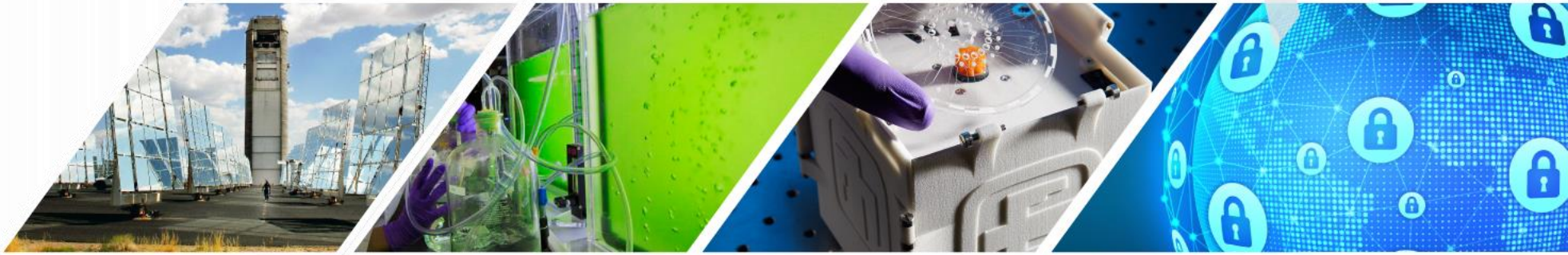

Energy & Homeland Security

Gen 3 Particle-Based CSP Technologies for Industrial Decarbonization

Clifford K. Ho, Ph.D.
Sandia National Laboratories

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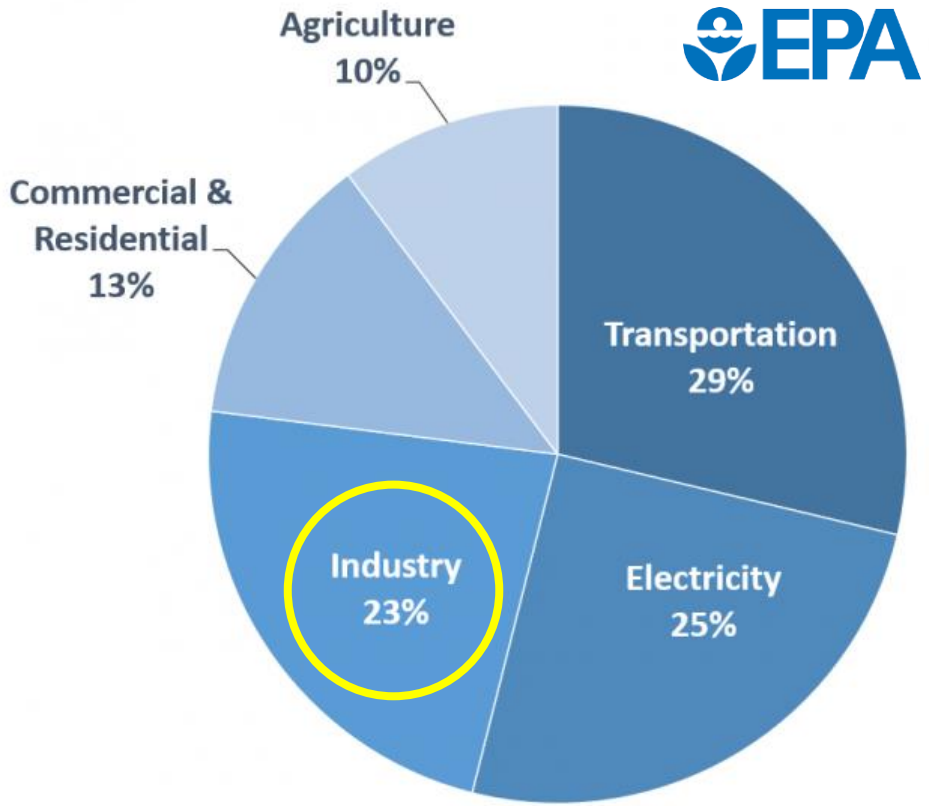
PROBLEM STATEMENT

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2019



Total U.S. Emissions in 2019 = 6.6 billion metric tons of CO_2 equivalent.

https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Nearly a quarter of all greenhouse gas emissions in the U.S. are from Industrial Processes and Manufacturing

