# High-Temperature Particle Heat Exchanger for $sCO_2$ Power Cycles

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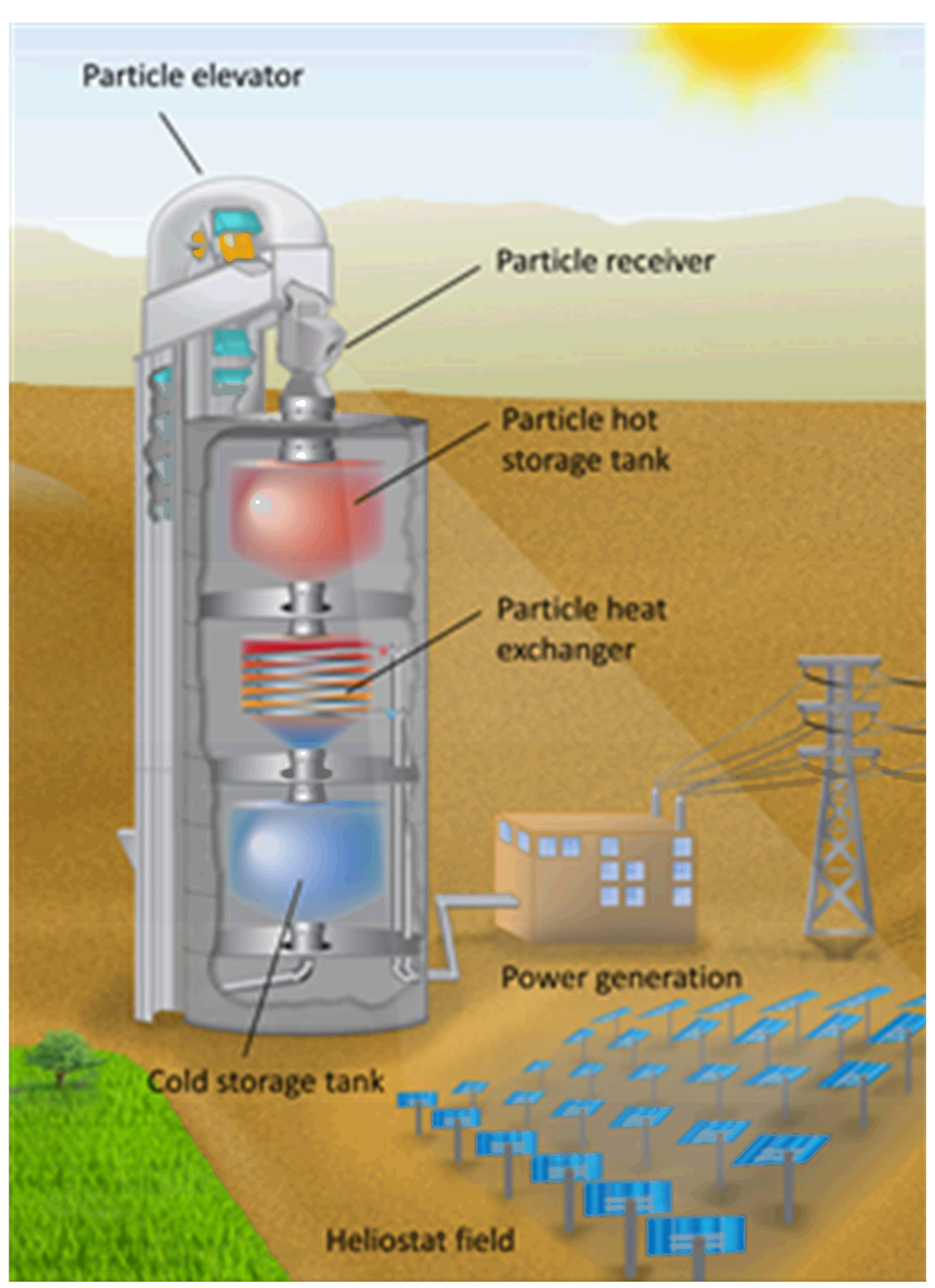
## PROBLEM STATEMENT

