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Energy Security Board
Post 2025 Market design project team
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19 October 2020

RE: Response to P2025 Market Design Consultation Paper

Dear ESB team,

Austela welcomes this investigation of alternative electricity market designs and is keen to remain engaged in this process. The detailed work that has been carried out since the 2019 consultation is apparent.

Austela is a non-profit association that advocates on behalf of the Solar Thermal industry. Concentrating Solar Thermal (CST) systems use solar concentrators to produce high temperatures in heat transfer fluids which ultimately transfer heat to superheated steam for use in steam turbines in the same way that heat from fossil fired boilers does. Most new systems and more than half of the existing CST systems incorporate intermediate storage of the collected heat using 'two tank molten salt' thermal energy storage. This is a strongly growing global industry which offers Australia many advantages given the wish to add firm capacity and increased competition in the National Electricity Market simultaneously with the wish to reduce greenhouse emissions.

CST systems offer all the characteristics of renewable dispatchable synchronous generation that are identified as being increasingly needed as existing coal plants progressively retire. To date Australia has not built systems because the RET and existing NEM rules have not offered the rewards for its combined values that are needed to cover costs of energy that are higher than variable wind or PV.

Market redesign is needed, however care needs to be taken to avoid perverse outcomes and to avoid locking in new fossil based generation unneccesarily.

CST like wind and PV, is a global industry, Australia, could move quickly to establish large scale systems using competitive tenders or other processes to attract experienced global players who would then establish appropriate supply chains that would incorporate large local content.

We provide high level commentary on the issues raised in the consultation paper and background material on CST technology and industry status.

Yours sincerely

on behalf of AUSTELA board

On page 30 of the consultation paper the essential problem of the current situation is clearly expressed as:
p30:

''Some market participants and investors are noting the current market is not 'investable' for the types of dispatchable resources that can provide these services. While it is true that significant volumes of VRE or DER capacity are coming online, concerns have been raised that in the current economic environment, it can be difficult to make a business case to invest in dispatchable plant. The externality risks, technology and demand risks are seen as too high and the time in which revenue can be earned is uncertain. Clarity around the types of essential services needed to support the system, and how these will be procured, will help support investment decisions factoring in a range of potential forward revenue streams.''

We very much agree that this is indeed the case and are hopeful that this design process can rectify this situation. There is however one key missing piece from this process. The dispatchable generation that is needed must also be zero emissions. There are a range of flexible dispatchable options available that are technically proven, these are essentially:

- Concentrating solar thermal systems with storage
- Pumped hydro energy storage
- Batteries
- Biomass powered thermal generators
- Natural (fossil) gas powered generators.

Whilst there are those who argue that new gas powered generators are needed, we suggest these are totally unnecessary give the zero emission options available, and if constructed, will lock in future GHG emissions and hold back the growth of zero emissions dispatchable solutions.

Avoidance of greenhouse gas emissions should be part of this new market design.

In designing the post 2025 market it is also important to avoid other unintended consequences. What is needed is market mechanisms that maximise the chances of reaching the lowest cost generation system that is totally zero emissions by 2050. This means an as yet undetermined mixture of technologies with a mix of durations, flexibilities and ability to provide system support services. It can be noted that the various zero emissions options have;

- Variations in the maturity of existing supply chains
- Variations in the time to construction
- Differing cost characteristics as a function of duration.

The most likely perverse outcome that should be avoided, is mechanisms that favour short lead time technologies and / or those with lowest capital cost per MW installed.

Such an outcome would be at the expense of building an overall least cost and zero emissions electricity system for the future.

The consultation paper presents the work that has been done against six market design initiatives, each of which is addressed by a dedicated chapter. We leave it to others to address in detail all of the feedback questions posed at the end of those chapters. Here we offer some general commentary regarding each initiative.

RESOURCE ADEQUACY MECHANISMS – MARKET DESIGN INITIATIVE A

Of all the market design initiatives, it is the resource adequacy mechanism that appears the most important. The consultation paper appears to be favouring a decentralised capacity market that works in conjunction with a modified Retailer Reliability Obligation. This could be a workable approach but clearly requires a lot more detail. The RRO as it stands seems best suited to the procurement of output from existing dispatchable generators or small short lead time battery systems. Systems like CST plants with long duration storage or pumped hydro systems, will need PPAs of 10 -20 years tenure to be successfully financed.

