PARSONS

STATUS OF LATEST OPERATING CSP PLANTS IN KEY CSP COUNTRIES: ISRAEL

CONFERENCE – ROLE OF CONCENTRATING SOLAR POWER IN THE EVOLVING ENERGY MARKET IN THE WESTERN U.S.

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AGENDA

Ashalim Plot A

- Project Overview
- CSP Lessons Applied

Ashalim Plot B

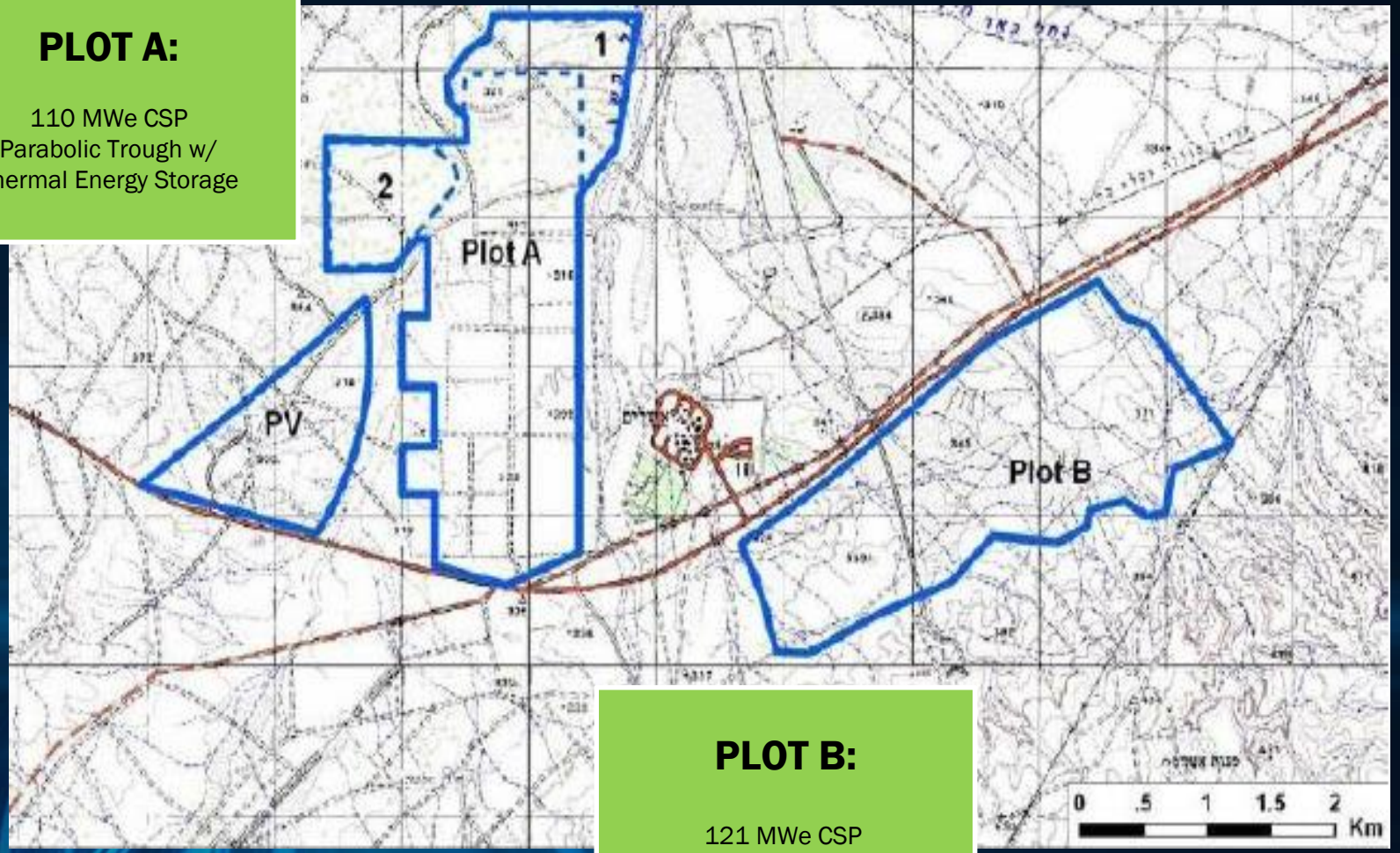
- Project Overview
- Performance
- CSP Lessons Applied

