Heat Transfer Fluid and Thermal Storage Systems and Components

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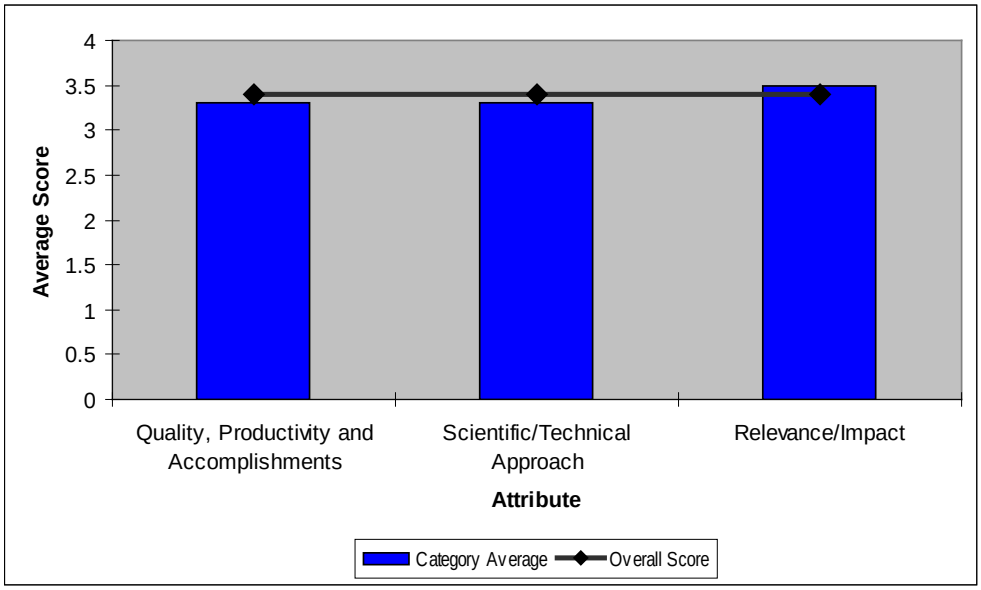

Details NREL's work in heat transfer-related CSP research. Activities such as materials characterization, storage systems performance modeling, nanofluids research, and storage systems cost analysis support the group's goal to improve cost and performance of heat transfer fluids, thermal storage components and storage systems for CSP plants.

Quality, Productivity and Accomplishments (Average Rating 3.3)

Rating	Comments
3.0	The goal of this project is of interest to industry. The team executing it is well qualified for the tasks it has to undertake.
3.5	Strong team with extensive experience in the relevant areas. Project accomplished the goals of this period. Only the last goal (thermal storage systems cost analysis) was not accomplished. Only a task ordering agreement is in place with sub contractor Worley-Parsons, the actual work has not progressed much yet. To be completed in 2009. Cost benefit analysis of different storage options and their applicability is a very important and urgent piece of work. Completing it as quickly as possible would benefit everyone. Right now, different technology providers are going with their preferred storage method (hopefully they are based on sound cost-benefit analysis). However, it is not transparent to others outside of those companies if that is the right option. A comparative study showing the cost-benefit of different storage and HTF and what type of application they are most suitable for would be of great benefit for the industry. Try to complete this work ASAP. It was unclear what the HTF for the thermocline was? If not decided yet, some discussion on how that will be determined or what are the possible options would have been beneficial.
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.

3.6 Nanofluids research work (500 -50 atoms) initiated for development of advanced heat transfer and storage fluids. Improve heat capacity. The addition of nanoscale materials to traditional fluids may greatly improve the fluid's thermophysical properties, such as thermal conductivity, heat capacity, freezing point, boiling point and high temperature thermal stability. Addition of a nanocluster or set of nanoclusters to a storage fluid may double its heat capacity, to allow the plant to store the same amount of thermal energy in half the amount of storage fluid.

Scientific/Technical Approach (Average Rating 3.3)

Rating **Comments**

3.0 The overall goal of the project is aligned with the interest of the CSP industry. The technical approaches used seem appropriate.

3.5 The first two tasks (GFO FOA support and establishing a materials lab) did not involve much scientific or technical involvement. The appropriate steps were taken and the goals were accomplished quite well. The use of CFD and other advanced techniques for adopting nano-materials as heat transfer fluid (goal 3) and performance modeling for two-tank and thermocline storage system seems appropriate, and considerable results have been produced.

