



V A S T S O L A R

1. FINANCIAL AND INSTITUTIONAL INNOVATION – KNOWLEDGE SHARING NARRATIVE REPORT

Vast Solar Knowledge Sharing Events and Activities –
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1 Our Story

The Australian Renewable Energy Agency (ARENA), and its predecessor the Australian Solar Institute, have provided grant funding and other valuable support to Vast Solar since 2012. This support has assisted Vast Solar to develop the world's first modular concentrated solar thermal power (CSP) technology that uses sodium as the heat transfer fluid.

This journey has involved the development of three substantive sites at which different elements of Vast Solar's unique CSP technology have been trialed, tested, refined, scaled and ultimately, delivered. This journey culminated in the delivery of the Jemalong CSP Pilot Plant which incorporates five CSP modules.

Vast Solar completed commissioning of the 1.1MWe Jemalong CSP Pilot Plant in June 2018, having first delivered power to the grid from the Pilot in January 2017. The Pilot Plant is a fully realised proof of concept of Vast Solar's CSP technology. It is an Australian world-first.

The journey to realise the CSP Pilot Plant would not have been possible without the support of ARENA who supplemented the private sector investment.

Knowledge Sharing forms part of Vast Solar's agreements with ARENA. Vast Solar has undertaken to share information via events and activities as documented in the Knowledge Sharing Plan agreed with ARENA.

This narrative report presents an overview of insights and learning drawn from Vast Solar's journey with regard to financial and institutional innovation and the opportunities and challenges Vast Solar has encountered in this domain as we have worked to develop new CSP technology, build a world- first CSP Pilot Plant in regional Australia and advance plans to construct a utility scale 30MW reference plant.



2 Introduction

2.1 Financial and Institutional Innovation

Vast Solar is a small, privately owned company whose journey to develop novel, world-leading modular CSP technology that uses sodium as a heat transfer fluid has involved innovative financial and institutional approaches. Challenges have been encountered that have called for responsive strategies and adaptations to the company's original business model and these have been considered and adopted. This report presents an overview of insights and learning drawn from Vast Solar's journey with regard to financial and institutional innovation and challenges encountered in this domain.

3 Opportunities and Challenges

3.1 The Business Approach – Early Days

The founders of Vast Solar brought to the establishment of the Australian business their considerable knowledge, energy and experience gained from work with research, development and technology start-ups in Australia and the United States. With the support of a long-sighted, private investor with substantial resources and an appetite for innovation in the sustainable industries of the future, they created Vast Solar in 2009.

The over-arching vision for the company was to develop and commercialise new generation CSP technology that would address and overcome the cost and technological constraints of existing CSP offerings. In the early days, in parallel with the vision of creating technological innovations, the business also pursued a vision to create financing innovations for renewable energy developments that would assist fund the business while the CSP technology was being developed.

The financing innovations considered by management at the time included:

- Project development and management of renewable energy project developments that would earn the company management fees
- Financial project development to create syndicated community solar project investments that would earn management fees and generate revenues from renewable energy sales



While both of the above innovations had merit (and have subsequently developed considerably in the Australian energy marketplace), in Vast Solar's early years these markets were still in their relative infancy in Australia. Furthermore, as the company progressed work to research, develop, trial and refine its CSP technology, the technology development task had to assume first priority given the enormous amount of work required.

Technology development thus became the primary business focus from 2012-2013 and financial innovation ideas for renewable energy developments were consequently shelved until 2017. At that time, Vast Solar saw an opportunity to use its power station development skills to develop a 50MW PV project at Jemalong. This project was successfully sold in 2018 and the development profit was used to fund ongoing development of Vast Solar's CSP technology.

3.2 Structure and Governance

3.2.1 A Nimble Board and Strong Investors

Since 2009 Vast Solar has progressively developed, trialed and scaled its CSP technology culminating in the successful construction and commissioning of the 1.1MW CSP Pilot Plant. This exciting R&D and technology development journey has included set-backs that have impacted upon project schedules and budgets.

Vast Solar's ability to withstand these set-backs is, in large-part, attributable to the support of a strong, long-sighted investor and a nimble board. Together, they have been prepared to provide stability and support to the management and engineering team to plan to address technology challenges at the Pilot, while maintaining their vision to focus on next steps to build the business.

