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

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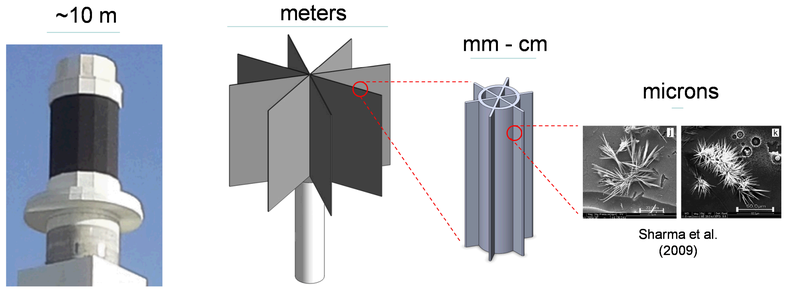
CSP SunShot SUMMIT 2016: RECEIVERS

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

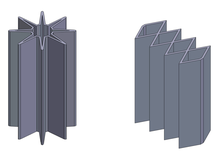


Conventional cylindrical solar receiver

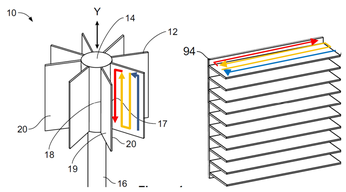
New fractal-like designs with light-trapping and low-emittance properties at multiple scales

Patents Pending

Tubular Receivers

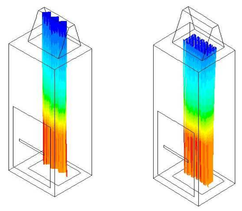


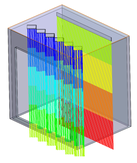
Light-trapping geometries

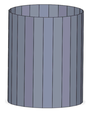


Reduced radiative view factors in hottest regions

Particle Receivers







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

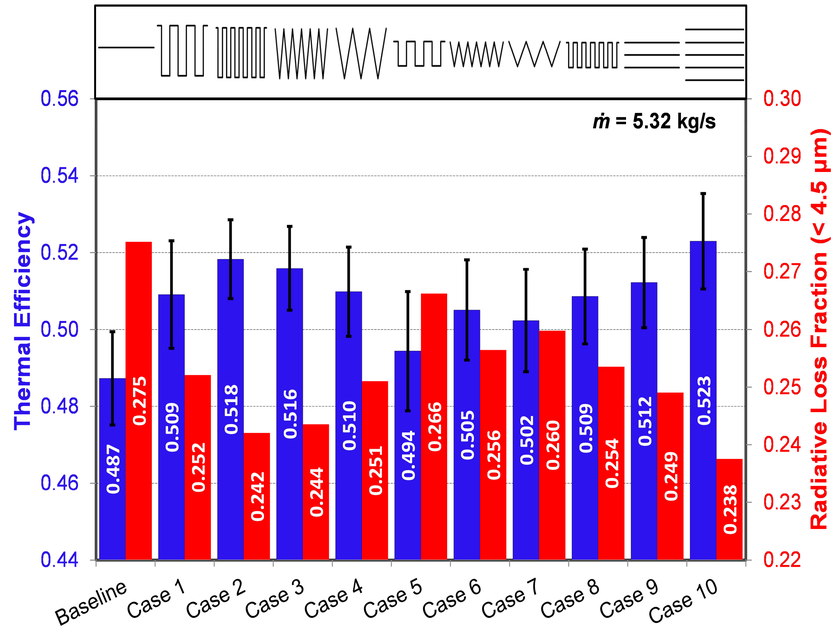
OBJECTIVES & APPROACH

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

- FY16 – FY17: $880K (DOE)
- Sandia National Laboratories

SunShot U.S. Department of Energy

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