AGEING THERMAL GENERATION STRATEGY – MARKET DESIGN INITIATIVE B

It is well understood that Australia's fleet of coal fire generators will be progressively retired by around 2040. For each closure it is essential that the notice of closure be sufficiently long that it allows for the rational site selection, project development and construction of systems such as CST plants or pumped hydro systems. This means around 4 -5 years not less. Further the mechanism should be such that once committed, a closure can not be simply delayed or reversed, so undermining the market for the new dispatchable systems being built in anticipation.

ESSENTIAL SYSTEM SERVICES – MARKET DESIGN INITIATIVE C

The zero emissions dispatchable generation options like CSP with storage, bring as a matter of course the characteristics of synchronous generators with inertia and frequency response capabilities. We would argue that if there is a well designed RAM in operation, there should be an excess of capacity to provide these essential system services. As has been the case with traditional generation historically, the revenue from sale of energy will in most cases dominate the revenue for system services. We do not have strong views on the exact market mechanism that should be followed for these. The greatest challenge will be dealing with intervals when variable wind and PV are at their maximum and pool prices likely to be their lowest.

We do not have firm views on how this should be structured, but support the idea that energy delivery and essential system services should be co-optimised.

A strong present example of a failure to co-optime is the recent significant investment in synchronous condensors that has been taking place. The role of high capex energy consuming synchronous condensors would be far better filled by ensuring the construction and operation of actual synchronous generators such as CSP plants.

SCHEDULING AND AHEAD MECHANISMS – MARKET DESIGN INITIATIVE D

The Unit Commitment of Security approach could be workable and appears to have merit. As noted above it is important that any mechanisms co-optimise energy supply and system services. It is important that any such mechanism not be designed in a way that only gas fired generators are able to comply. It can be noted that a CSP plant with thermal storage, could if suitably contracted, hold a portion of its stored energy always in reserve under such a mechanism.

TWO-SIDED MARKETS – MARKET DESIGN INITIATIVE E

Market redesign that allows consumers to manage demand in a more responsive manner to the benefit of the system appears to be a worthwhile effort.

It can be noted that CSP plants with thermal storage, although predominantly designed to capture their own energy from the sun, are also able to take up electricity from the network when prices are low, or controllable loads could offer other benefits.

VALUING DEMAND FLEXIBILITY AND INTEGRATING DER – MARKET DESIGN INITIATIVE F

CSP plants are typically in the range 50 -100MW and so not classified as DER in this discussion.

TRANSMISSION ACCESS AND THE COORDINATION OF GENERATION AND TRANSMISSION – MARKET DESIGN INITIATIVE G

This is an important topic that needs to be addressed. Mechanisms that underwrite transmission access for installed plants against the possibility of later additions that add to congestion are a good concept. It should be noted that a lot of the congestion and lowering of MLFs that is taking place is due to large installs of PV and wind. Thus the issues actually only apply when wind and solar resources are in abundance. Dispatchable generators installed in the same geographical areas that are able to 'fill in the gaps' should be rewarded, not penalised, for doing so. Thus for example, MLFs could be recalculated dynamically for every dispatch interval, or at the very least, allocated different average values for different times of the day.

Mechanisms to encourage investment in new zero emissions dispatchable generation

Further to the comments above in relation to Resource Adequacy Mechanisms, we present here a possible mechanism we have previously suggested.
Capacity payments for example could be workable, but challenges include; how will capacity be determined? Should flexible dispatchable capacity be valued more than traditional baseload? Should other measures be included to ensure new plant built with capacity payments actually operates at the times it is needed to ensure reliability and increased competition.
We argue that a modified Clean Energy Target (CET) or Renewable Energy Target (RET) could be a good mechanism to consider.

