 Illustration of the difference between solar resources for PV vs CSP plants

Where the NEM does reach higher DNI areas, the following issues have been encountered:

1. Transmission line capacity is too low sustain economically viable plants;
2. Instability at the fringe of the network (counterintuitively) inhibits the connection of grid stabilising CSP technology; and
3. The capacity is being allocated to PV generation during daylight hours.

The grid will require revolutionary change to enable the development of its CSP foundation, not incremental redesign, strengthening and extension. As raised in the Market Design Options paper, the NEM planning regime and evaluation criteria are designed to manage proposals for incremental rather than revolutionary changes to the transmission network in Australia. We encourage the Board to propose more sweeping reforms.

Incrementalism leads to sub-optimisation

In the Australian market today, a new CSP plant requires a large capital investment that is recouped on a $/MWh basis over many years. The capital for a CSP plant comprises fixed and variable components. Variable capex includes mirror arrays and thermal storage media (more arrays and storage means the plant can deliver more MWh), while fixed capex includes the steam generation system, turbine/generator and grid connection. Given fixed costs are a significant proportion of the overall cost of a CSP plant, the lowest cost per MWh results from maximising the number of MWh produced, incentivising plants that both collect and generate during the day, then continue to generate at night.

We are aware of locations in the NEM where a CSP plant could be developed (i.e., sites with good DNI, proximate load and robust transmission infrastructure) but network capacity during daylight hours is already utilised by PV generation. The lack of daytime network capacity halves the production window for a CSP plant, resulting in higher $/MWh energy cost. Thus, technology that could play an important role in making the grid more robust is excluded by the technologies causing the instabilities. In this example we are illustrating only the economic implications, but the benefits of dispatchability, inertia and other services are also lost.

Our concern is that pushing more reliability requirement tariffs down to the retailer may result in increased incrementalism and unintended consequences. For example, we have met with one state entity tasked with increasing the proportion of renewable energy. When asked how they would ensure that the variable generation projects they were investing in would not cause increased instability on the NEM, their answer was that they would buy caps, something that would not foster new development and only reward the incumbent fossil generators.

Again, this points to the need for a longer term planning horizon and clear vision for the post-transition end-state of the grid.

Risk of market distortions

In Australia we have two textbook examples of the classical economic problem, the tragedy of the commons. In the first, for the last 100 years, our coal plants have been discharging CO_2 into the atmosphere and now we are collectively faced with the cost of climate change and the renewal of the generation portfolio. The more recent example is PV and wind plants bidding variable generation with zero marginal cost (and RET incentives) into the merit order, resulting in the cost of firming pushed onto other generators (although this has been partially addressed through some recent curtailments).

Similar free rider risks exist during the coming transition. For example, government choices to support reliability by the construction of firming assets such as pumped hydro or gas peaking plants will incentive the development of more variable renewable generation, offsetting the stability benefits. We contend that regulations must ensure new assets have an ability to respond to changing conditions so they are able to assist with the transition in whichever way it unfolds.

The politicisation of energy

The search for soundbites and tweets has done much to undermine the value of thoughtful debate and energy system planning, and this has been compounded by the promotion of fear, uncertainty and distrust in the climate change debate. Earlier in the transition, a panacea of ‘clean coal’ and ‘carbon capture and storage’ was used as an excuse to postpone decision making. More recently, batteries and hydrogen are the emergent technologies that are promoted to resolve all challenges. This is compounded by a public tendency to conflate energy consumption technologies, such as batteries, pumped hydro and hydrogen with energy generation technologies

These new technologies have captured the popular imagination and spurred state and federal policies within which entities are trying to navigate the transition. This is a case of fashion coming before function as the laws of physics and economics are immutable, and the progress of technology predictable. What is needed is a clear vision for and yardsticks against which to measure development. Establishment of these will avoid ‘magic bullets’ like batteries and hydrogen which may be as much as decades away from economic. None of this is to say batteries and hydrogen won’t have a substantial role – they will – but only that planned action is required now if major disruption is to be avoided when the coal retires and climate goals are to be achieved.

Market design failure for a transitional state
The decision-making challenge faced by generation companies on the NEM can be simplified into two categories: when to invest in new technology based on NEM prices; and how to operate the equipment current assets to maximise shareholder return.

The daily decision about what price to bid their units into the NEM is a marginal cost equation, with the plant considered a sunk cost and the determinants of bid price being only direct variable operating costs (e.g., fuel cost for an open cycle turbine or the cost of shutting down a boiler in a coal plant) and expectations regarding the availability and bidding strategies of competitors. These dynamics drive such things as low mid-day pricing (with assistance from rooftop PV) and periods of negative prices.

Marginal pricing does not work for justifying large capital investments. For capital intensive projects with long payback periods, certainty around revenue streams is essential. A highly volatile and short term focused market does not match the needs of commercial lenders.

CSP plants take time to build
Although significantly faster than nuclear or hydro plants, CSP plants require around two years to build and the development process can take two to three years. We are gravely concerned that, once the network is degraded to the point where the services of the coal plants are recognised and valued, a replacement technology that can solve the problem elegantly and economically will be ignored in favour of technically inferior, more expensive but faster options. An example could be the use of batteries to deliver daytime coal power into the evening peak. Batteries are expensive and increase the carbon intensity and cost of the delivered power (due to round trip losses and capital recovery) but they can be deployed more rapidly in an emergency. Again, proper planning of the transition will avoid this issue.

Vast Solar’s believes its CSP technology has an important role to play in the transformation of the Australian electricity network. The technology offers many benefits that would benefit the grid today and that will be essential in the post transition state. We support the Energy Security Board in the introduction of regulations to support a stable transition, and we encourage the Board to think beyond the boundaries of existing regulatory frameworks.

We look forward to your response to this Submission and we would welcome the opportunity to discuss our Submission with the Board.

Yours sincerely,

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