Cement and steel production

Food processing and drying

Chemicals

Electrification/automation

Petroleum refining

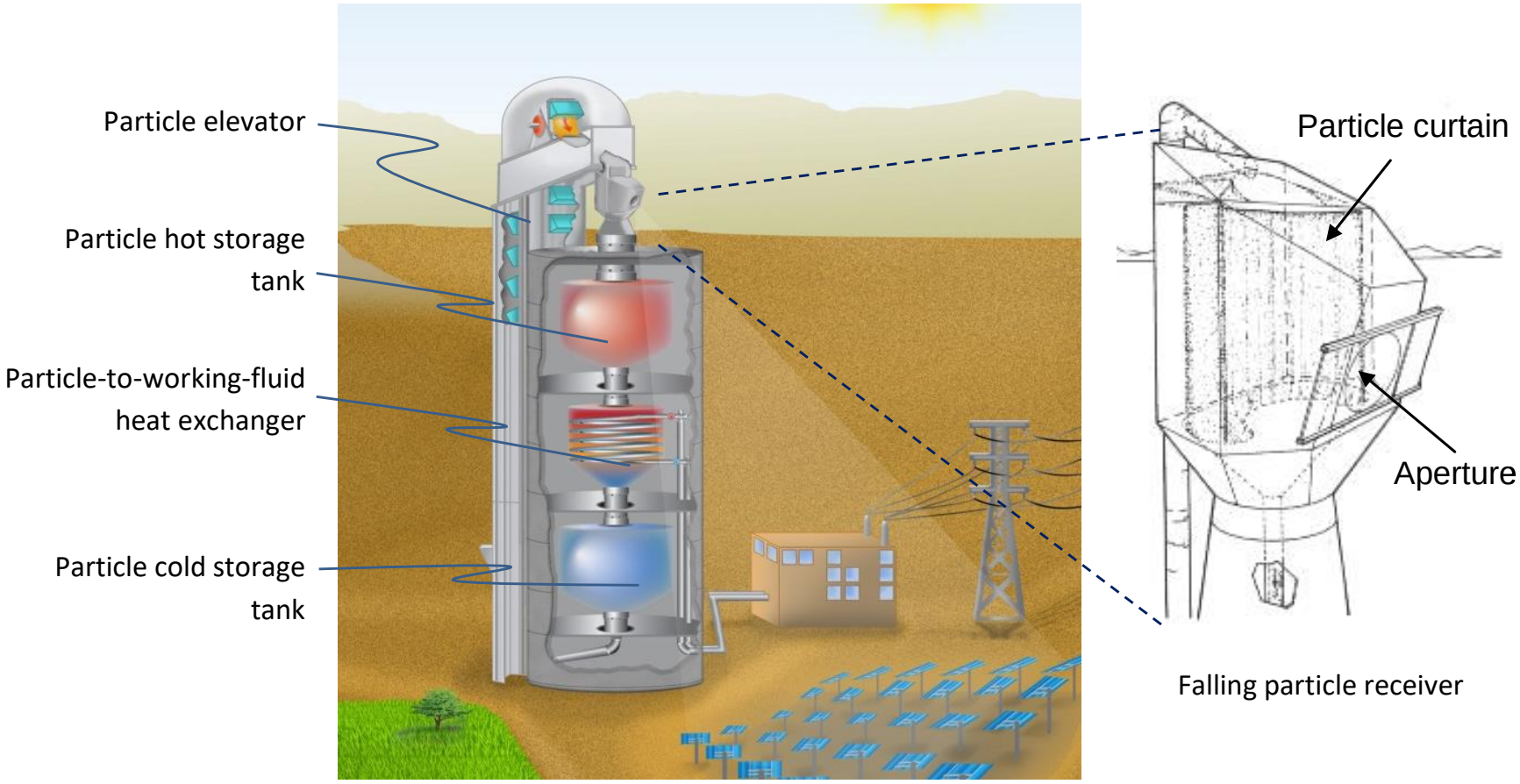
VALUE PROPOSITION

Concentrating solar thermal technologies can provide clean heating and electrification for industrial processes with long-duration storage

- ↑ **Increase range of temperatures for advanced power cycles and industrial process heating**
- ↓ **Reduce system costs**