- Conventional molten-salt central receiver systems are limited to temperatures <600 °C
- Advanced power cycles (combined air Brayton, supercritical $CO_2$ Brayton) require higher temperatures (>700 °C)
- Particle receivers are being investigated to achieve these higher temperatures, but particle heat exchangers operating at necessary temperatures and pressures (>20 MPa) do not exist

## OBJECTIVES & VALUE PROPOSITION

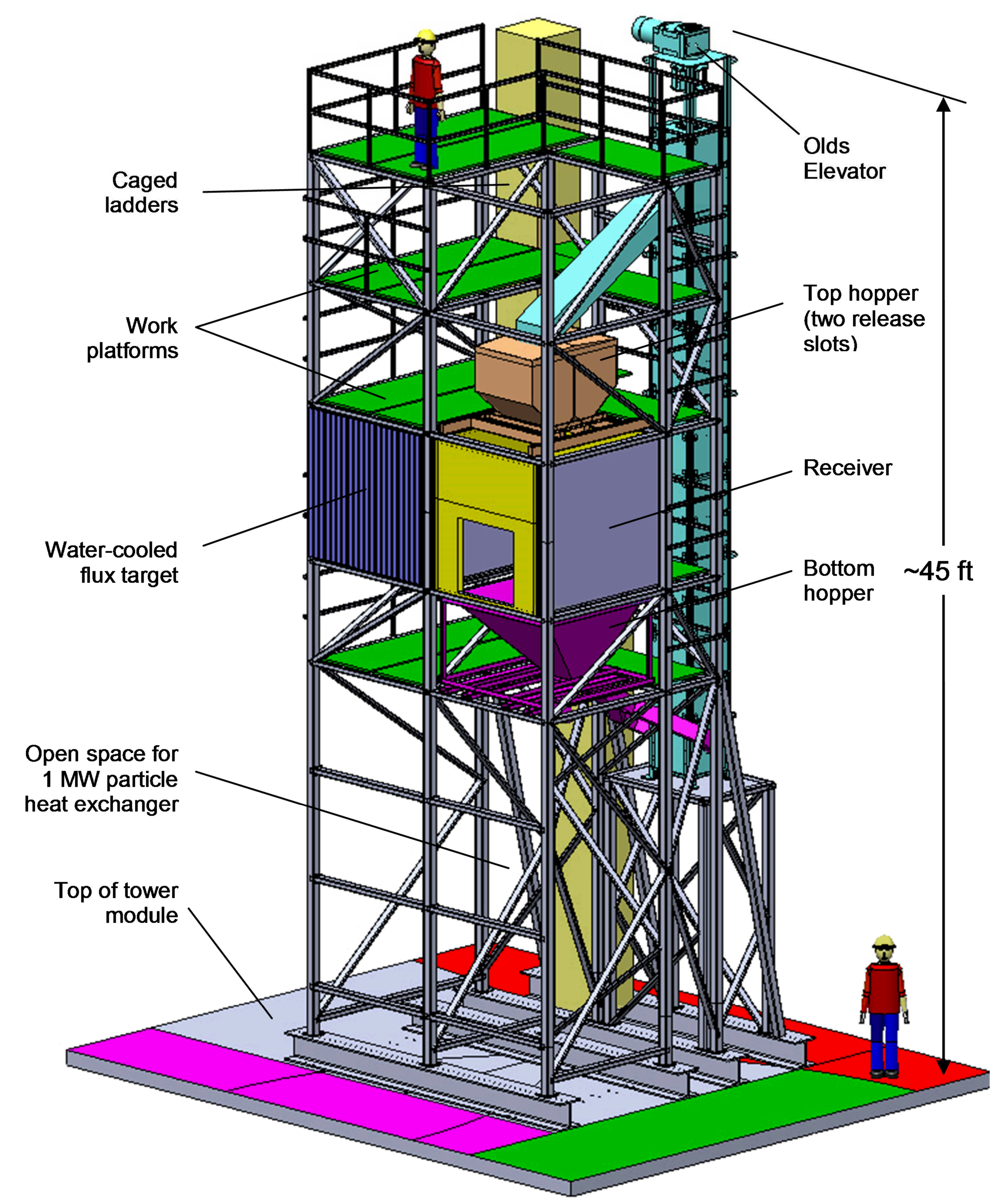
- Design, develop, and test the world's first particle/$sCO_2$ heat exchanger
  - Particle temperature ≥ 720 °C
  - $sCO_2$ temperature ≥ 700 °C
  - $sCO_2$ pressure up to 20 MPa
  - Overall heat transfer coefficient ≥ 100 W/m²-K
  - Total cost of power-block components ≤ \$900/kW$_e$
    - Specific cost of prototype heat exchanger ≤ \$30/(W/K)



