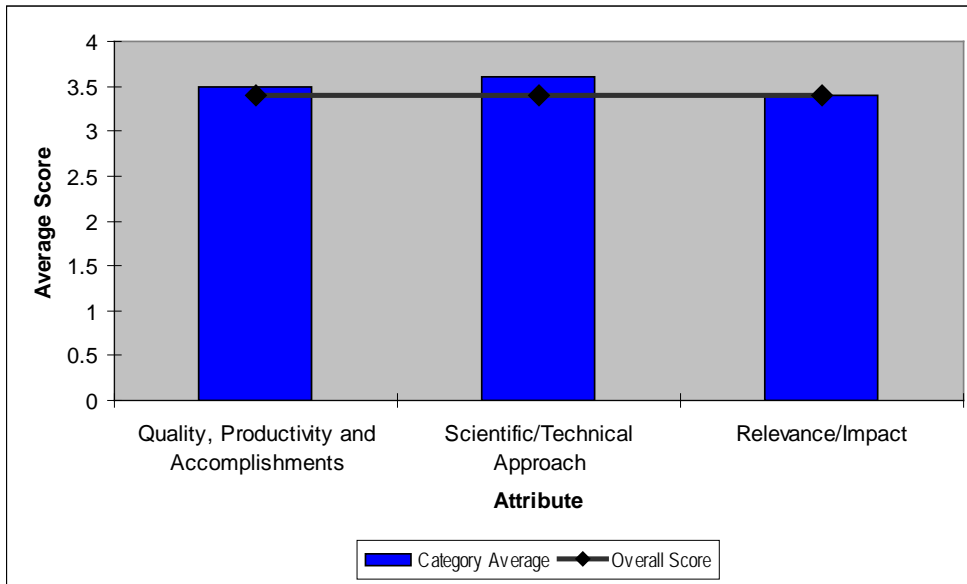


Power Tower Research & Development
Principal Investigator: Greg Kolb, Sandia National Laboratories



Review of SNL’s research and activities in CSP Solar Power Tower activities, which include long-distance heliostat tests, power tower software training, solid-particle receiver test and analysis, and upgrades to its steam receiver plant. Future activities will include tech transfer, heliostat CAD modeling, and work with Rocketdyne and eSolar.

Quality, Productivity and Accomplishments (Average Rating 3.5)

Rating Comments

- 3.0 This project represents the re-starting of Power Tower R&D activities at SNL, after long years of almost non-activity on this domain, due to lack of appropriate funding from DOE. Given the yet limited amount of resources allocated to it, the results obtained are excellent. The team executing the project is to be commended by its ingenuity and effectiveness in using the relatively low budget allocated to the project within FY 2008.

- 4.0 Very strong SNL project team. Limited mention of expertise of the industry participants. However, the team appears to have worked in close coordination with the industry partners. Sandia facilities used for the experiments are old but the best one could expect. However, they need to be upgraded and new capabilities need to be added.

The innovative set up for the heliostat tests was interesting. It demonstrated how ingenuity can produce meaningful results with very limited facilities. The Productivity and accomplishments of the project are very good. Expected results for the reporting period (2007 – 2009) have been obtained. Software training provided to Rocketdyne would be very useful for them to develop their heliostat technology.

- 3.0 An appropriate number of people, with well recognized technical credentials, have been engaged in this project. The members of the team and collaborators clearly demonstrate their ability to contribute to the project. The facilities deployed on the project appear to be adequate, but limited, for the task at hand. The work under way is producing an appropriate level of accomplishment relative to the costs incurred. The project team appears to be on schedule, but the project is clearly still in progress and not yet complete.

- 3.9
1. Rocketdyne is experienced in construction of solar one steam receiver and solar two salt receiver: first three are near-term, 4th is the longer term at Sandia. Now, new money going to R&D for power tower, which need high temp.
 2. Upgrade steam receiver plant model – lessons learned from Solar 1 // SOLARGY overpredicted about 15% annual production // trip receiver where insulation is less than 60%
 3. Power tower Software training
 4. DOE H2 work – Solid-particle receiver
 Molten salt only up to 600C, molten salt cheap storage, receiver must work at 1000C and be practical
- Future :
- Rocketdyne – heliostat and receiver panel tests
 H2 funding has dried up
 This is first step for power tower – 20 meter size instead of 7
 Alloy steel now, Wind load testing, Cycle testing, First time heliostat

Scientific/Technical Approach (Average Rating 3.6)

Rating Comments

4.0 The approach used in executing the project is very pragmatic and effective. It has helped to make the most out of the limited budget allocated to the project.

3.5 Use of SNL existing facilities and validation of approach and results with industry partners led to meaningful results. The primary and perhaps the only benchmark they have is Solar II, which produced very useful work. It was shut down in 1999, but the learning from it has been invaluable. Rocketdyne and BrightSource are planning to scale up (more than 10x) and there is no basis other than Solar II to help them, which is a limitation. The operational experience of the recently built Spanish plants (PS10 and soon to be completed PS 20) would be very useful. Development of the solid particle receiver is very important to push the envelope of tower technology beyond the temperature limitation of molten salt.