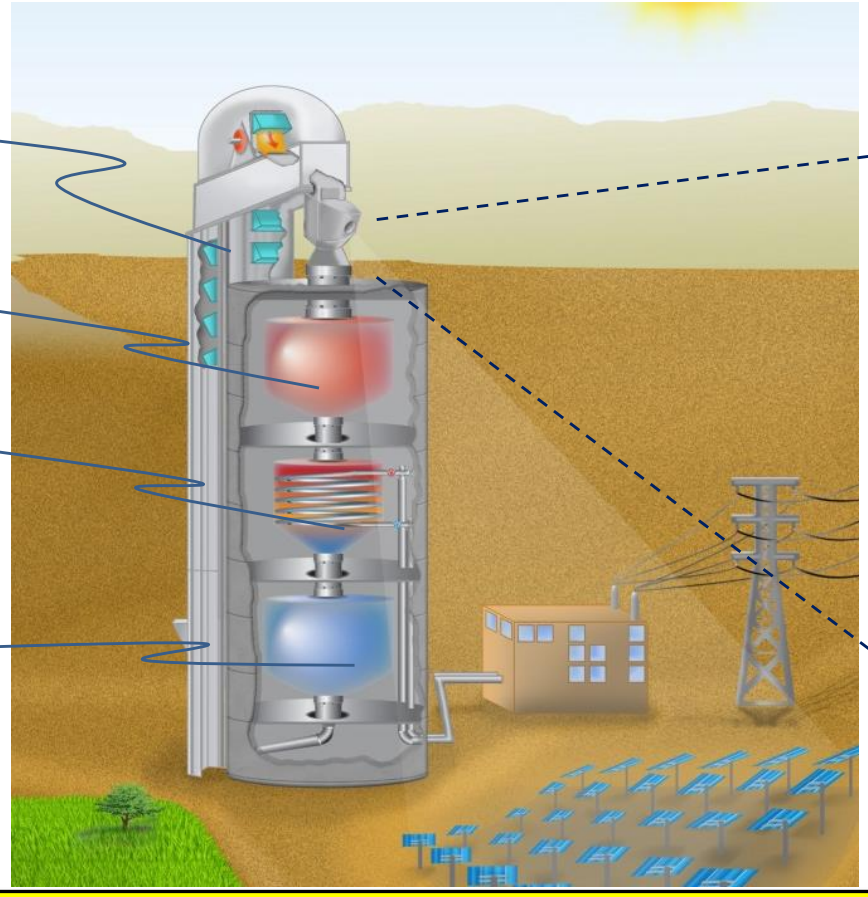
PARTICLE-BASED CSP

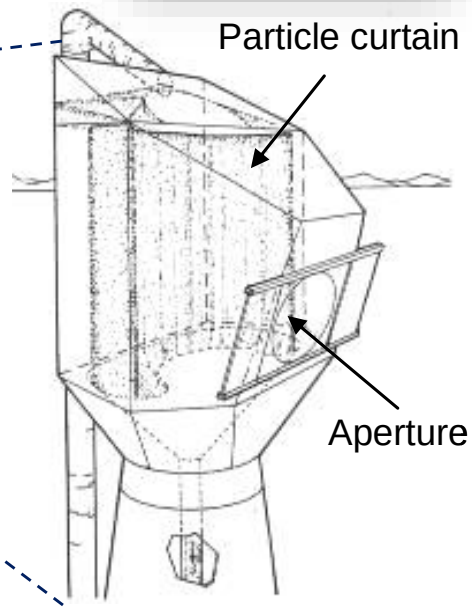
High-Temperature Particle-Based CSP



PARTICLE-BASED CSP

High-Temperature Particle-Based CSP



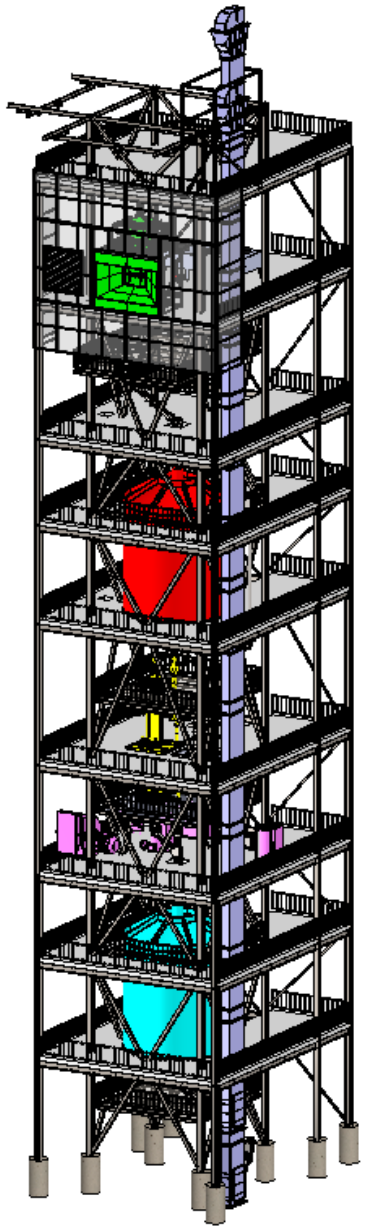


Falling particle receiver

National Solar Thermal Test Facility
Sandia National Laboratories

Particle-based CSP enables higher temperatures for next-generation power cycles and high-T process heat

GEN3 PARTICLE PILOT PLANT (G3P3-USA)



