# Fractal-Like Receiver Designs for High-Temperature High-Efficiency Operation

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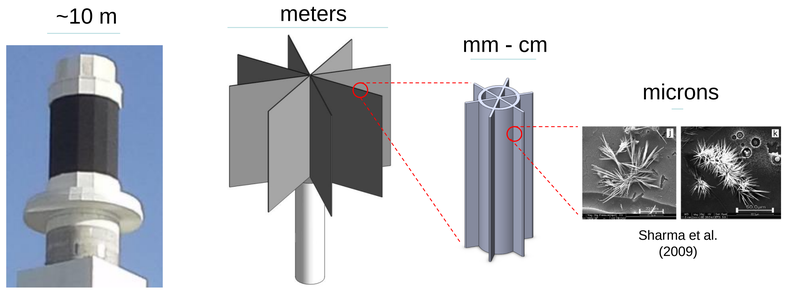
## PROBLEM STATEMENT & VALUE PROPOSITION

- Radiative heat losses are maximized in conventional receiver designs due to direct reflections and emittance to the environment
- Radiative heat losses become more important as we move toward higher temperature receiver designs
- Use of fractal-like, bladed, or other non-planar geometries can:
  - Increase light-trapping
  - Reduce radiative and thermal heat losses
  - Allow increased solar flux concentration for increased thermal efficiency
  - Apply to both tubular and particle receivers

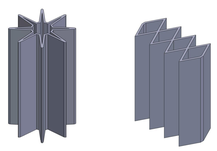



Conventional cylindrical solar receiver

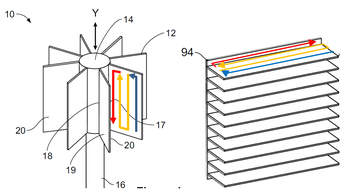
New fractal-like designs with light-trapping and low-emittance properties at multiple scales

**Patents Pending**

### Tubular Receivers

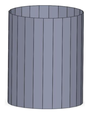


Light-trapping geometries



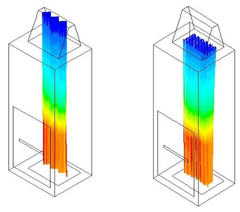


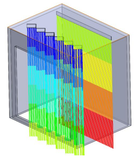
Reduced radiative view factors in hottest regions



Increased concentration ratio by reducing optical aperture size while maintaining same surface irradiance

### Particle Receivers





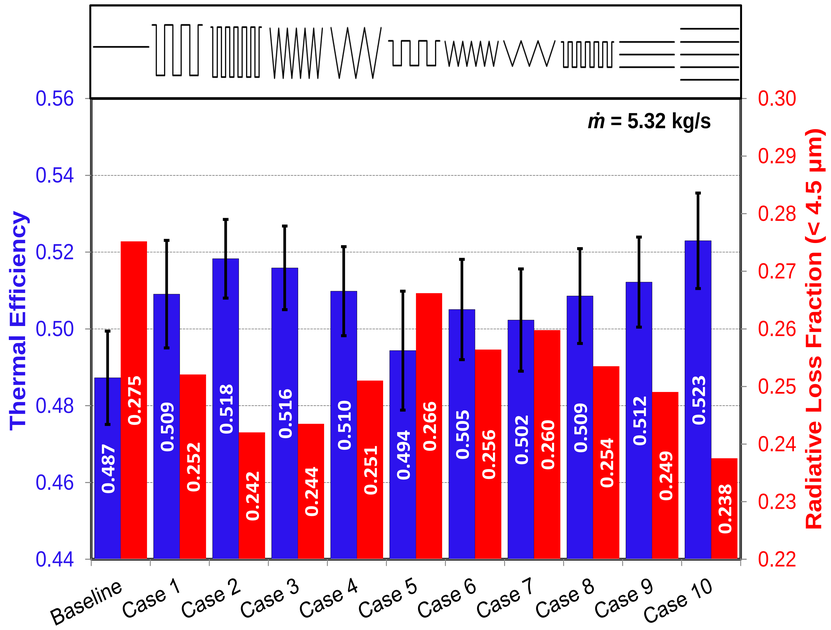
## OBJECTIVES & APPROACH

Employ fractal-like (zig-zag, volumetric) particle receiver designs to increase efficiency at higher particle temperatures

- Develop computational models and experiments:
  - Characterize particle flow and stability for novel release patterns
  - Optimize release patterns to maximize particle temperature rise and thermal efficiency relative to baseline (planar) case
- Perform on-sun tests to validate models

| Case | Depth (m) | Scaled Illustration | Case | Depth (m) | Scaled Illustration |
|---|---|---|---|---|---|
| Baseline | N/A | | Case 7 | 0.2 | |
| Case 1 | 0.4 | | Case 8 | 0.2 | |
| Case 2 | 0.4 | | Case 9 | 0.2 | |
| Case 3 | 0.4 | | Case 10 | 0.4 | |
| Case 4 | 0.4 | | Case 11 | 0.6 | |
| Case 5 | 0.2 | | Case 12 | 0.4 | |
| Case 6 | 0.2 | | Case 13 | 0.6 | |

## RESULTS




Simulated thermal efficiency and radiative heat loss for different particle release patterns

## PATH TO MARKET

- Collaborated with Abengoa Solar on design of 1 MW falling particle receiver system in Spain
- Received DOE APOLLO award with Abengoa Solar on high-temperature falling particle receiver for combined air-Brayton cycle
- Working with DOE ELEMENTS program to develop reactive particle receivers with thermochemical storage
- Developing concepts and designs for solarized supercritical $CO_2$ Brayton cycles

## FUNDING & KEY INSTITUTIONS

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- Sandia National Laboratories

SunShot U.S. Department of Energy

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