SAND2012-9168P

King Saud University Statement of Work and Deliverables for FY13

10/15/12

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This project seeks to make revolutionary advancements in falling particle receivers for concentrating solar power applications that will enable higher temperatures and greater efficiencies at a lower cost. Technical innovations that will be pursued include (1) advances in receiver design with consideration of particle recirculation, air recirculation, and interconnected porous structures; (2) advances in particle materials to increase the solar absorptivity, energy storage, and durability; and (3) advances in the balance of plant for falling particle receiver systems including thermal storage, heat exchange, and particle conveyance.

Specific Tasks and Deliverables
(Note: Numbering matches tasks and milestones in proposal 0595-1558 awarded by DOE)

Subtask 1.1.2 Evaluate commercial receiver lift designs and design small-scale particle lift - Systematically evaluate available commercial lift designs, types, and their adaptability to high temperature service based on cost, parasitics, and capacity.

Subtask 1.3.1 Lab-scale evaluation of flow & thermal characteristics in ceramic porous structures - Testing will evaluate the flow of different candidate particle types through different size and distribution of porous structures. Thermal testing in a laboratory and on-sun will evaluate shock resistance, thermal performance, and durability of porous ceramic structures.

Subtask 1.3.4 Modeling of flow and heat transfer in irradiated porous structure - Modeling will attempt to accurately represent the effects found in 1.3.x tasks to allow for better understanding of the underlying physics as well as allowing optimization of properties such as foam density and pore size.

Deliverable 1.3.1 – Complete systematic study using mass measurements after successive particle passes through the porous structures that demonstrates particles will not continue to accumulate (clog) the porous structures at temperatures > 700 °C (or the minimum particle temperature identified in Subtask 3.2.1, whichever is greater). Demonstration of particles no longer clogging is defined as a weight gain of less than 0.1% of total mass over 50 consecutive passes[1]. Particle temperature rise and clogging as a function of pore-size distribution will be determined. **Due 8/30/13.**

Subtask 3.1.1 Experimental evaluation and modeling of prototype thermal energy storage designs – Testing and modeling of candidate materials for the storage of heated particles will be evaluated to select the best materials, configuration, and design for thermal energy storage system.

[1] This is mathematically defined by the following: the difference in the weight of the foam plus any particle mass entrained in the foam at pass (X + 50) and the weight of the foam plus any particle mass entrained in the foam at pass (X) divided by the weight of the foam plus any particle mass entrained in the foam at pass (X).

Deliverable 3.1.1 – Deliver a ranked list of concept designs for Sandia on-sun storage testing at up to 1000°C with heat loss corresponding to less than 5% per day for the prototype system (a dimensional analysis shows that this corresponds to a 1% per day heat loss for commercial-scale systems that are ~100 times larger; the corresponding surface area-to-volume ratio is 5 times less). **Due 8/30/13.**

Subtask 3.2.2 Experimental evaluation of heat exchangers – Evaluate and test heat exchanger designs for particle-to-fluid heat exchange.

Deliverable 3.2.1 – Validation of the model predictions with experimentally determined data. Using the validated model establish preliminary designs for heat exchangers for temperature up to 1000°C, projected cost <$30/kWth,[2] and exergetic efficiency (as defined in the ARPA-E HEATS FOA) is ≥ 95% (90% for prototype system). **Due 8/30/13.**

Subtask 3.3.1 Engineering Evaluations of various particle lift elevator concepts – Commercial and conceptual lift concepts will be evaluated for suitability to application. Develop model of tower lift including analysis of losses and parasitics.

Deliverable 3.3.1 – Develop at least two viable designs that account for: 1) less than 0.01% of particle mass flow rate (subject to refinement based on technoeconomic systems analysis; 2) the increased cost of the lift system as the height of sand transfer is increased; and 3) the impact of sand on any moving parts. Other considerations identified during the evaluation of transport of granular media will be addressed in the design. **Due 8/30/13.**

Reporting requirements: The contractor shall (1) participate in monthly teleconferences/meetings to review progress and provide updates, (2) provide written quarterly reports as scheduled by the funding agency (U.S. Department of Energy), (3) provide written input for a year-end report that will be submitted to DOE, and (4) participate, if available, in the year-end go/no-go review meeting with DOE.

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[2] The cost of the heat exchanger associated with heat transfer from the storage media to the working fluid is allocated to the "Balance of Plant" or "Steam Generation" costs (see Table 1 of the "Power Tower Technology Roadmap and Cost Reduction Plan," SAND2011-2419).