High-Temperature Particle Heat Exchanger for sCO_2 Power Cycles

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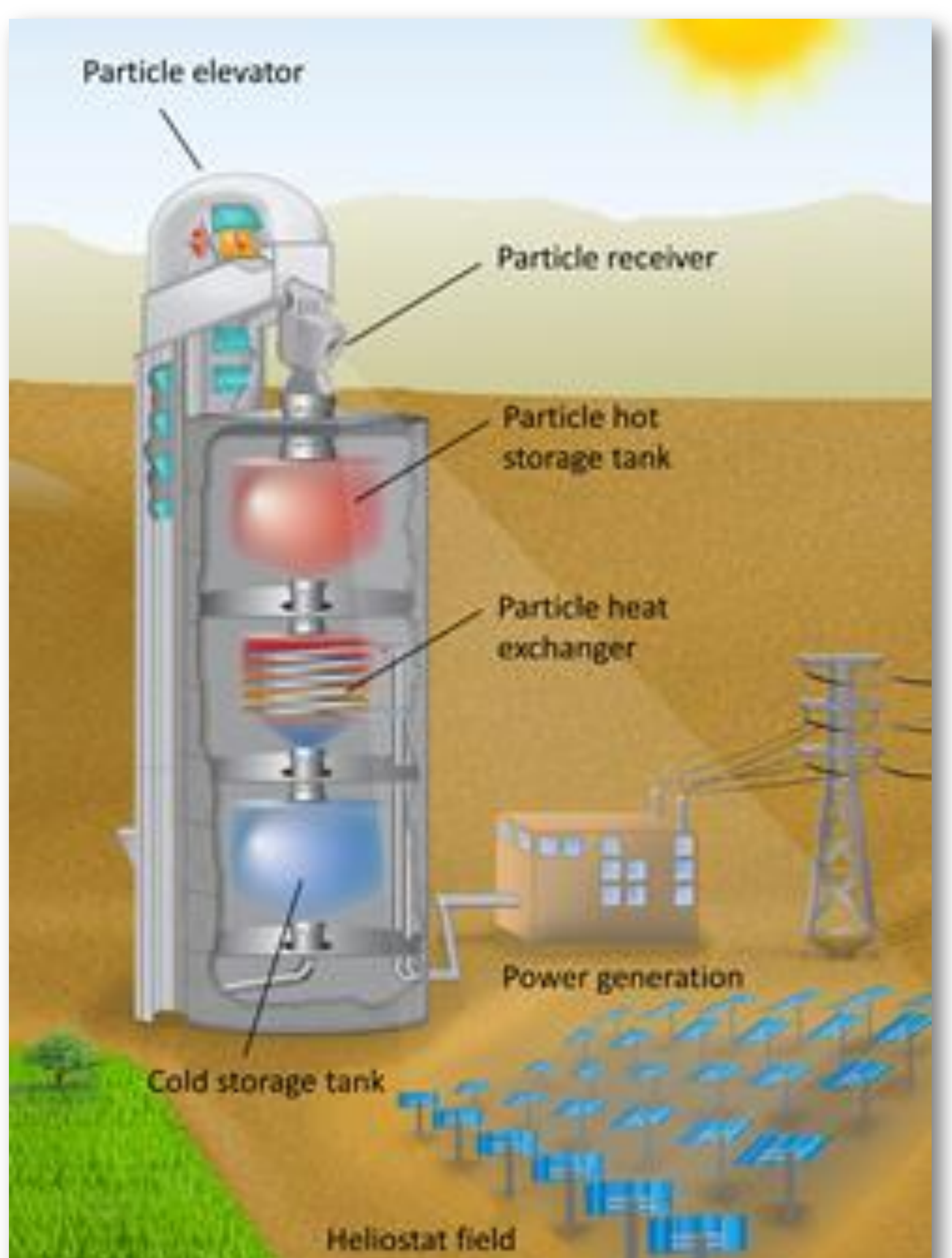
PROBLEM STATEMENT

