

CSP/T. Concentrated Solar Power/Thermal with Storage.

Australia's cheapest renewable energy solution?

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BHB RENEWABLE ENERGY

Solar CSP/T - Concentrated Solar Power technology options



Molten Salt storage, CSP Parabolic Trough facility in California





CSP/T Pictorial, Typical.





The Current Australian Situation and where CSP/T can help

Current State of the NEM

- Wholesale electricity prices more than doubled in the December 22 quarter compared to the same period in 2021
- Wholesale gas prices are 3-4 times above normal levels (with divergences across the states and territories)

Key Factors

- · Persistently high coal and gas prices
- Accelerating coal retirements
- Underinvestment in coal-fired plants, increasing downtime
- Objections to new gas exploration and new gas-fired power stations
- · Growing need for dispatchable electricity storage capacity
- · Lack of renewable heat options





Example 1. CSP facility cost estimate as at March 23, Pilbara

Costs - CAPEX

\$ 569,783,209.94
\$ 139,540,080.00
\$ 161,599,257.92
\$ 68,504,514.31
\$ 200,139,357.71
\$ \$ \$ \$ \$

Based on 230/220 MWe with 13 hours (full power) Storage = 2.860 GWhe @ 220MWe

Heliostat cost \$123/m² → Recent Likana project ~80/m²





Example 2. CSP/PV facility cost estimate for the NT, August 22

Conceptual for West Arm support.

200 MWe CSP/T 200 MWe PV and Electro Thermal 300 MWe PV and BESS*

This plant operates optimally during the day at 500MWe.

CSP/T and PV Electro Thermal provides 400MWe at night.

Costs shown are USD

* Small BESS installation to ensure grid stability at all times.

EPC Direct Cost	879,021,986	
Solar Field	199,176,975	
Tower and Receiver	70,350,069	
TES	158,638,579	
Power Block and BOP	150,024,350	
PV + BESS	300,832,014	
EPC Indirect Cost	82,746,812	
Owner Indirect Cost	177,246,255	
Development (Land, FEED Engineering.)	4,000,000	
Others (Financial reserves)	173,246,255	
Total Project Cost	1,139,015,054	



Example 3. CSP facility cost overseas, USD

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Power Station:	Noor Energy 1 / DEWA IV 700MW CSP+ 250MW PV	Ivanpah Solar Electric Generating System	NOOR II	NOOR III
Location:	Dubai, UAE	California, USA	Ouarzazate, Morocco	Ouarzazate
Owners (%):	Noor Energy 1 (Dubai Electricity & Water Authority, ACWA Power, Silk Road Fund, Co.)	NRG, Brightsource, Google	Acwa Power Ouarzazate 2 (ACWA Power, MASEN).	Acwa Power Ouarzazate 3 (ACWA Power, MASEN, SENER)
Technology	Parabolic Trough & Power Tower	Power Tower	Parabolic Trough	Power Tower
Solar Resource:	1,967	2,768	2,503	2,508
Nominal Capacity:	950 MW	377 MW	200 MW	150 MW
Start Year:	2022	2014	2018	2018
Total Construction Cost (Million \$)	\$4,024.50 (AED 14,780.00)	\$ 2,339.89	\$ 1,119.20	\$ 877.05
Remuneration USD/kWh Deflated (2020)	0.07	0.14	0.14	0.15
PPA or Tariff Period (Years)	35	25	25	25
Support Scheme Type	РРА	РРА	РРА	PPA



Additional CSP/T Applications- Vast, Clean Fuels example

CSP's ability to generate both power and heat lowers the cost of renewable energy used to create green fuels to power aviation and shipping





Why CSP/T

- 1.0 ARENA:- 'RE storage must expand massively and diversify if Australia is to meet NET ZERO by 2050'. ARENA have provided 220 million AUD to Australian companies for this research.
- 2.0 CSP/T is a 'greener' and more 'humane' lifecycle solution that can provide storage and fully dispatchable heat and electrical energy 24 hours per day.
- 3.0 CSP/T is well suited to Australia with the world's highest average DNI of 2.4 kWh/m2 over the largest useable land area compared with the world average of 1.0 kW/m2
- 4.0 CSP/T technologies are expanding and improving remarkably quickly and becoming cheaper every day. Stated currently as the cheapest form of energy storage. Reference CSIRO, ARENA, IRENA, etc.
- 5.0 CSIRO:- 'Energy Storage Roadmap identifies CSP as the lowest cost technology for long duration renewable energy storage among current storage technologies required to reach NET ZERO by 2050'
- 6.0 IRENA:- 'CSP costs have fallen by 68% from 2010' CSP'. CSP with storage is forecast to be the lowest cost technology for utility scale facilities from 2023. (2021 prediction)
- 7.0 CSP with storage compares favourably cost wise to any other form of Renewable Energy source including PV over 4 hours back up duration although to date, 2 hours seems to be the norm.
- 8.0 New CSP/T technologies are making Hydrogen and Ammonia directly (Fusion Fuels and NREL in the US and the STCH, Solar Thermochemical Hydrogen Production system)

Further arguments for Solar CSP/T going forward





Where to from here?

The Past

- Industrial production of fuels and chemicals via refineries has delivered massive economies of scale
- Along with molecular balance, these systems are an energy balance
- Cheaper energy inputs = cheaper refinery products
- Bulk energy provision by heat is more effective than throwing 55% of the heat away to create electricity via steam turbines
- CSP has a key role to play through provision of both green heat and dispatchable electricity

The Future

- Solar powered refineries will be built to replace existing refineries, likely in favourable climates like Australia!
- Massive intermittent generation (PV and wind) will be complemented by CSP for dispatchable and night time generation
- CSP will be a key source of process heat required in industrial processes and green fuel production
- Phenomenal export opportunities into Asia, Europe and elsewhere
- Low-cost energy input for domestic industry and increased energy sovereignty (particularly fuels)

We have the technology, the legal stability, the renewable resources, the expertise and the capital...what are we waiting for?!



CSP in Australia



Vast Solar 1

Location: Port Augusta (SA) Size: 30MW-e Storage: 8 hours Output: Heat & electricity Company: Vast

Carwarp Project

Location: Carwarp (VIC) Size: 3MW-e Storage: 17 hours Output: Electricity Company: RayGen



Solar Methanol 1

Location: Port Augusta (SA) Size: 7,500tpa Storage: N/A Output: Clean fuels Company: Vast

Wodonga Project

Location: Wodonga (VIC) Size: 18MW-th Storage: 150MWh Output: Heat Company: Mars Petcare

Lake Sustainable

Location: Lake Cargelligo (NSW) Size: TBA Storage: TBA Output: Heat Company: Graphite Energy

MGA TES Project

Location: Tomago (NSW) Size: 0.5MW-th Storage: 10 hours Output: Heat Company: MGA Thermal

Heat

CSIRO - Newcastle

Location: Newcastle (NSW) Size: Testing Facility Storage: N/A Output: N/A Company: CSIRO