- The RET (or a CET) could be modified for a growing target post 2020 but with certificates allocated to renewable generation with a **Market Value Multiplier** applied that is proportional to the wholesale pool price at the time of generation. Ie
  Certificates earned = C x (Generation in half hour NEM settlement period) x (Pool price in NEM settlement period) / (Average pool price in previous month)
  where C is a factor to be determined from time to time that sets the relative incentive for generation at high pool price times vs low and so can adjust the actual total levels of RE generation to match the target for each year.
- Using this methodology, certificates earned would be higher for generation at times when the pool prices was high and those earned would be lower than generation when the pool price was low. They would be negative if the pool price is negative, thus incentivising no further generation at such times.
- The RET has in the past had a mechanism of multipliers, where small solar systems in particular were for a time awarded certificates that were a multiple of their actual deemed generation. The administrative methods for this clearly exist. Even though the ‘currency’ of the market is MWh, the volume of certificates earned does not have to equal actual generation.
- This incentive would encourage dispatchable renewable generators to generate in high price periods and thus have the further effect of increasing competition and lowering the pool price at such times.
- As the fraction of RE increases towards 100%, the pool price will increasingly be determined by renewable generators and the certificate price will progressively trend to zero such that the two markets become one in a smooth fashion.
- At very high levels of RE in the NEM questions remain as to how an energy only market will function when all the generators have very low (or zero) marginal costs of generation, some form of capacity mechanism may also need to be considered. Indeed the CET / RET acts in many ways like a capacity payment that is generation linked.

Appendix
Concentrated Solar Power (CSP) within the National Electricity Market (NEM)

The National Electricity Market (NEM) is in rapid transition and will continue to be so into the foreseeable future. The convergence of numerous game-changing trends, including more engaged consumers, a changing energy mix, and rapid technology advancements are creating some unique integration challenges. Central to these challenges is the need to provide supply secure, reliable, affordable and sustainable energy solutions to consumers.

The Problem with Intermittency

The NEM has seen a significant uptake of renewable energy in the form of photovoltaic and wind generation. While these technologies have immense value, they also bring challenges. Specifically, these technologies are intermittent generators, with the resulting variable supply creating reliability and capacity management challenges. These intermittency challenges will increase as more PV and wind is introduced.

Addressing this challenge requires access to firm capacity, which can be quickly dispatched on demand. This is currently managed through conventional power plants that can generate and dispatch electricity 24 hours a day. These power plants provide a firm, reliable and predictable supply of electricity able to balance system requirements. However, Australia's coal-fired plants are aging and many will retire in the next 10-20 years.

New renewable energy technologies are required that can provide the same firm capacity, reliability and resilience of a coal fired power plant, at similar or lower cost. These new technologies also need to be able to accommodate future energy systems with a high level of intermittent renewable energy assets.

Concentrated Solar Power (CSP) is a technology solution can meet this need. CSP does everything that a coal-fired plant does, using a similar thermal energy conversion process, but with zero-emissions and with much greater operational flexibility. Through its utility scale energy storage, CSP can provide the NEM with firm capacity and on demand dispatchable generation. These characteristics allow CSP to address future generation intermittency problems resulting from the accelerated uptake of PV and wind.

The Importance of Dispatchability

Dispatchability, delivered through energy storage, allows for the provision of electricity on demand. Energy storage improves the availability, resilience and utilisation of renewable energy. There are a number of renewable energy storage technologies that are likely to play an important role in the NEM's transition to a renewable energy future.

Lithium batteries are emerging as a valuable renewable energy storage solution. Batteries are currently a good option for short term storage (30 minutes – three hours) of renewable energy. They also provide an important system balancing role through the provision of fast response frequency control and ancillary services (FCAS).

While great for short-term storage, batteries become progressively less commercially viable when it comes to utility scale systems with over three hours of storage. Currently, the two best forms of utility scale renewable energy storage are Pumped Hydro and CSP. Both storage solutions have their pros and cons in terms of cost, utility, resource availability and scalability. Pumped Hydro is a good option for seasonal loads where you have available water and suitable reservoirs. However, for daily dispatch, and in areas that are flat, dry and hot, CSP is a better option.

There is no singular renewable energy storage solution for Australia. All options need to be assessed and deployed where they deliver the best value within the NEM and to energy users, based on cost, technical performance, geographical considerations and resource availability (i.e. wind, solar and water). This noted, CSP is emerging as one of the most cost-effective options to provide firm night-time generation capacity on a day to day basis.