- 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

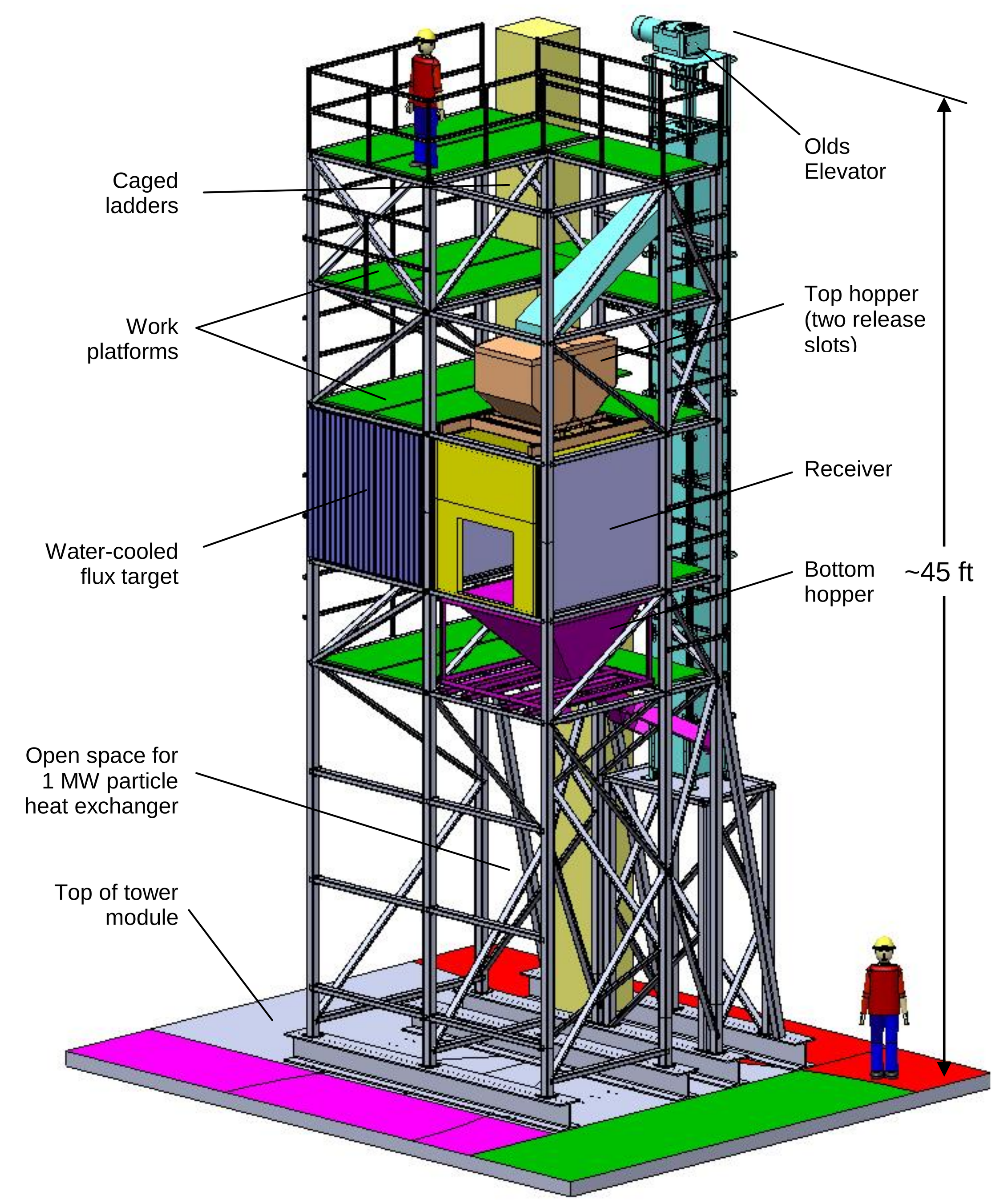
- Design, develop, and test the world's first particle/CO_2 heat exchanger
  - Particle temperature ≥ 720 °C
  - sCO_2 temperature ≥ 700 °C
  - sCO_2 pressure up to 20 MPa
  - Overall heat transfer coefficient ≥ 100 W/m^2-K
  - Total cost of power-block components ≤ \$900/kW$_e$
    - Specific cost of prototype heat exchanger ≤ \$30/(W/K)



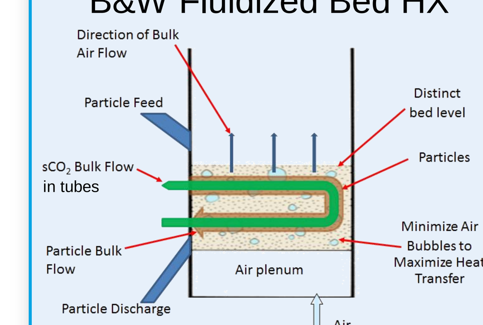
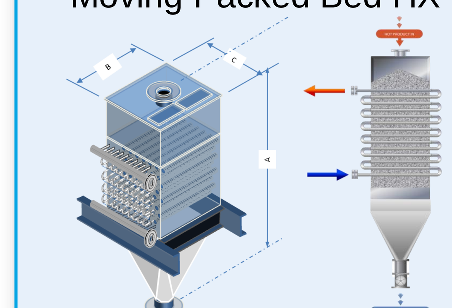
APPROACH