3.0 The project team applied an appropriate technical approach in pursuit of project objectives. The design and execution of the approach are good. Advanced heat transfer fluids and test systems. External subcontractor for most of cost analysis Worley –parsons. New materials lab for pcm material characterization. Two tank and thermocline systems.

$688k FY08
$1031k FY09
Milestones on schedule

3.7 Multiphase transitions
Comparison of operation and efficiency of two-tank and thermocline storage systems – performance modeling and cost analysis
Develop cost to include commodity prices
Cost of storage SYSTEMS
Heat transfer fluids
Double tank thermal storage is better but depend on salt prices
Thermocline filler material is cheap, but operation is more complex
Need independent cost analysis
Steam power system
AZ needs storage, while southern CA does not

Relevance/Impact (Average Rating 3.5)

Rating **Comments**

3.0 Although at its initial stage, the project has the potential to make important contributions to the development of reliable solar thermal storage systems for CSP plants. The overall goal of the project is aligned with the interest of the CSP industry. The technical approaches used seem appropriate.

4.0 Development of Thermal Storage is critical for wide-scale application of CSP at utility scale central power stations. So, the research topic and the goals are highly relevant for the industry. Assisting in FOA, which is the vehicle to award contracts to carry out the identified research, is a valuable and relevant activity.

Meeting market needs:
• thermal storage allows CSP to generate reliable, dispatchable electricity to the grid
• allows CSP electricity generation to match the intermediate load profile
• reducing costs
• improved HTFs result in higher operating temperatures, greater thermodynamic efficiency and low LCOE
• improved storage materials result in lower storage inventory and lower capital costs
• performance & cost analysis optimizes storage systems design and operation resulting in lower LCOE

3.0 Molecular dynamics modeling of nanoclusters of 50-500 atoms to enhance tf properties Two tank vs thermocline molten salt storage system. Operating strategies for thermal storage systems to optimize performance and minimize costs – what are the critical parameters that you plan to optimize, and what measures of performance do you anticipate? Roundtrip efficiency for any thermal storage system is primary performance criterion. Is this definition appropriate to include in a performance metric standard? Parameters – configuration issues -- consider an aluminum oxide shell on the cluster, and then limit the phase change to the material inside of the oxide shell. Analytical techniques must be used to complement empirical techniques.

4.0 The CSP program goal for parabolic trough power plants is to achieve cost-competitive power generation for intermediate power markets by 2015 (estimated at 7¢/kWh with up to 6 hours of storage) and for baseload power markets by 2020 (estimated at 5¢/kWh with up to 16 hours of storage). These cost targets will be adjusted based on the real cost of conventional fuels.

Overall (Average Rating 3.4)

Rating	Comments
3.0	The goal of the project is aligned with the interest of the CSP industry. The team executing it is well qualified and the technical approaches it is following are appropriate. The project has the potential to make important contributions to the development of reliable solar thermal storage systems for CSP plants.
3.8	An update on the projects awarded through the recent HTF and TES FOA would have been valuable. Involving some external reviewers in the down-select of the FOA projects (to be done later this year) for next phase would be beneficial.
3.0	This should be one of the highest priority work areas for CSP. Recommend a study to develop a design guide (tied in with SAM analysis) demonstrating what type of thermal storage is appropriate for what kind of CSP technology. For example, Solar Reserve is going w/ 2 tank molten salt – is that really best? Coupling this design guide analysis with both SAM and the probabilistic work of Cliff Ho would be very powerful and compelling, could have both positive technical impact and positive developer/ financial institution acceptance impact.
3.7	The goal of this work is to improve the performance and decrease the cost of thermal storage components and systems for CSP power plants. This goal directly supports the CSP Program goal of achieving the near-term and long-term cost targets for CSP electricity. The benefit of nanoscale materials is to lower costs for the storage fluid and the storage tanks resulting in lower cost electricity. The results indicate sufficient progress towards achieving the program's mission and goals.

Thermal Storage System: One of the highest priority work areas for CSP is a study to assess what type of thermal storage is optimum for what kind of CSP technology? E.g. is the solar reserve w/ 2 tank molten salt best thermal storage alternative?