Concentrated Solar Power (CSP) Value Streams and Risk Mitigation Benefits within the NEM

Concentrated Solar Power (CSP) systems can deliver a wide range of value streams and risk mitigation benefits when deployed within the NEM. These value streams and benefits include:

- firm capacity;
- on-demand dispatch;
- arbitrage;
- system strength
- inertia;

- frequency control;
- enablers higher PV and wind penetration - system strength to address variable generation profile;
- allows for low-cost storage of excess daytime PV / Wind;
- nigh time baseload;
- evening peaker;
- high capacity factor (70%+)
- high storage efficiency – once stored, only small energy loss over time (can store for weeks);
- synchronous generation;
- geographic suitability (good in hot dry areas); and
- works well in defined renewable energy zones

Overview of Current CSP System Performance, Cost and Operations

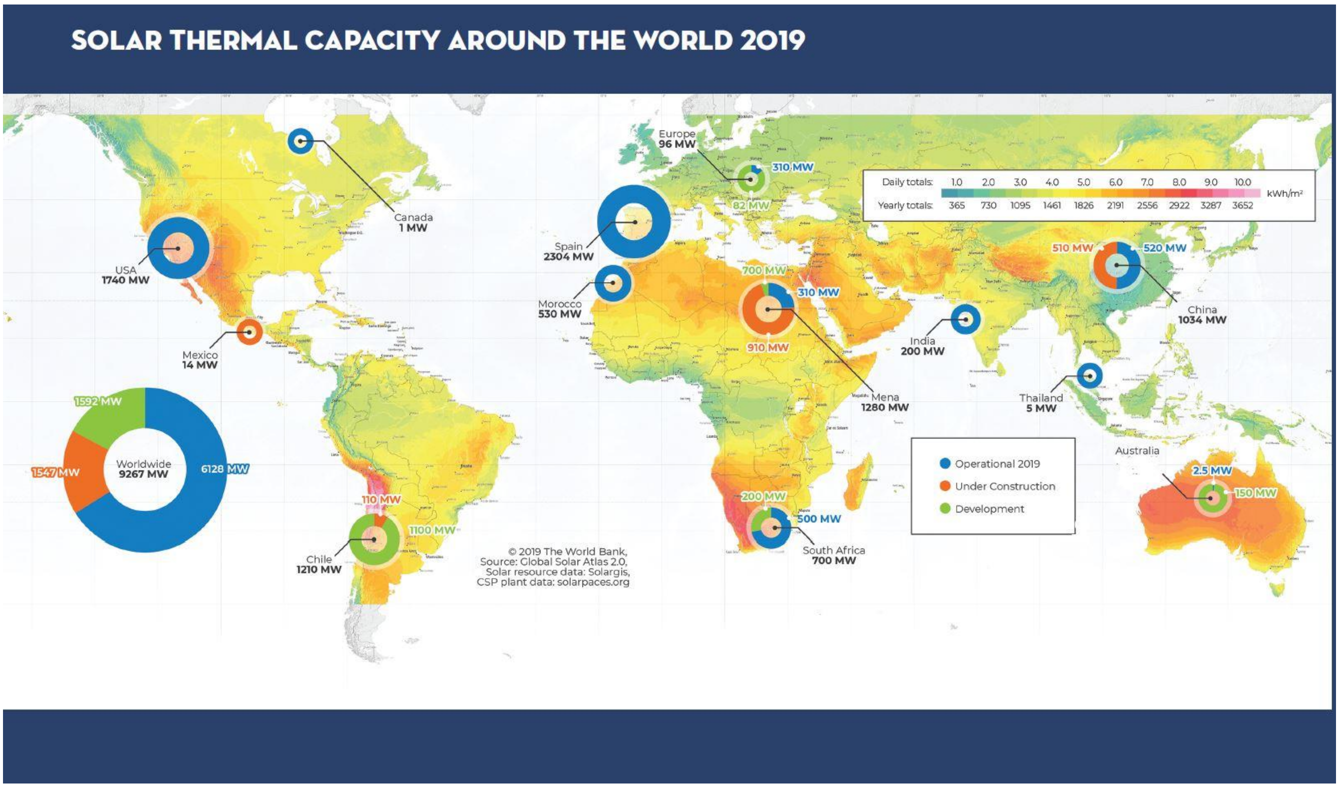
Globally, the installed capacity of CSP systems has grown steadily over the last two decades. CSP had a global total installed capacity of 6,128 MW at the end of 2019, an increase in over 1,000 MW from 2018. There are now more than 80 commercial CSP plants around the world. Most new plants have multiple hours of storage to provide firm capacity and dispatchable generation at any time of day or night.

