PROJECT NAME: Light Trapping, Enclosed Planar-Cavity Receiver for Heating Particles to Enable Low-Cost Energy Storage and Chemical Processes (LTPCR)

Last 5 digits of project number: **38896**
Principal Investigator (PI): **Zhiwen Ma**
Lead Organization: National Renewable Energy Lab
PI Email: **Zhiwen.ma@nrel.gov**

BACKGROUND and OVERVIEW

- A novel modular, scalability receiver design for various Concentrating Solar Thermal (CST)-Concentrating Solar Power (CSP) applications and scale of economics.
- High-temperature, high performance operation to support Generation 3 CSP and solar thermochemical processes.
- Effective interaction with solar heliostat field for high solar concentration and low thermal-optical losses.
- Low maintenance and 30-year service life.

METHODS

- Assessed solar field layouts, tower height, & receiver design to meet thermal-mechanical performance.
- Incorporated particle heat transfer enhancement in enclosed particle receiver.
- 1. Flux spreading to accommodate a low heat-transfer media; 2. Leading edge strategies; 3. Enhancing particle/panel wall heat transfer, 4. Thermal-mechanical performance and service life.

KEY MILESTONES

- Protect leading-edge subjected to high incident solar flux.
- Increase particle heat transfer by internal fins and fluidization control. Particle flow and heat transfer modeling using MFIX software and lab test at CSM, UTK, UCSD for heat transfer >1,000 W/m^2-K
- Thermal-Mechanical Modeling use ANSYS and FENICS software with ANL Creep-Fatigue method Alloy-740 metal panel to achieve 30-yr service lifetime.
- Improve thermal performance by thermal management for 90% receiver thermal efficiency.
- Cost analysis shows <100 $/kWt for a 50-MWt receiver assembly including a wind tower and particle lift device.
- Mitigated risks and developd a 100 kWt prototype receiver for on-sun testing.

CONCLUSION

- LTPCR design enables inexpensive non-black particles for low-cost, high efficiency CSP and solar thermochemical processes.
- Developed the principle of the planar-cavity receiver for flux spreading and light trapping.
- LTPCR enclosed particle receiver is feasible with particle heat transfer enhancement and optical/thermal/mechanical performance.
- The LTPCR receiver design has potentials to support next generation CST-CSP.

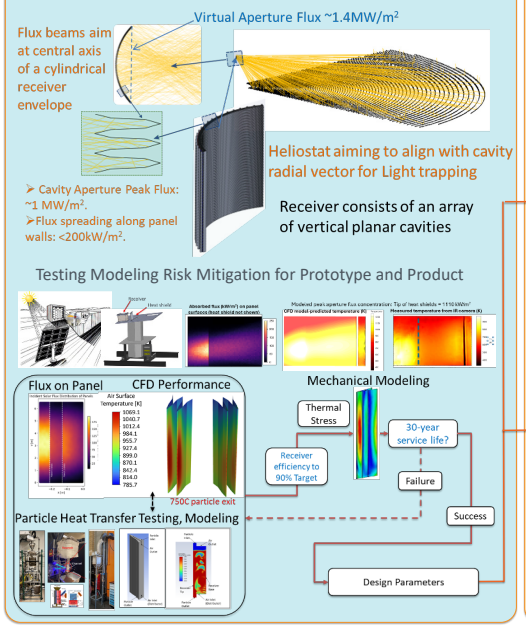
CONCENTRATING SOLAR-THERMAL POWER TRACK

A Novel Scalable, Light Trapping Receiver under Testing, Modeling, Prototyping Verifications to Enable High-Temperature, High Performance Designs for Gen3 Particle CSP and Thermochemical Processes

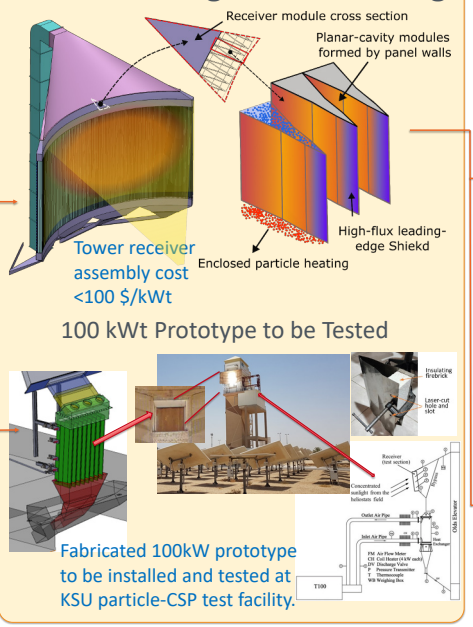
U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY
SOLAR ENERGY TECHNOLOGIES OFFICE

NREL/PO-5700-89182

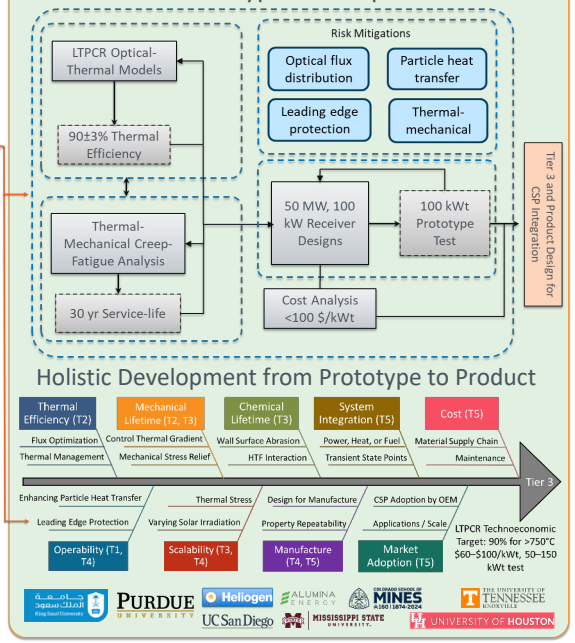
Optical Modeling of the Light-Trapping Principle- Enabling >1MW/m^2 Solar Flux



50-MWt Commercial LTPCR Receiver Design and Modeling



Comprehensive Modeling, Testing, Product and Prototype Development



Additional Project Contributors: J. Martinek, M. Shah, S. Jeong, J. Hirschey, J. Gifford, H. Xin, J. Netter, T. Farrell (NREL), K. Brewster, A. Laksana, G. Jackson (CSM), K. Appaswamy, C. Wedikkara, A. Morris (Purdue); O. Abourazzouk, L. Li (MSU/UCF), B. Xu, M. Farias (UH), Y. Aider, P. Singh (UTK); H. Al-Ansary, E. Djajadiwinata, N. Alabsi (KSU); X. Zhang, R. Chen (UCSD); S. Braun (Alumina)