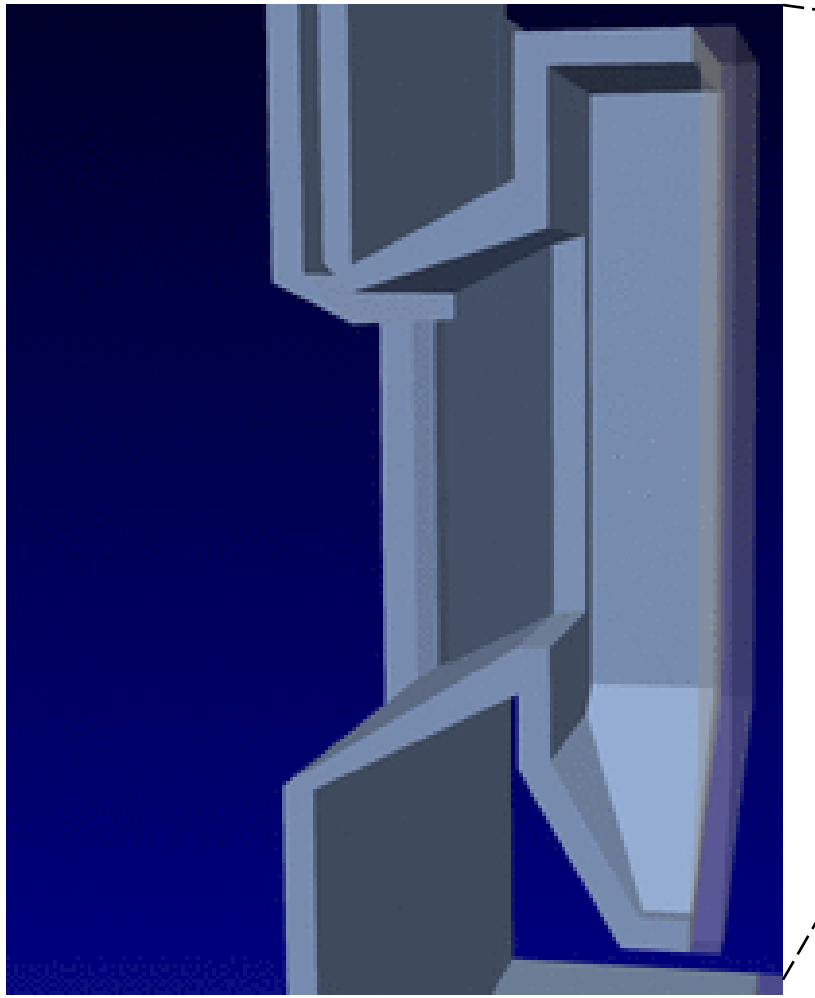
K. Albrecht, SNL

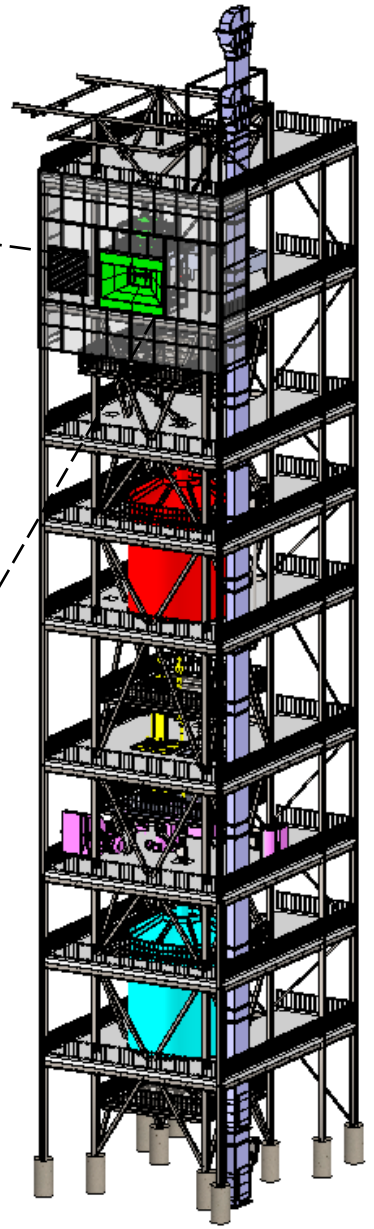
Gen 3 Particle Pilot Plant

- ~1 – 2 MW_t receiver
- 6 MWh_t storage
- 1 MW_t particle-to-sCO_2 heat exchanger
- ~300 – 400 micron ceramic particles (CARBO HSP 40/70)