Most of the early development of CSP occurred in Spain and the USA, and they remain the countries with the largest installed capacity. These two countries alone account for over half of the global capacity. In the past few years, CSP plants have also been built in Morocco, China, South Africa, India and the United Arab Emirates. There is another 1.5 GW of large CSP plants under construction across a number of countries including China, Chile, Morocco, Israel and Saudi Arabia.

How many CSP systems are there globally?

There are currently around 64 CSP plants that are 50 MW or larger and another 32 or so smaller plants. Installed capacity is increasing, with a range of industry studies estimating average compound growth of over 25% annually, primarily driven by China, and the Middle East. Spain has announced plans for another 5 GW by 2030. China has indicated plans for another 10 GW of CSP by 2030.

Refer to public info: https://www.solarpaces.org/csp-technologies/csp-projects-around-the-world/



How long has CSP been operational?

Commercial utility scale CSP systems have been operational since the mid-1980s (in the form of 9 plants in California). The 27 commercial CSP plants in Spain have been operating for almost 10 years. The eight more recent plants in the US have been operation for over five years. Another 20 plants in other locations have been operating for over 12 months.

Current global CSP generation capacity – 6GW

CSP had a global total installed capacity of 6,128 MW at the end of 2019, an increase in over 1,000 MW from 2018.

Current capacity factors

Typical CSP Plants with storage have a capacity factor of between 50% to 70%, which is double that of PV. The increased capacity factor allows you to generate revenue over a longer time period on a daily basis and so leads to lower LCOE than plants without storage. .

Future capacity factors

While capacity factors above 95% are technically possible, they require excellent DNI with next to zero cloud cover, and larger storage systems. There are locations in the middle east and in South America (e.g. Atacama Desert) where such capacity factors are possible. There are also locations in Australia with high DNI and minimal cloud cover where capacity factors in excess of 85% may be possible. However future market signals are likely to favour plants that are deliberately designed to preferentially deliver energy in peak periods when PV and wind are not available, via increase in the size of power blocks relative to solar field and storage capacity. Such ‘’peaker’’ plants will deliberately have lower capacity factors.

Current availability statistics

Public access to availability information is limited. Major CSP system developers operating in Spain, Africa, USA and China indicate that overall plant availability exceeds 96%. CSP developers and system owners may be able to provide site specific information if requested.

Current generation statistics

Public information is available online from the US EIA site for all US power plants. For example this includes generation data for the following three plants:

- Genesis solar (SENER): https://www.eia.gov/opendata/qb.php?sdid=ELEC.PLANT.GEN.57394-ALL-ALL.A
- Mojave (Abengoa): https://www.eia.gov/opendata/qb.php?sdid=ELEC.PLANT.GEN.50821-ALL-ALL.A
- Solana (Abengoa): https://www.eia.gov/opendata/qb.php?sdid=ELEC.PLANT.GEN.56812-ALL-ALL.A Spanish CSP generation data:

Public information on generation data for Spanish CSP systems is available from:

- https://www.protermosolar.com/la-energia-termosolar/el-sector-en-cifras/

Public information on generation data for the Supcon Delingha 50MW system, now operating at over 100% of the required generation targets, can be found at:

http://www.supconsolar.com/upload/file/2020-04/1586312950638634.pdf.

Construction cost for a first Australian build of a 50MW + 6 hours of storage system

A firm EPC cost for a 50MW + 6Hours of storage is difficult to provide, since different technologies and company specific considerations would be required.

In 2018, ITP Thermal prepared a report for ARENA examining Dispatchable Renewables Energy Options. Based on the ITP report a 50MW CSP Tower Plant with 6 hours of storage would cost approximately $330m (2017 AUD).

Based on the same configuration (i.e. 50MW + 6 hours of storage), several CSP companies provided commercial construction cost estimates for a first Australian build CSP Plant ranging from $360m to $400m (2020 AUD).