The CFD analysis of the sand curtain is interesting and useful. The concept of creating suction by drilling holes on the inside wall to prevent the sand from being blown out by wind is very good. However, this may not be 100 % safe. The effect of wind (from various directions) on the sand curtain needs to be studied more extensively and more mitigation plans need to be developed.

Efforts made by SNL staff to outreach to BrightSource is appreciated. However, continued effort to get them engaged and learn what they are doing would be beneficial. Any help you can offer them to be successful would be helpful. Having signed all those large agreements (at least on paper) the general public has no idea how realistic they are and whether they would really be able to build them successfully. An assessment of all the announced CSP agreements and their likelihood of being built would be a good study to undertake.

3.0 The project team applied an appropriate technical approach in pursuit of project objectives. The design and execution of the approach are good.

3.8 Best ASME paper
 Rocketdyne trying to commercialize molten salt USA ten times scale up (factor of 13)
 Spain 3 times
 Worked with Rocketdyne, who is experienced in construction of Solar One steam receiver and Solar Two salt receiver. However, Rocketdyne is new in the field of heliostat production.

Rocketdyne building own heliostat
 1 mile test
 Need flat heliostat
 Rocketdyne is new in the field of heliostat production
 Good software substitution – use of Sandia’s DELSOL and SOLERGY by Rocketdyne instead of upgrading their own software

Relevance/Impact (Average Rating 3.4)

Rating Comments

3.0 As noted earlier, this project represents the re-start of Power Tower R&D activities at SNL. As such, it is targeted to rapidly renovate and increase the R&D capabilities of SNL within that field of research, in order to allow SNL to make substantial contributions to the development of the CSP Power Tower industry in the near future.

4.0 Work is very relevant for the CSP industry, especially the partners in the project (Rocketdyne, eSolar, Brightsource, Solar Reserve). BrightSource has over 2000 MW agreement for CSP. The results of this project can play a strong role in the success of those projects.

3.0 \$233k FY08 for Power Tower R&D program
 \$400k FY08 for particle receiver H2 Program
 540MW thermal planned solar power tower Rocketdyne deployment
 More than 10,000 heliostats will be used in the commercial project
 60-70 sq meter heliostat design
 DELSOL optical software
 Solar One – steam receivers
 Solar Two – molten salt receivers
 SOLERGY code upgrade and revised in 2008
 DELSOL and SOLERGY are now core tools at rocketdyne
 Last time any serious heliostat design was done was back in the early 1980s
 Try to include a better analysis of uncertainty in DELSOL and SOLERGY
 Just starting to get back into the power tower business after a long time

Salt freezing in Solar Two under certain conditions
 Plan is to go with steam turbine design for rocketdyne
 Steam vs. molten salt vs. aluminum oxide
 Some think brayton cycle may be the way to go for the long term
 Really need to be looking at a parallel development path, using concepts of sbce

What do you view as main focus of power tower?
 Conduct detailed cad modeling of heliostat DFM
 Collector represents 40-50% of the cost of the system
 Need to have a path for internal r&d for heliostat and recvr design
 Need more work on steam receiver for power towers
 Brightsource, some went to esolar
 Solar paces – 37 abstracts in solar power tower in Berlin, Germany

3.8 • Good software substitution – use of Sandia’s DELSOL and SOLERGY by Rocketdyne ,instead of upgrading their own software.
 • Solid particle receiver is a new program since 2008
 • Solid particle receiver test – prototype receiver did not operate at higher flux levels or temperature as required for commercial operation – Does it need additional testing?
 • Is the effect of ambient wind well understood for the system stability?

- Is the overall concept feasibility confirmed?

Overall (Average Rating 3.4)

Rating	Comments
3.0	This project represents the re-starting of Power Tower R&D activities at SNL, after long years of almost non-activity due to lack of appropriate funding from DOE. The approach used in executing the project is pragmatic and effective. The team executing the project is to be commended by its ingenuity and effectiveness in making the most out of the limited budget allocated to the project in FY 2008. The paths reopened by this project will allow SNL to make substantial contributions to the development of the CSP Power Tower industry in the near future.
3.8	<p>It is unclear how old the Solar One and Solar Two results used in this project, how valid they still are. The Sandia models used are old, were developed in the 1980s, not enough details are provided to assess how much those models have been updated or what new features have been added. Even the solid particle receiver (SPR) was developed in the 1980s. How different is the one used in this project from the original one? What is the status of Rocketdyne's initial heliostat prototype? Was the SOLERGY model tuned to get more accurate predictions for DNI data at 15% interval?</p> <p>SOLERGY model automatically trips the receiver when the solar insolation reaches 60%. Is that realistic? How valid is this value for the Brightsource or eSolar receivers? Rocketdyne and Solarreserve planning to build plants 10 times larger than Solar II. Future work: to build CAD model for Heliostat, they don't have it now. For any CSP plant, the collector cost is about 50%, this is one of the more important area of focus for cost reduction. Completed a lot of good work with very little budget and resources. Project team is commended for their efforts and accomplishments.</p>
3.0	Effort should be increased in this area.
3.8	Initial test of Sandia heliostat performed at 1 mile. SOLERGY model was recreated and improved to provide better prediction on partly cloudy days for energy output and subsystem efficiencies. Increased effort should be provided in the Power Tower area to take advantage of future potential. Bright Source, who is a major player for the solar technology, should be part of this effort.