The ability of our private investor to provide further financing and stay the distance during difficult times has lent credibility and confidence to the project. This in turn has provided confidence to partners and grant providers, such as ARENA, to continue and extend their support to the project to enable critical project milestones to be met.

Vast Solar's private investor and ARENA have, together, showcased innovative financing arrangements for Australian technology development, providing practical demonstration of how government and the private sector can work together to support the innovation process.



The R&D and technology development process is, by its nature, one that involves trial, testing, success and set-backs, re-engineering and re-design. Most phases can be anticipated and contingencies otherwise budgeted for. Some can not. Doing business in regional Australia adds further complexity to this mix. For example, Vast Solar has experienced mice plagues, bushfires, floods and poor internet and telecommunications that have at times made doing business difficult.

Set-backs sometimes seed further success. This was demonstrably the case following initial commissioning of the Pilot Plant in early 2017. Sub-optimal operation of the receivers indicated the need to re-engineer and re-design the receivers and associated protection systems. With the close involvement of Vast Solar's Board and ARENA, this was expedited and the Pilot Plant, with new receiver designs, was re-commissioned in 2018. The overall process has delivered a superior product – improved design, operability and manufacturability – which is delivering performance results that demonstrate world-leading thermal controllability.

Vast Solar's Board is comprised of a small number of highly skilled people with commercial experience. A reflection from our journey is that a larger, more balanced Board with broader experience relevant to the technical nature of what we do may improve outcomes. Professional people who possess experience in areas such as industrial engineering, construction, heavy manufacture and/or energy, power and utilities may add value going forward.

3.2.2 Management Talent

In common with many small businesses there are many demands on Vast Solar's small and sometimes stretched executive and engineering team. Technology, management and other reporting obligations can be especially onerous for a small team split between locations and whose work is heavily focused upon R&D and related technical tasks.

Vast Solar has extensive engineering, safety, certification, management and reporting obligations arising from the Australian regulatory environment and large grants and associated financial arrangements. High quality governance, planning and reporting has been required to access, comply and sustain financial benefits from both ARENA and the Australian Tax Office R&D Tax Concession programme. Vast Solar has effectively engaged with and managed these processes.



Establishing and maintaining a high calibre executive, research and engineering team and establishing and coordinating flexible and appropriate work arrangements to match the ebb and flow of executive and research tasks has been a significant management achievement. These work arrangements represent a form of financial innovation as they have enabled the company to recruit and retain high calibre staff and consultants on a sustainable basis consistent with the financial position of the business.

Today, the executive team is located in Sydney and most of the technology and engineering development team are located in regional NSW at Jemalong, west of Forbes, but also in Melbourne, Brisbane and Newcastle.

3.2.3 Engineering and Research Talent

Vast Solar operates in a highly specialised technology environment. Identifying and securing high calibre talent has been a challenge that the company has addressed through institutional innovation.

The company has collaborated with Australian research universities through research programs and by providing student internship opportunities for engineering students. It has also contributed to the initiatives of the Australian Solar Thermal Research Initiative (ASTRI) and, in 2016, provided opportunities for ASTRI researchers to contribute on site to commissioning of the Pilot Plant. These arrangements have introduced Vast Solar to many high calibre students and researchers, some of whom have joined Vast Solar.

The company has recruited expert talent internationally in areas that we have been unable to recruit Australian candidates and/or where there is no comparable Australian talent pool. An example of the former was the recruitment and employment of a highly qualified French pressure welder to assist with the pilot construction. An example of the latter was the strategic recruitment of Vast Solar's current Project Director who possesses international experience across CSP technologies and has been involved in the engineering, manufacturing supply chain and financial strategic development of CSP projects on more than three continents. Securing talent such as the aforementioned people involved management efforts to secure 457 Visas and in turn Permanent Residency status for our Project Director.



The company has also welcomed numerous undergraduate engineering students as Interns over many years and has recruited fine graduate engineers from this process.

In the early-mid stages of the CSP Pilot Plant project, particularly during the construction phase (2014-2016), recruiting and retaining qualified project engineers was a challenge due in part to the competitive marketplace for engineering talent in regional Australia at that time.