Some publicly available cost information, from several owners of recent CSP plants are detailed in the table below. Please note that these costs ($USD) include items such as land, access costs, financial costs, etc.

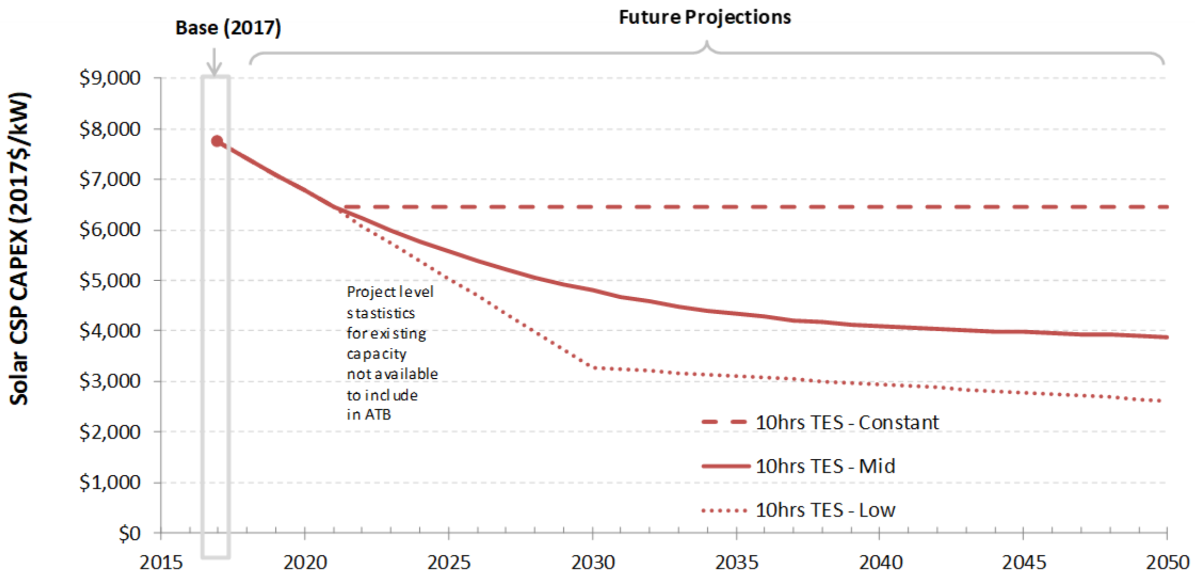
Planta *Plant*	Tipo *Type*	Potencia (MWe) *Capacity (MWe)*	País *Country*	Almacenamiento (Horas) *Storage (Hours)*	Fecha operación *Date in operation*	CAPEX ($) *CAPEX ($)*
Atacama-1 (Cerro Dominador)	Torre *Tower*	110	Chile *Chile*	17.5 *17.5*	01/06/17	1.275 *1,275*
Shagaya CSP Project (Phase One)	CCP	50	Kuwait *Kuwait*	9	01/07/17	257 *257*
Noor II	CCP *PTC*	200	Marruecos *Morocco*	7	01/07/17	1.100 *1,100*
Solar Thermal Power Plant Akesai	CCP	50	China *China*	15	01/08/17	318 *318*
Xina Solar One	CCP *PTC*	100	Sudáfrica *South Africa*	5 *5*	01/09/17 *01/09/17*	652 *652*
Noor III	Torre *Tower*	150	Marruecos *Morocco*	7	01/10/17	861 *861*
Qinghai Delingha (CGN) Phase I	CCP *PTC*	50	China *China*	7	31/12/17	397 *397*
Ashalim Plot B (Megalim Solar Power)	Torre	121	Israel *Israel*	-	31/12/17	735 *735*
Kathu CSP	CCP *PTC*	100	Sudáfrica *South Africa*	4.5 *4.5*	01/06/18	716 *716*
Ashalim Plot A (Negev Energy)	CCP *PTC*	110	Israel *Israel*	4.5 *4.5*	01/07/18	980 *980*
Ilanga CSP 1 (Karoshoek Solar One)	CCP *PTC*	100	Sudáfrica *South Africa*	5	01/10/18	592 *592*
Atacama- (Cerro Dominador)	Torre *Tower*	110	Chile *Chile*	15	01/06/19	1.176 *1,176*
Waad Al Shamal ISCC Plant	CCP *PTC*	50	Arabia Saudí *Saudi Arabia*	-	01/07/19	1.000 *1,000*