De-Risking Process

Ashalim Solar Complex – Negev Desert, Israel

PLOT A:

110 MWe CSP
Parabolic Trough w/
Thermal Energy Storage



PLOT B:

121 MWe CSP
Power Tower

ASHALIM PLOT A

PROJECT OVERVIEW

Project Participants

- Owner/SPC: Negev Energy
- EPC JV: Shikun & Binui – Solel Boneh / TSK
- O&M: Shikun & Binui – Renewable Energy / TSK

Procurement / Financing / Cost

- Concession Agreement with State of Israel (P3)
- Build, Operate for 25 years, Transfer to State (BOT)
- Lenders: Bank Leumi, EIB, OPIC
- Construction Cost at Closing: $833M

Services Provided

- Rate structure based on production during high priority, medium priority, and low priority hours
- Offtaker: Israel Electric Corporation (IEC)
- PPA/Tariff: 0.76 NIS per kWh
- Started operation in September 2019

Plant Configuration

- 100 MWe Parabolic Trough w/ 4.5 hrs Thermal Energy Storage
- Solar Field: SCAs with HTF pumped to HXs to heat feedwater
- Power Block: Siemens SST-700 Steam Turbine Generator
- TES: single set of dual tanks (hot and cold molten salt storage)

ASHALIM PLOT A: CSP LESSONS APPLIED

Best Practices

- When TSK took over Abengoa's role in the EPC Joint Venture, they held a detailed design review in which TSK reviewed the Abengoa design and incorporated changes in the salt system and control scheme based on TSK's experience with other plants.
- Initial design benefited from experience with earlier Abengoa plants, especially Solana. Lenders required its LTA to investigate Solana, including site visits and interviews with key personnel, for lessons learned that would be applicable to the Plot A Project.

Design and Construction

- Owner specified single pair of hot/cold salt tanks rather than six pairs at Solana to make construction and operations easier and more economical.
- Final Plot A design uses tube and shell HTF/Salt heat exchangers based on experience with plate and frame heat exchangers at Solana.
- Plot A uses cavitation sensors on TES pumps to identify low salt levels in the tanks, based on experience at Solana.
- Plot A uses immersion heaters in the salt tanks to maintain salt temperature during outages or shutdowns instead of internal circulation pumps to simplify operations.

Operations

- TSK brought in experienced personnel and subcontractors to manage Commissioning.
- O&M contractor's mostly local hires are supervised by TSK personnel during Cx and Ops training.
- TSK continues an active role in operations during EPC performance warranty period.
- Plot A has planned for adequate resources for mirror washing – some multiple of previously budgeted rates has typically been needed to maintain reflectivity.

ASHALIM PLOT B

PROJECT OVERVIEW

Project Participants

- Owner/SPC: Megalim Solar Power
- EPC JV: Alstom (GE) / BrightSource
- O&M: GE / BrightSource

Procurement / Financing / Cost

- Concession Agreement with State of Israel (P3)
- Build, Operate for 25 years, Transfer to State (BOT)
- Lenders: Bank Hapoalim, EIB
- Construction Cost at Closing: $792M