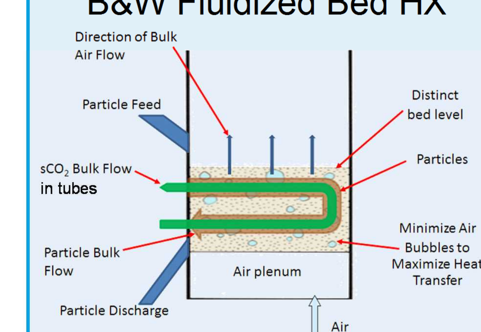
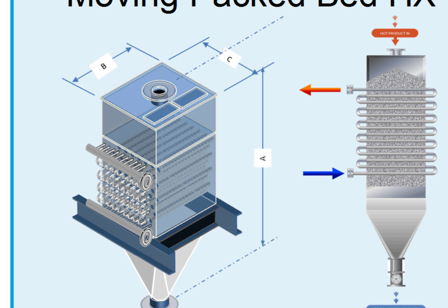

## APPROACH

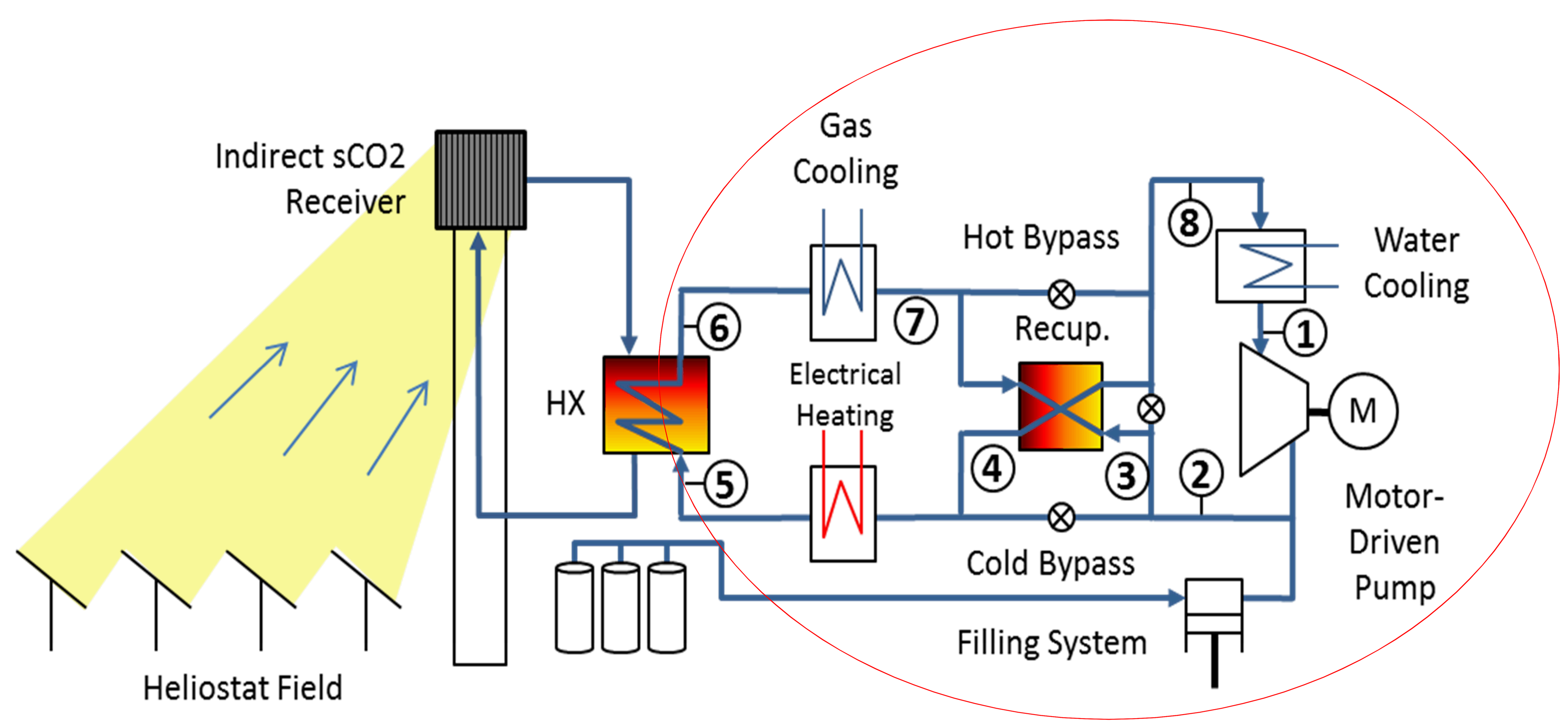
- Work with industry leaders to design and develop particle-$sCO_2$ heat exchanger that meets cost/performance requirements (Year 1)
- Utilize experience and infrastructure at Sandia, NREL, and Georgia Tech to downselect, procure, and test components (Years 1 & 2)
- Integrate heat exchanger with high-temperature falling particle receiver and skid-mounted $sCO_2$ flow loop (Year 3)

1 MW$_t$ falling particle receiver provides >720 °C particles to heat exchanger




### Particle/$sCO_2$ Heat Exchanger Design Options

| Design Options | Pros | Cons | Risk Mitigation |
|---|---|---|---|
| B&W Fluidized Bed HX   | • High heat transfer coefficient, low heat transfer area<br>• Possible counter flow design | Parasitic power requirements and heat loss from fluidizing gas | Minimization of fluidization velocity to reduce power requirements and heat loss through CFD modeling |
| Solex – Shell-and-Tube Moving Packed Bed HX  | • Gravity-driven flow<br>• Tubes can handle high-pressure $sCO_2$<br>• Possible counter flow design | Particle flow stagnation area on top of tube and shadow area beneath tube may impede heat transfer | Improve particle/tube heat transfer via staggered tube arrangement with optimized spacing and/or extended surfaces |
| VPE – Shell-and-Plate Moving Packed Bed HX  | • High potential surface area for particle contact<br>• Possible counter flow design | Unreliable contact between particles and plate walls is a concern | Enhanced particle-wall contact through optimized plate spacing and arrangement |




$sCO_2$ flow system provides pressurized $sCO_2$ to heat exchanger for test and evaluation

## PATH TO MARKET

- We are partnering with industry leaders (B&W, Solex, VPE)
- By engaging and working with these companies during the early design, development, and testing phases of this project, we will enable and develop a manufacturable technology and path towards rapid commercialization

## FUNDING & KEY INSTITUTIONS

- FY16 – FY18: \$4.6M (DOE)

Sandia National Laboratories | B&W | VPE | NREL | SOLEX THERMAL SCIENCE | Georgia Tech