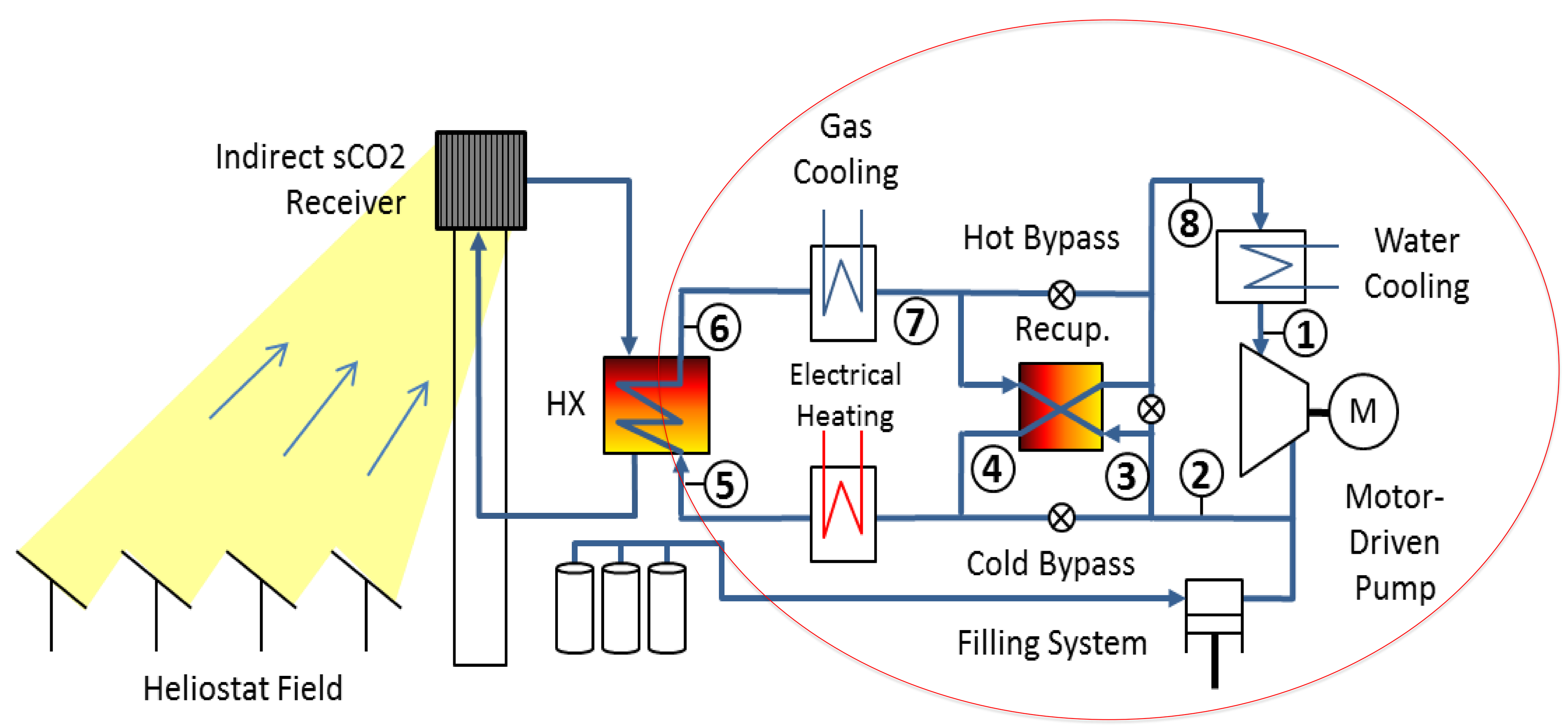
- Work with industry leaders to design and develop particle-sCO_2 heat exchanger that meets cost/performance requirements (Year 1)
- Utilize experience and infrastructure at Sandia, NREL, and Georgia Tech to downselect, procure, and test components (Years 1 & 2)
- Integrate heat exchanger with high-temperature 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 • 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 • Tubes can handle high-pressure sCO_2 • 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 • 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 Georgia Tech

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