www.**futurenergyweb**.es

http://helioscsp.com/current-status-of-concentrated-solar-power-csp-globally/

Capex Information in $USD/kW, prepared by the US National Renewable Energy Laboratory (NREL), in 2019, is illustrated in the figure below. The figure shows the Base Year estimate and future year projections for CAPEX costs. Three cost scenarios are represented: Constant, Mid, and Low. The estimate for a given year represents CAPEX of a new plant that reaches commercial operation in that year.

It is important to note that a single $/kW capex figure for CSP can be misleading. Capex depends on the sum of contributions from; solar field; storage system and power block, all of which can be configured in varying ratios to achieve various performance characteristics and average capacity factors. Location is also a key factor with higher DNI locations resulting in lower CAPEX costs.



CAPEX historical trends, current estimates, and future projection for solar CSP

Source: National Renewable Energy Laboratory Annual Technology Baseline (2019), http://atb.nrel.gov

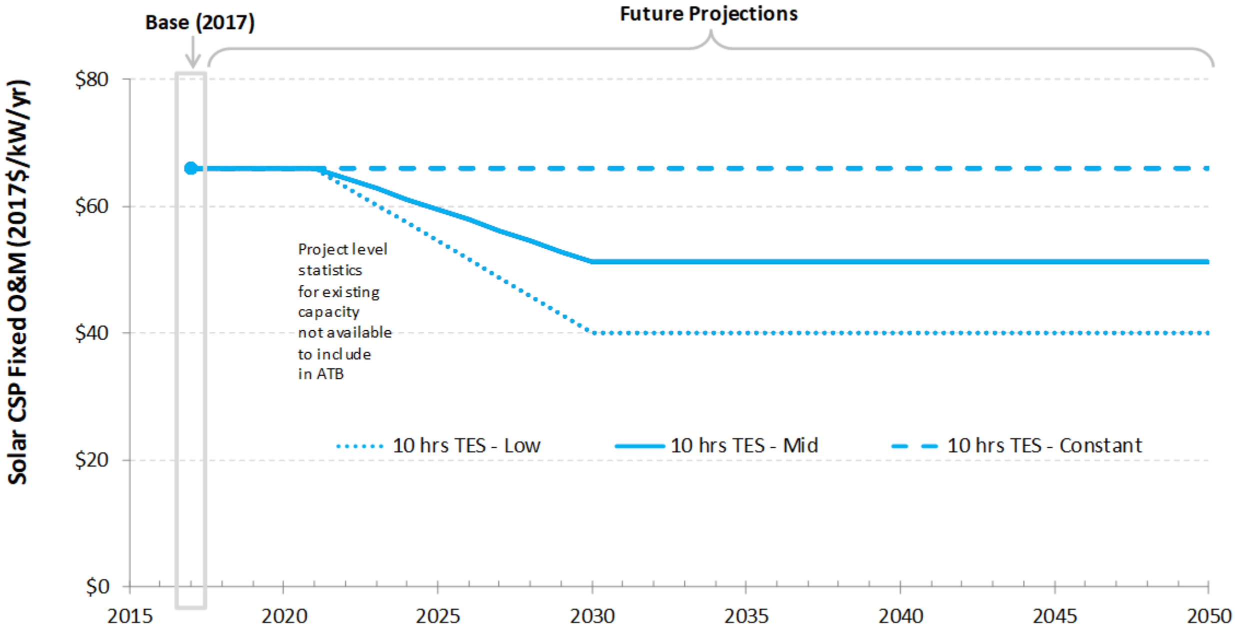
https://atb.nrel.gov/electricity/2019/index.html?t=sc

Current O&M cost data

Operation and Maintenance (O&M) costs in $USD/kW/year, prepared by the US National Renewable Energy Laboratory (NREL), in 2019, is illustrated below. The O&M costs represent the annual expenditures required to operate and maintain a solar CSP plant over its lifetime, including:

- Operating and administrative labour, insurance, legal and administrative fees, and other fixed costs;
- Utilities (water, power, and natural gas if any) and mirror washing; and
- Scheduled and unscheduled maintenance, including replacement parts for solar field and power block components over the technical lifetime of the plant.

