SolarDynamics

CSP Plant Construction, Start-up, and O&M Best Practices Study

Session 4 - Past Experience with CSP

Project Team

Mark S. Mehos – NREL (Principal Investigator)
Hank Price – Solar Dynamics (Project Lead)
Robert Cable - Consultant
David Kearney – KA Solar
Bruce Kelly – Solar Dynamics
Greg Kolb - Consultant
Fred Morse – Morse Associates, Inc.

Cost Share Partners

NREL Transforming ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE U.S. Department Of Energy
World Bank
SolarPACES
ESTELA
EPRI

Project Intent, Objective and Audience

- **Intent** - to help developers, EPCs and O&M providers avoid the detrimental practices that have hindered some projects in the recent early commercial growth stage of power plants using CSP technology.
- **Objective** - to publish best practices and lessons learned from the engineering, procurement, construction, commissioning, operation and maintenance of existing parabolic trough and central receiver plants.
- **Audience** - developers, investors, lenders, off-takers, EPC firms, vendors, O&M providers, and policy makers.
- **R&D -** Identify issues that could benefit from further R&D

CSP Stakeholder Participation

Aalborg
Abengoa
ACWA
Advisian/Worley Parsons
Atlantica Yield
BrightSource
Cerro Dominador
ChemTreat
CMI
Cobra
CSP Services
DEWA
DLR
Gemasolar plant
Fichtner
Flowserve
FTI
Huiyin Group
La Africana plant
Lointek
MASEN
Mott MacDonald
Nevada Solar One
NRG
OCA Global
Parsons Group
Sargent & Lundy
SBP
SENER
SolarReserve
SolEngCo
SUNCAN
Terra-Gen (SEGS VIII/IX)
TSK
Virtual Mechanics
Vast Solar

CSP Facilities

90 commercial tower & trough plants in operation (+4 that have been decommissioned)

- 14 tower – 6 molten-salt, 8 steam
- 80 trough – 31 with TES

CSP Best Practices Report

- **Report Structure**
  - Parabolic trough technology
  - Molten-salt tower technology
  - Operation and maintenance
  - Project organization & project execution

- **Report Status**
  - Sensitive information reviewed by participants
  - External expert review completed
  - Stakeholder review
  - Issue Final Report - March 2020

General Findings

- **CSP plants are relatively complex power projects**
  - More of the issues identified are related to implementation in contrast to technology
  - It is best to work with experienced teams with proven solar plant track records
  - Projects need to have detailed Owner Technical Specifications (OTS)
  - Projects with more involved owners often fare better
  - Well-executed QA/QC in all phases of the development, design, procurement, construction, commissioning, and operation of a CSP power plant cannot be overstated
- **Some of the more significant problems are with conventional equipment**
  - Such as heat exchangers, valves, pumps, instrumentation, heat tracing
  - Plants need to be designed for good reliability and performance in off-design cases
- **Efforts to cut costs can end up costing projects more in the long run**
  - E.g. Low cost valves are not cheaper in the long run
- **Performance modeling has not been adequate for many projects**
  - The PM needs to handle transient plant behavior during startup and intermittent clouds to be accurate

Molten-salt tower technology experience

- **Successes**
  - Long shafted salt pumps have worked well
  - Receiver technology has generally worked well
- **Areas where issues remain**
  - Salt tank and foundation design
  - Steam generator reliability over full 1% to 100% design operation
  - Heliostat and DSC System: automation, control logic and alarm management can be improved
- **Details matter**
  - Design and QC of heat tracing and insulation on salt piping
  - QC on welding
  - Good heliostat optical quality
  - Cleaning of heliostats is challenging in some regions

Trough plant technology experience

- **Successes**
  - Most trough plants are operating well
  - Solar technology generally mature
- **Areas where issues remain**
  - Collector interconnection issues with ball joints, rotary joints, and flex hoses
  - Ullage system: important to remove and control degradation products
  - Designing plants for transient operation
  - Heat exchangers for SGS and TES: robust designs/good control system
  - DSC System: automation, control logic and alarm management can be improved
  - Standards need development: structural design for wind loads and collector optics
- **Performance modeling**
  - The latest advanced models offer better accuracy

Operation & Maintenance

- Having an O&M team with strong prior CSP experience is highly desirable
- The O&M organizations must be prepared to take over at COD
  - Important that projects invest appropriately in the O&M mobilization, preparation, and training.
  - EPCs typically provide some training for the O&M team, but depth and timeliness is critical. Projects need to realize that the training provided by the EPC is only a portion of the overall training program required to fully mobilize the O&M organization.
  - EPCs typically prepare “O&M manuals” but the O&M team needs more advanced material at COD to operate the plant
- Having the O&M leads involved in the design, construction and commissioning of the plant is highly recommended
- O&M costs are often not budgeted correctly in financial projections

Conclusion

- We believe the few remaining technology issues for parabolic trough and molten-salt tower projects are really design issues that can be resolved by appropriate engineering and equipment selection.
- Plants and equipment must be designed for the transient behavior that they will see.
- CSP projects are complex, they need to be properly managed. Best to work with experienced team with good track record.
- Desirable to have an experienced O&M team and to get them involved early.
- Accurate solar and wind resource assessment of the site is essential.
- Based on our finding, we are confident that future tower and trough plants can be built on time and budget and to perform as expected.

Thank you for your attention!

Hank Price, P.E.

Hank.Price@SolarDynLLC.com
+1 720-955-6404