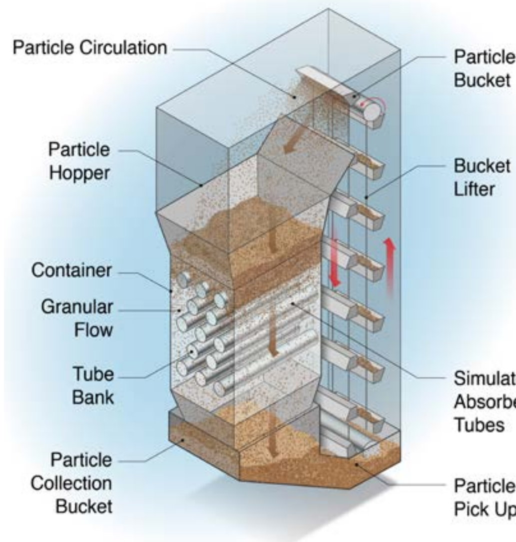
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Particle Receiver Will Enable High-Temperature CSP

Highlights in Research & Development

Near-blackbody enclosed particle receiver can support high-temperature thermal energy storage and high-efficiency power cycles.

National Renewable Energy Laboratory (NREL) scientists are designing and developing an innovative high-temperature particle receiver and integrated heat-exchanger system to be used in high-efficiency concentrating solar power (CSP) systems.



Schematic of NREL's particle receiver module design that features highly effective solar heat collection.
Illustration by Al Hicks

This configuration is addressing the temperature, efficiency, and cost barriers associated with current molten-salt CSP systems. Even with significant improvements in operating performance, these molten-salt systems face challenges to satisfy desired cost and performance targets.

The technical focus for NREL's new receiver absorber, however, is a design that leads to greater than 90% receiver thermal efficiency for particle exit temperatures of 800°C, which will achieve a working fluid temperature greater than 650°C. In addition, the materials selected will withstand these high temperatures while yielding a receiver cost of less than $150 per kilowatt-thermal.

To analyze the receiver module performance, NREL has developed comprehensive thermal/mechanical modeling tools based on NREL's SolTrace ray-tracing model for receiver flux simulation, ANSYS Fluent thermal model, and mechanical simulation for service life. NREL has also built a particle-flow/heat-transfer test setup to characterize certain steps in the process that are difficult to evaluate through modeling.

These new modeling and testing tools are being used to design a prototype receiver whose performance will be verified in on-sun testing.

This development work is also leveraging existing technology and manufacturing capabilities for the fluidized-bed thermal system, which will accelerate the realization of the technology and minimize the technical risk.

Technical Contact: Zhiwen Ma, *zhiwen.ma@nrel.gov*

References: Ma, Z. (2014). "Development of Fluidized-Bed Technology and Near-Blackbody Enclosed Particle Receiver for CSP with Thermal Energy Storage." Summary for SunShot Initiative CSP Program Review, May 2014.

Ma, Z.; Glatzmaier, G.; Mehos, M.; Sakadjian, B.; Fan, L.; Ban, H. (2013). "Development of a Near-Blackbody Enclosed Particle Receiver for a Concentrating Solar Power Plant Using Fluidized-Bed Technology." SunShot Initiative CSP Program Review 2013, April 23–25, Phoenix, AZ, pp. 91–93.

Ma, Z.; Glatzmaier, G.; Mehos, M.; Sakadjian, B. (2014). "Development of a Concentrating Solar Power System Using Fluidized-Bed Technology for Thermal Energy Conversion and Solid Particles for Thermal Energy Storage." SolarPACES 2014, forthcoming.

Key Research Results

Achievement

NREL has developed comprehensive thermal/mechanical modeling tools and has built a test setup for its particle receiver design.

Key Result

NREL modeled the thermal efficiency for its receiver module with average particle temperatures of 527°C and 727°C with respect to receiver aperture flux. At a solar flux of less than 1 MW/m^2, both particle-temperature cases modeled showed a receiver thermal efficiency of greater than 90%.

Potential Impact

With its ultimate receiver design, NREL aims at a 30-year service life with a cost estimated at less than $\$100/kW_{th}$. The receiver can be integrated with particle thermal energy storage that costs less than $\$6/kWh_{th}$ to make a high-temperature CSP system.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

NREL/FS-5500-62504 | August 2014

NREL prints on paper that contains recycled content.