PARTICLE HEATING

Next-Generation High-Temperature Falling Particle Receiver





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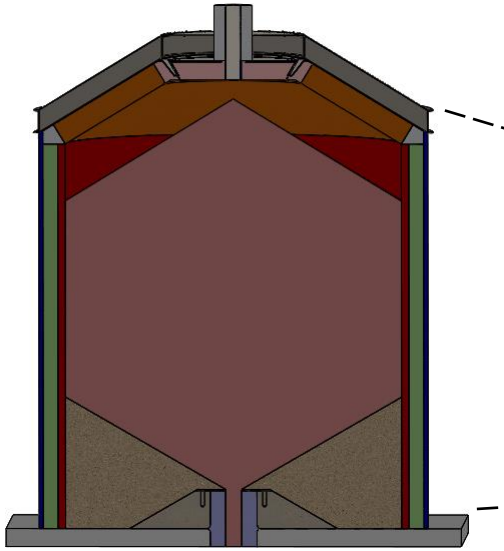
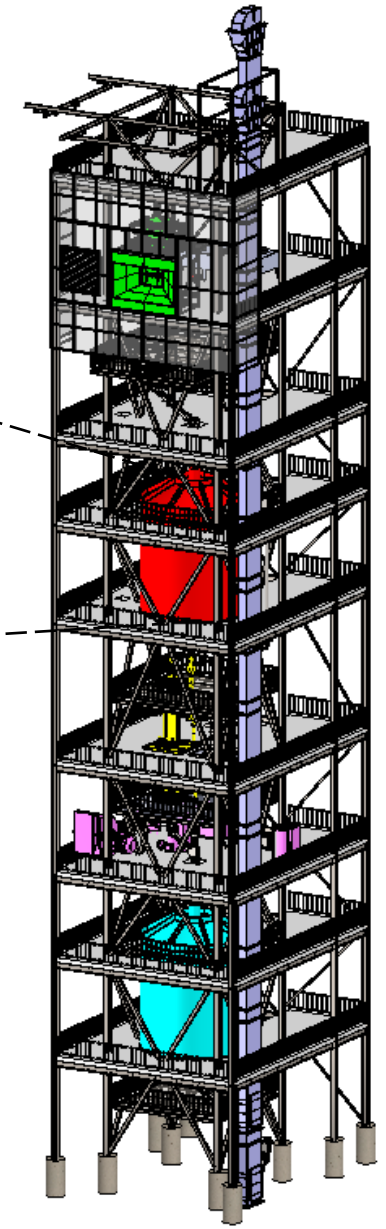
Key Remaining Gaps

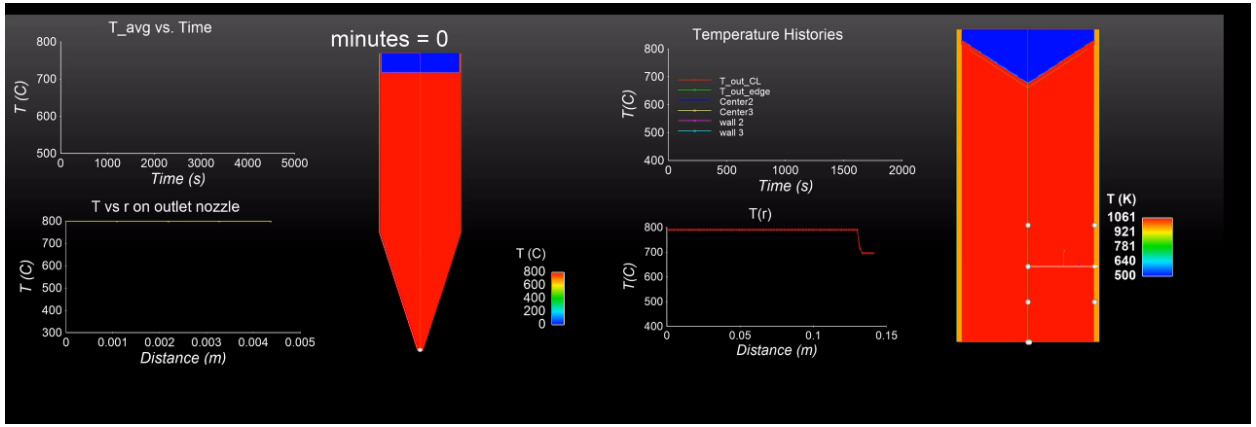
- Mitigation of adverse wind impacts (particle/heat loss)
- Integrated on-sun testing
- Long-term operation and controls
- Commercial scale-up

PARTICLE STORAGE

High-Temperature Particle Storage Bin (Allied Mineral Products, Matrix PDM, Sandia)