The following figure shows the Base Year estimate and future year projections for fixed O&M (FOM) costs. Three cost scenarios are represented. The estimate for a given year represents annual average FOM costs expected over the technical lifetime of a new plant.



Solar CSP plant O&M projections

Source: National Renewable Energy Laboratory Annual Technology Baseline (2019), http://atb.nrel.gov

https://atb.nrel.gov/electricity/2019/index.html?t=sc

For all CSP plants the main O&M activity is mirror cleaning. This is a continuous daily/weekly operation, which requires the consumption of water.

The rest of the O&M costs typically involves standard equipment maintenance activities (lube oil, greases, chemical dosing, etc.). The power block within a CSP is a steam power block identical to that being used in a conventional power generation plant. It should be noted that no refill of HTF or molten salt is needed during the lifetime of the plant under normal conditions.

In the case of parabolic trough plants using a Heat Transfer Fluid (HTF), O&M costs also the monitoring, management and replacement, on a regular basis, of the HTF. This is a relatively simple procedure.

How is a CSP Plant operated?

The operation of a CSP plant is done from a from a centralized control room, assisted by a generation forecast system and automatic controls. This includes alignment of heliostats, management of flux on the receiver, storage management and power generation.

Key operability issues – and how addressed

The main operability issue with CSP plants is the management of transients. During operation, the management of thermal shocks (i.e. spikes in temperature) across the different systems (steam generation system, molten salt/HTF heat exchangers, steam turbine) is critical. This is the single most important issue for the successful operation of a CSP plant.

The management of transients / thermal shock needs to occur in accordance with the manufacturer's specification for ramp up and down rate. CSP systems have automated protection settings, weather alert programs and trained operators to ensure that transients are effective managed within the plant.

Key maintenance issues – and how addressed

The key maintenance issue is mirror cleaning. This is typically undertaken using purpose-built mirror cleaning trucks and trained drivers to minimise cleaning time and water use, and to minimize mirror damage.

impact of DNI on value (2000 gives you x, 2400 gives you y, 2800 gives you z)

For a tower CSP plant, heliostats represent over 30% of the total upfront construction cost. For a trough plant, the troughs systems represent an even higher proportion of the costs.

The higher the DNI the smaller the solar field (heliostats or troughs) required to deliver the same power output. This reduction in the solar field delivers a direct reduction in cost.

Trough Versus tower / cost capability trade-off.

The main factor determining the use of a tower or a trough system is site location. The closer to the equator, the higher the optical efficiency of any CSP plant. The further away from the equator, a tower plant drops efficiency less than a trough or linear Fresnel system.

Trough systems typically represent less technology risk. There are currently more than 80 trough plants that have been operating for many years in more than a dozen countries. With current trough systems, steam temperature is limited to approximately 400ºC due to HTF temperature limitations. This lower steam temperature results in a lower output efficiency from the steam turbine.

Tower systems, with molten salt receivers and storage represent higher technical risk. At present there are only five molten salt tower systems in commercial operation. These include Gemasolar (commercially operating in Spain since 2011) and NOOR 3 (commercially operating in Morocco since 2018). There are however an increasing number of tower-based systems under construction or being commissioning.

CSP plants with storage have the advantage of decoupling heat capture and electricity generation, providing more stable output regardless of weather conditions; and providing for longer storage hours. Tower plants heat molten salt to higher temperatures and are able to store 3 times as much energy for the same investment in the storage system as trough plants. The steam temperature for tower systems is also much higher at 565ºC due to the higher hot molten salt temperature. This higher temperature results in higher output efficiency from the steam turbine.

Can CSP plants be used for PV / Wind Arbitrage.

CSP systems can in principle be used for PV and wind arbitrage. Backup electric heaters are a standard component of molten salt energy storage systems. These can be increased in size as required. Some countries are considering using molten salt system storage for PV/wind arbitrage. Several companies are also developing components to allow for this to occur, especially for the repowering of coal fired stations and off-grid applications. It should be noted that the round-trip efficiency of PV/Wind storage for arbitrage will be limited by the efficiency of the steam cycle (around 40%).