To realise the construction and operation of the CSP Pilot Plant, the company worked extensively with, and to develop, the skills and capacities of local personnel and contractors. Skilled personnel from the traditional power sector were also actively recruited – notably, two senior operators with turbine qualifications who had previously worked at Hazelwood Power Station.

Vast Solar has innovatively built a strong professional team. In 2016 the business was rebranded and new HR and WHS policies developed and implemented, in parallel with and as part of management's commitment to a smart and safe workplace and culture.

3.3 Challenges of a Conservative Market

3.3.1 A Challenging Innovation Pathway

Pathways, timeframes and opportunities to develop and commercialise technology vary between regions and countries and in response to dynamics that may include public and private sector R&D cultures, industrial networks and the manufacturing ecologies that support them as well as the possibilities that particular places, technologies and industries may suggest.

Vast Solar's CSP technology is complex and large-scale. To be commercialised, all aspects of the technology – individually and collectively - need to be demonstrated in at least one utility-scale integrated CSP facility. The target markets for Vast Solar's CSP system are both national and international. These markets are evolving at different speeds in different regions around the world.

Our potential technology adopters and investors operate in complex and sometimes contested markets and sectors. In one way or another, they are all stakeholders in the energy and/or power generation space. They are participants in the energy transition and their technology investment decisions are influenced by the wideranging social and economic development, business and



policy debates (and market uncertainties) that the energy transition and changes in energy markets collectively entail.

Vast Solar's management has long understood that development and commercialisation of Vast Solar's technology would necessarily take - at a minimum - as many years as were required to develop the fundamental technology; to then build, trial, test and refine the technology (the Pilot Plant); and to then construct and demonstrate the integrated CSP system at scale. While the technology has been developed and proven at different scales, Vast Solar has invested considerable efforts, in parallel, to develop and advance plans to construct a utility scale 30 MW CSP plant. These efforts include investment of management time and expertise in planning development and approvals processes, detailed engineering and design, development of manufacturing and supply chains and recruitment of expert personnel and expertise (either as staff and/or consultants or partners).

With the above steps in mind, a horizon of some 6 - 8 years appeared a credible timeframe in which to deliver the Pilot Plant; to develop sufficient proprietary IP and technical know-how to move to the next phase; and to commence and materially advance plans for the next phases that would include development of a 30MW utility scale plant (our 'reference' plant) in parallel with international marketing of the technology. We now expect this timeframe to be at least some 10 – 12 years, given the complexity of the technology and due to our under-estimation of the conservatism of the market.

The company has invested time and resources to develop and submit a development application for the 30MW CSP facility to be built in NSW. This application was subsequently withdrawn as results from the pilot confirmed the optimal location for the reference plant, our first large scale plant, is one that has higher DNI resources. The expenditure of resources on this development application (including extensive site based studies) were not wasted as these studies were subsequently used to support the development and submission of a development application for a 50MW solar photovoltaic plant on the same site. This project was successfully developed and planning approval received from the NSW Department of Planning and Environment in early 2018.

3.3.2 A challenging and conservative marketplace

Vast Solar has found the innovation pathway to be more difficult than anticipated because of unforeseen obstacles in some areas. For example, we had anticipated that securing a PPA in the



NSW marketplace on reasonable terms for power from either the prospective 30MW CSP plant or from the 50MW PV project we developed would have been more readily possible. A PPA would enable us to leverage other innovative financial tools and strategies, but this has not been possible notwithstanding growth of renewable energy in the market. Consequently, we chose to sell the 50MW Jemalong Solar PV project and to reinvest the development premium in our ongoing CSP business.

With the pilot completed, demonstrating the technology in a utility-scale reference plant remains a key step of the commercialisation journey. This step is essential for 'each and all' of the commercialisation pathways that may be pursued: whether technology licencing; project development; energy sales revenues; CSP components and systems manufacture; supply and sale; or a combination of aforementioned pathways over time.

We have been surprised by the unwillingness of Australian energy companies to engage with prospective new technologies that may offer them a competitive advantage and by the Australian financial sector's unwillingness to address (or price) technical risk. The degree of conservatism and negativity displayed distinguishes Australia from all other markets in which Vast Solar has been engaged.

3.3.2.1 The Financial Sector

Vast Solar anticipates that the 30MW CSP project, our reference plant, will attract ARENA and CEFC support.