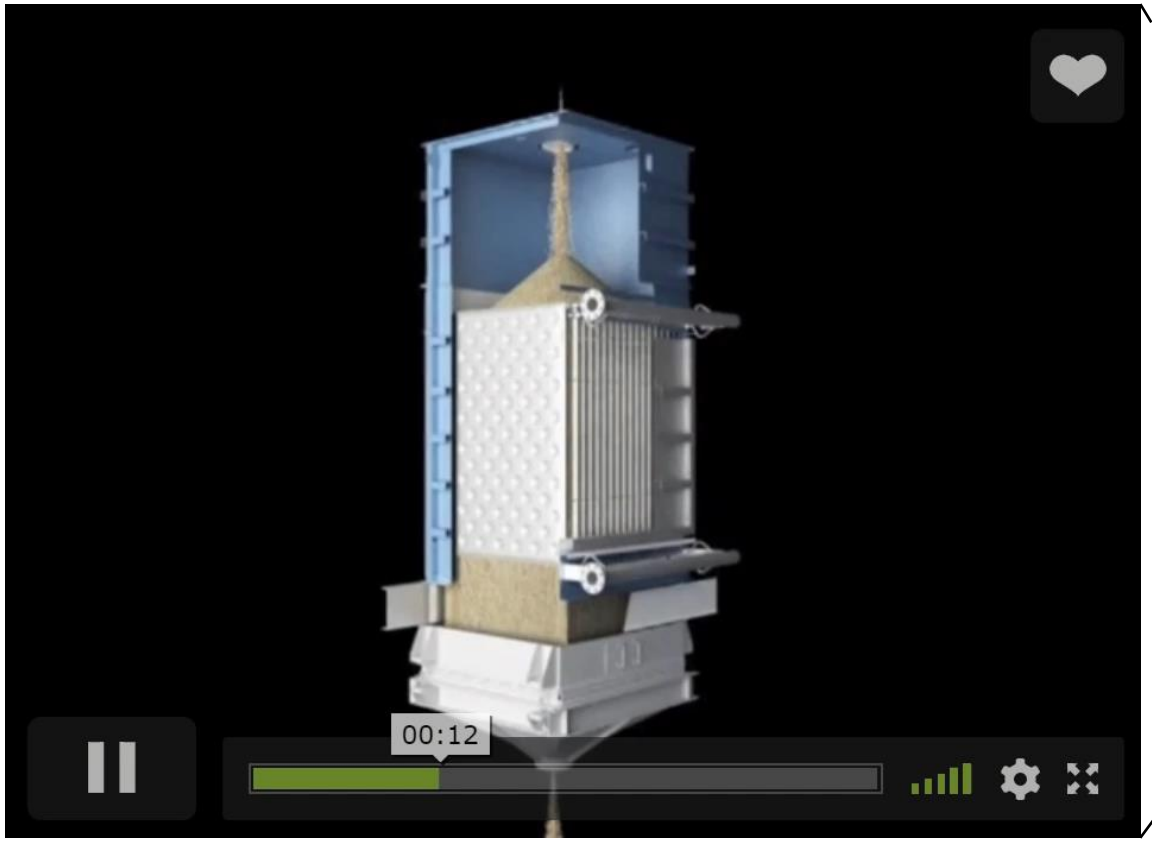
Key Remaining Gaps

- Demonstration of large-scale, long-duration particle thermal storage
- Low-cost refractory insulation and installation
- Commercial scale-up

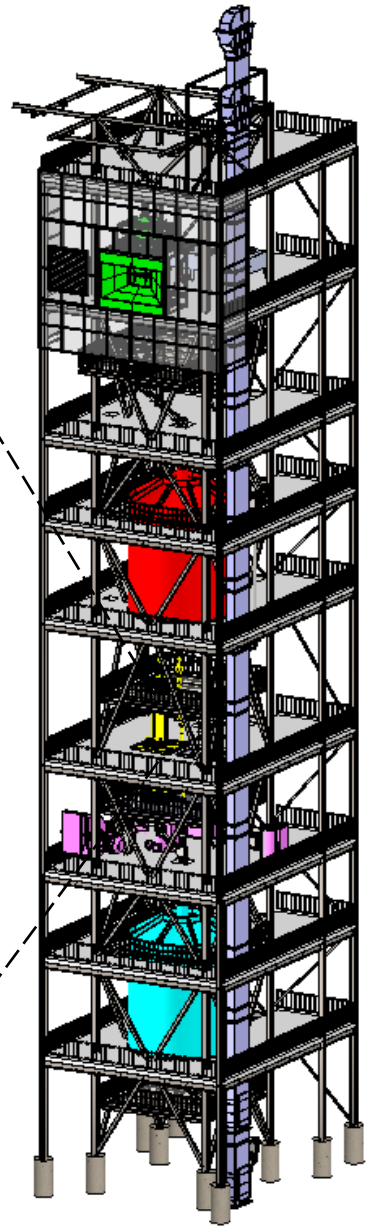
K. Albrecht, SNL

PARTICLE HEAT EXCHANGER

High-Temperature Particle-to-sCO_2 Heat Exchanger (VPE, Solex, Sandia)



