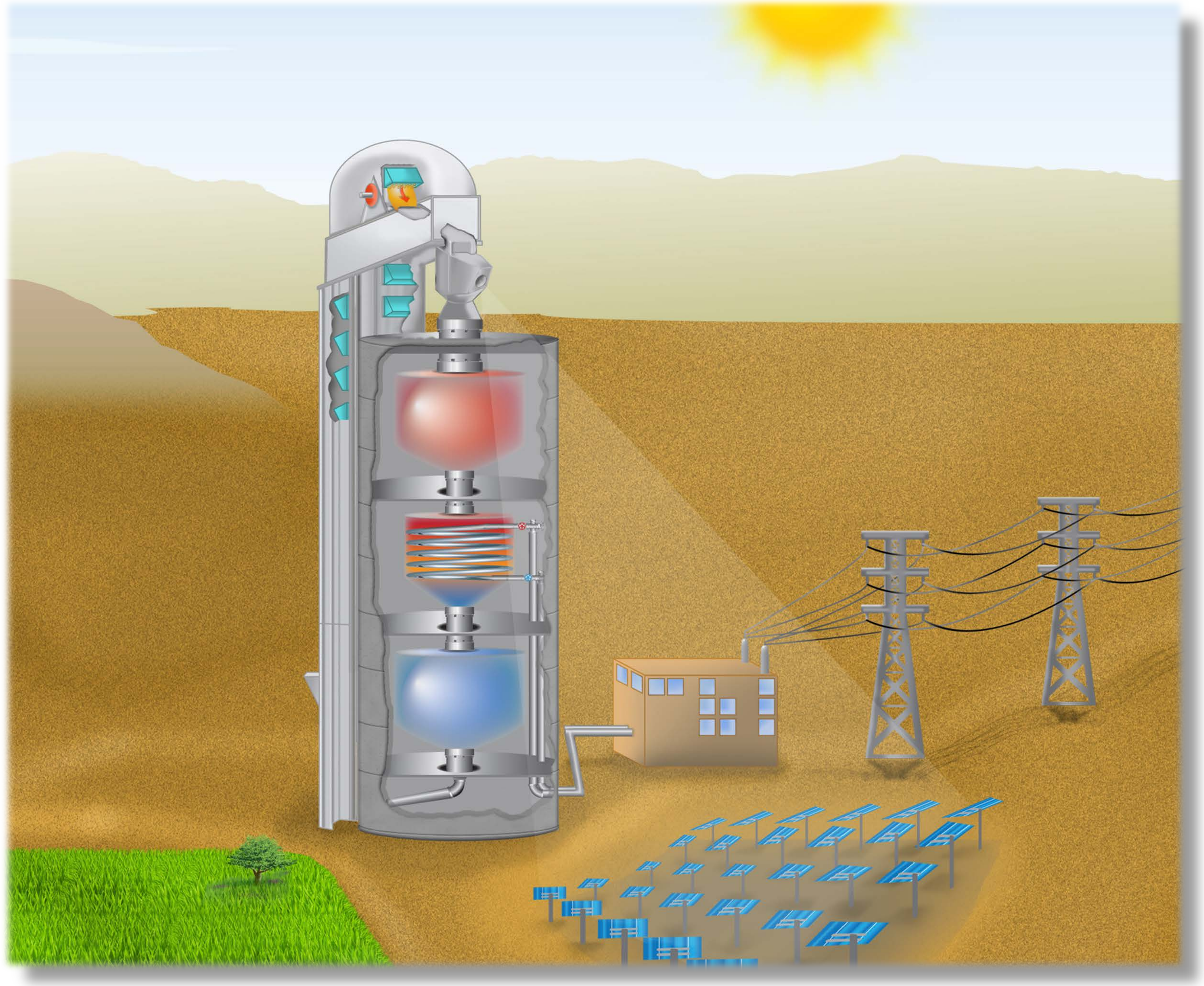
High Temperature Falling Particle Receiver

SunShot CSP R&D FOA Award Recipient (DE-FOA-0000595)