The financial security and third party credibility provided by the above, in conjunction with a changing marketplace that is recognising the need for dispatchable power suggests that there will be avenues for Vast Solar to access finance at reasonable rates.

Discussions with Australian merchant and investment banks indicate that Vast Solar's capacity to raise debt is negligible. Our experience indicates that the financial sector will only consider technology investments when the technology is demonstrably proven in several plants.

3.3.2.2 The Energy Sector

Our experience gained through extensive engagement with industry leaders, investors and commercial and academic commentators in the sector indicates that the Australian power



generation sector is experiencing high levels of change and uncertainty. Consequently, it appears that many established power and utility companies may not have the depth of expertise to explore or to engage with new technology or have the commercial or technical confidence to invest in new and different forms of generation capacity. This latter point appears particularly the case with regard to a relatively new (and as yet immature) technology such as Vast Solar's CSP system.

The Australian power generation energy sector is deeply conservative and is struggling with major technical and commercial challenges. In parallel, the complex market is transitioning to clean energy while being in a state of considerable commercial and regulatory uncertainty and flux. A small number of generator retailers ('gentailers') have, and are increasingly securing, vertical integration in the marketplace which is of particular interest to Vast Solar given the premium pricing dispatchable renewable power should attract.

The energy sector is very conservative and generally does not look favourably upon innovation. Most innovation in this sector that we have observed in the industry over the past 5-10 years is from external – and often international – players entering the industry.

3.3.2.3 Power Purchase Agreements (PPA's)

A Power Purchase Agreement (PPA) provides a power generator with price certainty for the power it will generate for the period of the PPA. Local Councils, community organisations and an increasing number of Universities and corporations have elected to procure renewable energy via a PPA. This enables them to lock in access to renewably sourced power and agreed pricing for a portion of their total energy demand. Importantly, a PPA provides the renewable generator cash flow and revenue certainty that in turn can be banked to raise debt or equity.

Vast Solar has actively pursued PPA opportunities to support the development of the 30MW plant. Numerous State and Territory governments, including South Australia, Queensland, New South Wales and the Australian Capital Territory have entered into discussions with Vast Solar about opportunities to provide and/or support the company via access to PPAs.

Vast Solar has invested considerable time and effort in preparing submissions to processes coordinated by the ACT and South Australian governments to secure dispatchable renewable energy. These conversations and contributions have been positive but have not resulted in commercial PPA arrangements.



We believe that a PPA with an appropriate government or corporate entity continues to be an important form of financial and institutional innovation that could assist Vast Solar to fund our next project. A PPA or a Contract for Difference for the power to be delivered from the 30MW plant would materially assist the company to secure traditional sources of debt as part of the financial package required for the plant's development and construction. We are particularly excited about profiled PPA's that include time of day pricing/incentives entering the market in due course.

3.3.2.4 Engineering, Procurement and Construction

Engineering, Procurement and Construction (EPC) is a form of contracting arrangement in which the EPC contractor is responsible for all activities including design, procurement, construction, commissioning and execution plus performance of the plant.

As a small company, Vast Solar will need to partner with a firm(s) with EPC skills to deliver its reference 30MW CSP utility scale plant. To this end the company has met with a number of major engineering and construction firms and held detailed discussions in which issues pertinent to the need to craft an 'innovative' model to recognise and address potential risks associated with a new and novel technology were canvassed.

Construction of our next plant will require sophisticated project engineering and construction management. These are skills that Australia has in abundance and an 'EPC ex-performance risk' arrangement would bring to the project a depth of skills and experience to enable delivery of rapid and best practice construction.

3.3.3 Future Innovation Pathways?

Vast Solar's operating environment suggests that the medium-term innovation pathway for our world-first CSP technology will be in the international marketplace, where there appear to be a small number of investors who may have one or more of the following positions:

1. understand CSP, it's past challenges, and can appropriately value Vast Solar's current technological contributions to address past challenges
2. consider CSP an important 'hedging' technology to invest in as part of a portfolio of clean energy solutions



3. interested in making strategic investments to adapt their core business activities and business models in order to strategically respond to the energy transition
4. recognise the particular role that dispatchable CSP power has to play in a world transitioning to renewable electrification and want to build new CSP businesses and plants

The above is occurring at a time when ARENA has recently released the CST Roadmap and Commonwealth and State governments are looking for new sources of power generation that can deliver firm generation capacity. These developments may help to create opportunities for Vast Solar CSP within Australia and these are opportunities Vast Solar warmly anticipates and undertakes every endeavour to address.