https://www.solexthermal.com/our-technology/cooling/



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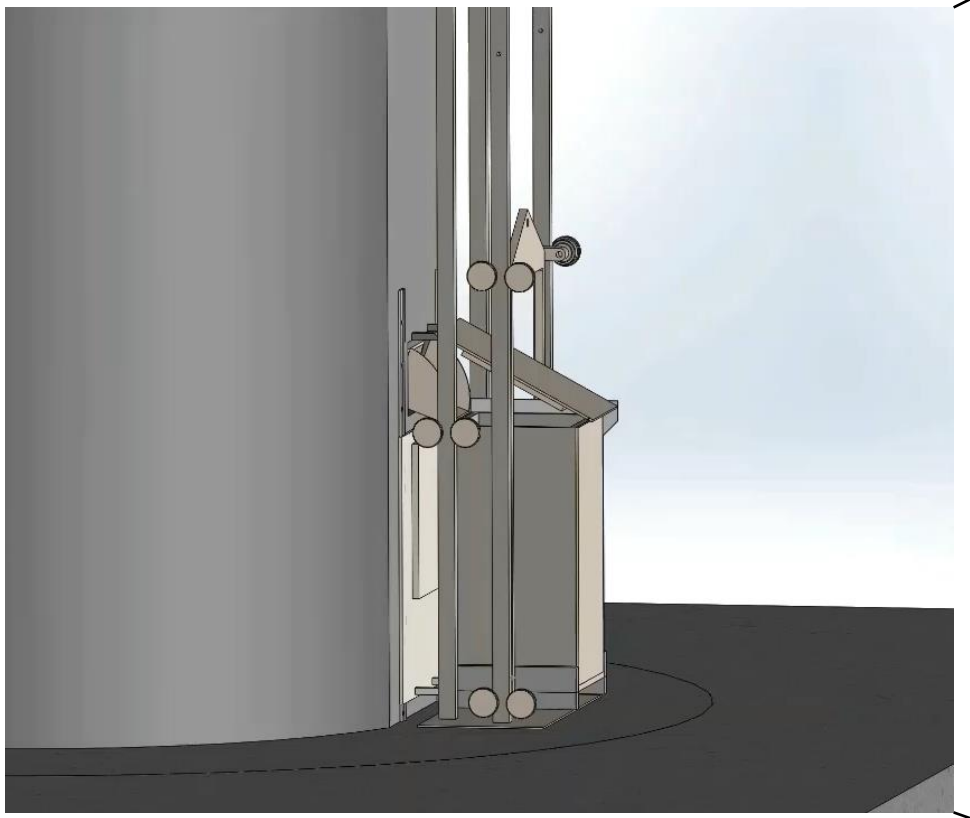
Key Remaining Gaps

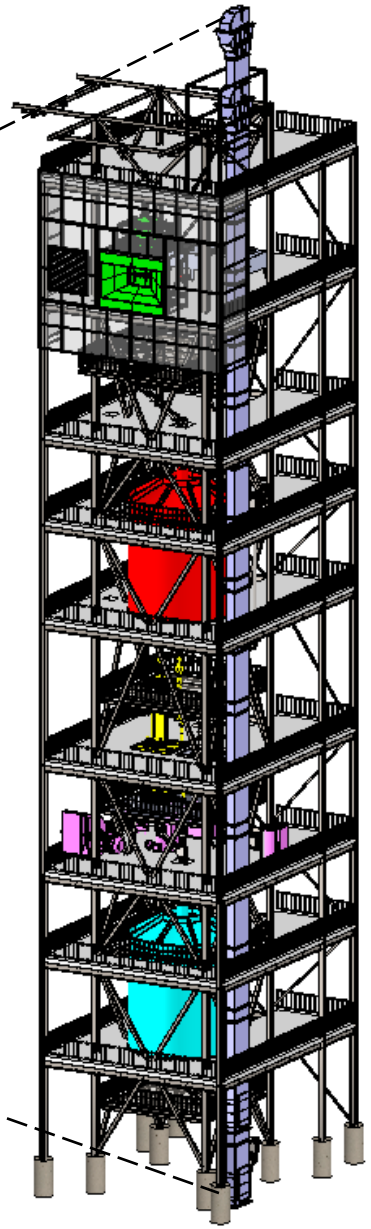
- Lower cost materials and manufacturing methods
- Fatigue, creep, and erosion analyses
- Increased particle-side heat-transfer coefficients (alternative heat-exchanger designs)
- Commercial scale-up