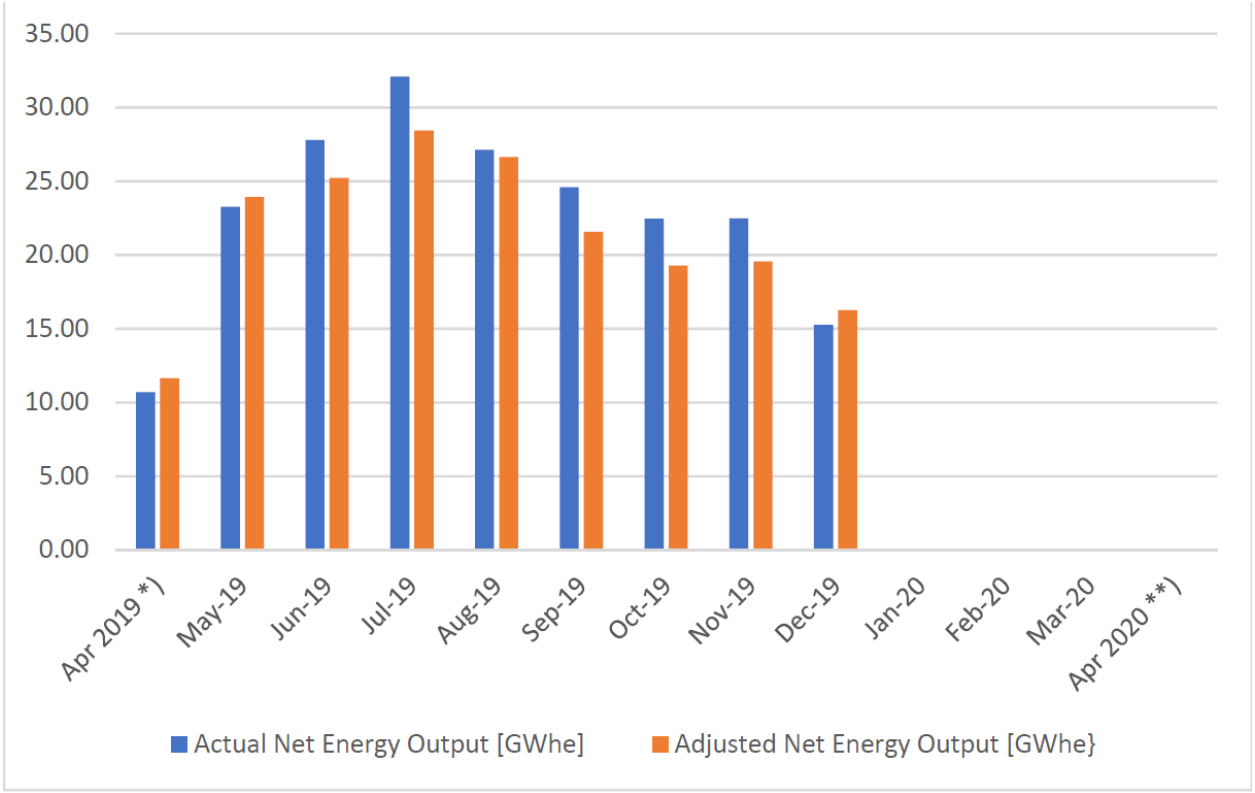
Services Provided

- Rate structure based on production during high priority, medium priority, and low priority hours
- Offtaker: Israel Electric Corporation (IEC)
- PPA/Tariff: 0.79 NIS per kWh (320 MWh/yr)
- Started operation in April 2019

Plant Configuration

- 121 MWe Power Tower, 240m – Direct Steam Receiver
- Solar Field: 50,600 BrightSource LH-2.4 Heliostats
- Power Block: Alstom Steam Turbine

ASHALIM PLOT B: PERFORMANCE



ASHALIM PLOT B: CSP LESSONS APPLIED

Best Practices

- First-of-a-kind plant designs coupled with inexperienced owners and EPCs can take significantly longer to achieve design performance, as long as 2-4 years following initial start-up. Plant designs based on mature technology with incremental design improvements, implemented by experienced participants can routinely achieve ~90% of design performance within a year.
- By implementing lessons learned from earlier direct-steam power tower CSP plants, Ashalim Plot B was able to achieve more than 80% of the P50 projected output, adjusted for actual insolation, within 6 months of start of operation.

Design and Construction

- Owner was proactive in management and oversight of EPC. Used experienced OE, gave them adequate resources and made sure they had the authority to properly oversee the EPC.
- Critical components underwent adequate qualification. Components such as heliostats, elevation/azimuth drives, and adhesives had accelerated life cycle testing to ensure performance and prevent early or cascading failures.
- Performed adequate modeling and wind tunnel testing up front to validate tower/receiver and heliostat design to avoid redesign and expensive rework.

Operations

- Brought O&M Contractor and O&M staff on early for an active role before Commissioning to ensure operational readiness.
- Training of O&M staff before hand-over to O&M for experience in both normal and off-normal operating conditions.
- Solar field control software and systems and heliostat design and availability has evolved considerably since first examples.
- Mirror washing has been traditionally under-costed. Manual washing has proven to be more cost-effective.