In the short-medium term Vast Solar remains committed to building our first utility-scale 30MW CSP plant in Australia and to working with governments and communities to build sustainable jobs and industries for the future in Australia.

4 Insights and Sharing Points

Vast Solar's innovation journey would not have been possible without the consistent and professional support of ARENA and the steadfast support of our anchor private investor. The Australian energy marketplace is a challenging space for many reasons and new energy technologies face uphill challenges for uptake and adoption. ARENA has been a major force for positive change in the energy and related innovation space. The grant funding provided, along with support and understanding when Vast Solar has found it necessary to request that project milestones be adjusted, has been invaluable to the company and the team as we have worked to overcome technical hurdles.

Australia is a relatively small marketplace in terms of depth and diversity of manufacturing. Consequently, technological innovation in areas of engineering related to components manufacturing is challenging, particularly in regional Australia. Australia's engineering and manufacturing ecologies and networks are in transition (think the mining boom, the car industry and other) or shrinking while other sectors, such as medical research and innovation, grow and excel. Vast Solar's technology journey has been at the interface of the energy sector and highly skilled manufacturing and engineering.



Vast Solar has been extremely fortunate to have developed and sustained robust partnerships with ARENA, ASTRI, Australian Research Universities, Forbes Shire Council, local businesses and the Jemalong community. The importance and nature of these partnerships are elaborated, where applicable in other Knowledge Sharing Narrative Report topic areas. In many cases these partnerships represent forms of institutional innovation – both formal and informal in nature.

Vast Solar has invested considerable business development time and energy to meet with prospective partners and to explore new financial mechanisms such as PPA's and commercial partner arrangements such as EPCs. We have submitted numerous project proposals and submissions to state Government expressions of interest and tender processes for dispatchable energy. For a small company, investing executive time and focus in complex (and often exploratory) government procurement processes can be a significant drain upon executive and financial resources.

Our technology is proven but still relatively immature insofar as a further 3-5 years of investment will be required to move it to a commercial proposition. In the Australian financial and engineering environment in which we operate, there is little appetite for risk and there is relatively little financial innovation to facilitate the transition between being a start-up technology company and an international technology player. The innovation journey is difficult and our next step is large – in terms of time, investment required, potential risk and scale. We have learnt that until our technology is fully proven it may be difficult to secure traditional, let alone innovative, forms of finance in Australia.

In terms of financial and institutional learning and insights, we have learnt much from our internal journey. We have experienced technology delays and setbacks along the way. We have learnt that these could have been better anticipated and planned for. Had this been done the financial journey would have been smoother for all stakeholders.

4.1 Key learning's

2. Strong financial partners are invaluable
3. Strong technical partners are essential. In retrospect Vast Solar would have involved its technical international 'dream team' far sooner



4. A strong anchor investor – who can provide credibility to government and other private investors and institutions – is an enormous asset to a company embarking upon an audacious technology development pathway
5. When developing technology through phased projects and over time, realistic project budgets and schedules are critical and these need to include allowances for things to go wrong
6. Project governance and structure. It is important to build a Board and/or Steering Committee that includes technical and industrial people as well as commercial people. Vast Solar has developed an industrial technology. Representatives from the power sector, the engineering and manufacturing sector and from the large scale construction and infrastructure sector may have added considerable value to our Board or Steering Committee.
7. World-leading technology advances require world-leading people and partners
8. World's best skills are needed throughout the entire chain: project development; product design; manufacturing; logistics; construction; commissioning; operations.
9. Engineering is a process and short-cuts are a risky and costly thing. Anything less than best practice in procurement and manufacturing ruins performance and increases risk
10. Australia is an unbelievably hard place to develop a novel industrial technology. Many of the higher order dynamics that contribute to this have been discussed in preceding sections the on ground reality is that we have experienced high labour costs and low productivity, considerable costs of regulation and compliance, and general personnel, logistical and accommodation difficulties and costs associated with working in regional areas.

Ends.