PARTICLE LIFT AND CONVEYANCE

High-Temperature Particle Lift and Conveyance
(SNL, Georgia Tech, MHE, KSU, Magaldi)



K. Repole and S. Jeter, Georgia Tech



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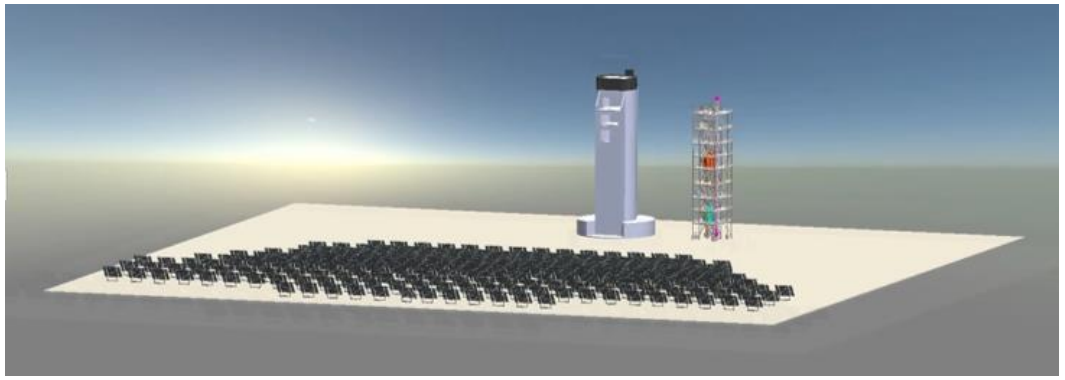
Key Remaining Gaps

- Demonstration of high-temperature, large-capacity particle lift and conveyance with low heat and particle loss
- Heat loss and reliability of chain-driven bucket elevators
- Loading and unloading processes for skips
- Commercial scale-up

APPLICATIONS

- DOE Gen 3 CSP
  - Develop next generation particle-based CSP
  - ~16 domestic & international partners (FY19–FY23)
- DOE TESTBED/Heliogen
  - Solarized supercritical CO_2 power cycle with **thermal storage; solar fuels; process heating**
- International Interest
  - **Process Heat** (HiFlex – **Barilla**, **drying of pasta using heated particles**, Foggia, Southern Italy)

Sandia Gen 3 Particle Pilot Plant



Breakthrough Energy Ventures

Significant DOE and international interest in particle-based CSP and industrial process heat

Barilla

DLR and Sandia received a $1.5M DOE Technology Commercialization Fund award

CONCLUSIONS

- Concentrating solar thermal technologies can provide **both heat and electricity** for industrial processes
- **Particle-based CSP** can achieve **higher temperatures** for more efficient electricity generation and high-temperature industrial processes
- **Key gaps**
  - Reduction of particle and heat losses from receiver
  - Improved materials and manufacturing methods to reduce costs and increase performance of heat exchanger and storage bins
  - Large-scale demonstrations of integrated components and commercial-scale up

ACKNOWLEDGMENTS

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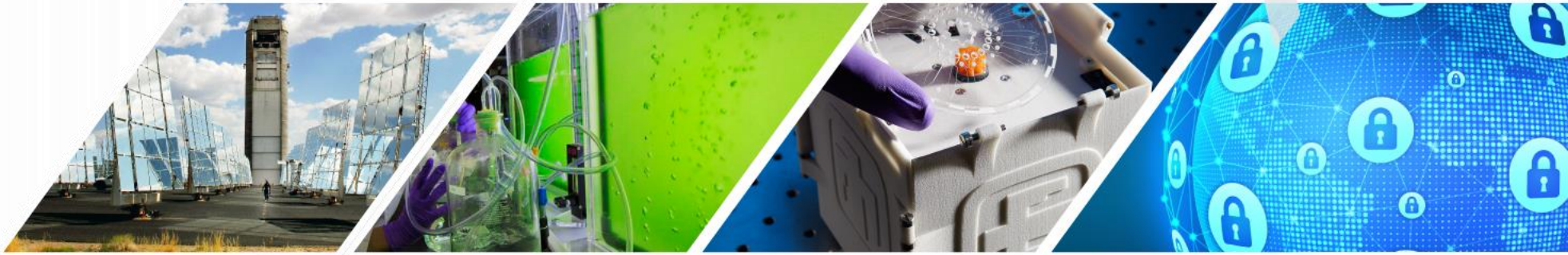

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Questions?