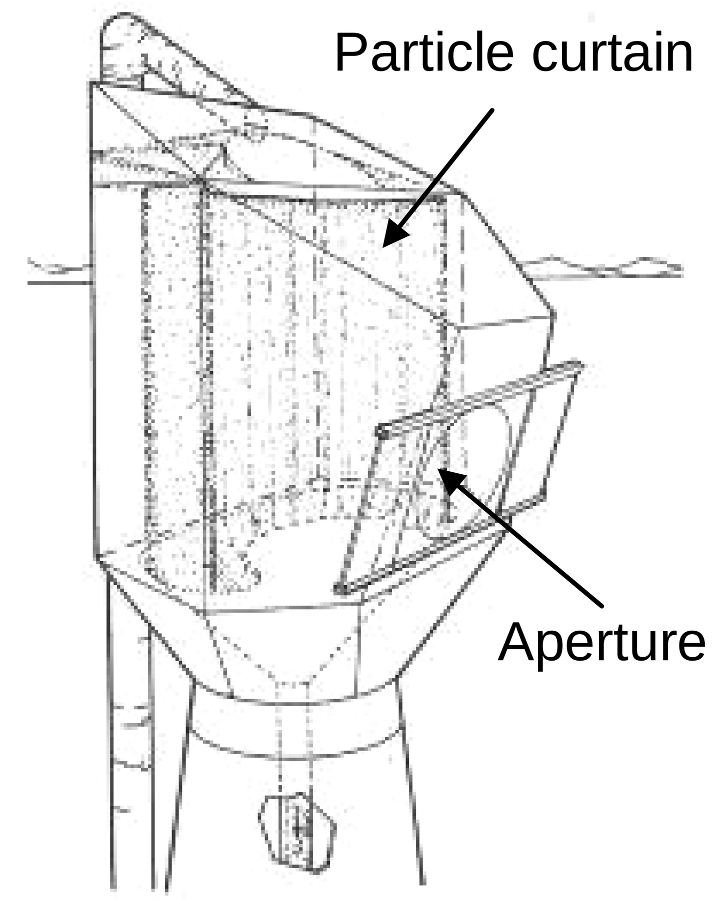
PI: Clifford K. Ho, (505) 844-2384, ckho@sandia.gov

Technology Summary

The falling particle central receiver is an enabling technology that can increase the operating temperature for concentrating solar power (CSP), improving efficiency and lowering the costs of energy storage for large scale electricity production. Conventional central receiver technologies are limited to temperatures of around 600 °C. At higher temperatures, nitrate salt fluids become chemically unstable. In contrast, direct absorption receivers using solid particles that fall through a beam of concentrated solar radiation for direct heat absorption and storage have the potential to increase the maximum temperature of the heat-transfer media to >1,000°C. Once heated, the particles may be stored in an insulated tank and/or used to heat a secondary working fluid (e.g., steam, CO_2, air) for the power cycle. Thermal energy storage costs can be significantly reduced by directly storing heat at higher temperatures in a relatively inexpensive medium (i.e., sand-like particles). Because the solar energy is directly absorbed in the sand-like working fluid, the flux limitations associated with tubular central receivers are significantly relaxed. The falling particle receiver appears well-suited for scalability ranging from 10 – 100 MW_e power-tower systems.



Conceptual drawing of a high-temperature falling-particle receiver system to achieve greater efficiencies and lower costs



Direct absorption of concentrated sunlight by falling particles

Program Summary

- Period of performance: 36 months
- Federal funds: $4,315,017
- Cost-share: $1,081,814
- Total budget: $5,396,831

Technology Impact

Current central receiver systems are limited to temperatures less than 600°C with power-cycle efficiencies up to ~40%. The falling particle receiver system will enable higher temperatures (>650°C) which will increase power-cycle efficiencies (>50%) and allow cheaper thermal storage that will lower the levelized cost of electricity towards the SunShot goal of $0.06/kWh.

Key Institutions and Personnel

Sandia National Labs: Dr. Clifford K. Ho (PI), Dr. David Gill

Georgia Tech: Dr. Sheldon Jeter, Dr. Said Abdel-Khalik

Bucknell University: Dr. Nathan Siegel

King Saud University: Dr. Hany Al-Ansary

DLR: Dr. Reiner Buck, Lars Amsbeck

	Key Milestones & Deliverables
Year 1	• Show feasibility and performance of lift and recirculation systems for operation above 650°C • Select concept designs for storage and heat exchangers
Year 2	• Test lift, recirculation, heat exchanger, storage, and particle designs operable at T>650°C at lab scale • Estimate cost and performance of system based on tests and design studies
Year 3	• Construct and perform on-sun tests of a 1 – 5 MW_{th} prototype falling-particle receiver with different flow rates and power levels to demonstrate technical targets

Proposal Number: 0595-1558

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

SAND2012-4793P