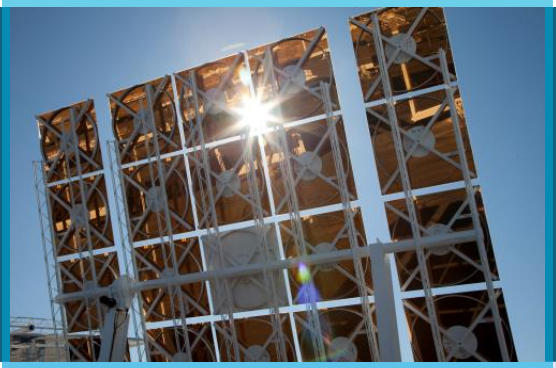
Presented at the 2021 Thermal-Mechanical-Chemical Energy Storage (TMCES) Workshop, August 10, 2021, San Antonio, TX

Sandia National Laboratories

High-Temperature Thermal Storage in Moving and Fixed Particle Beds



PRESENTED BY

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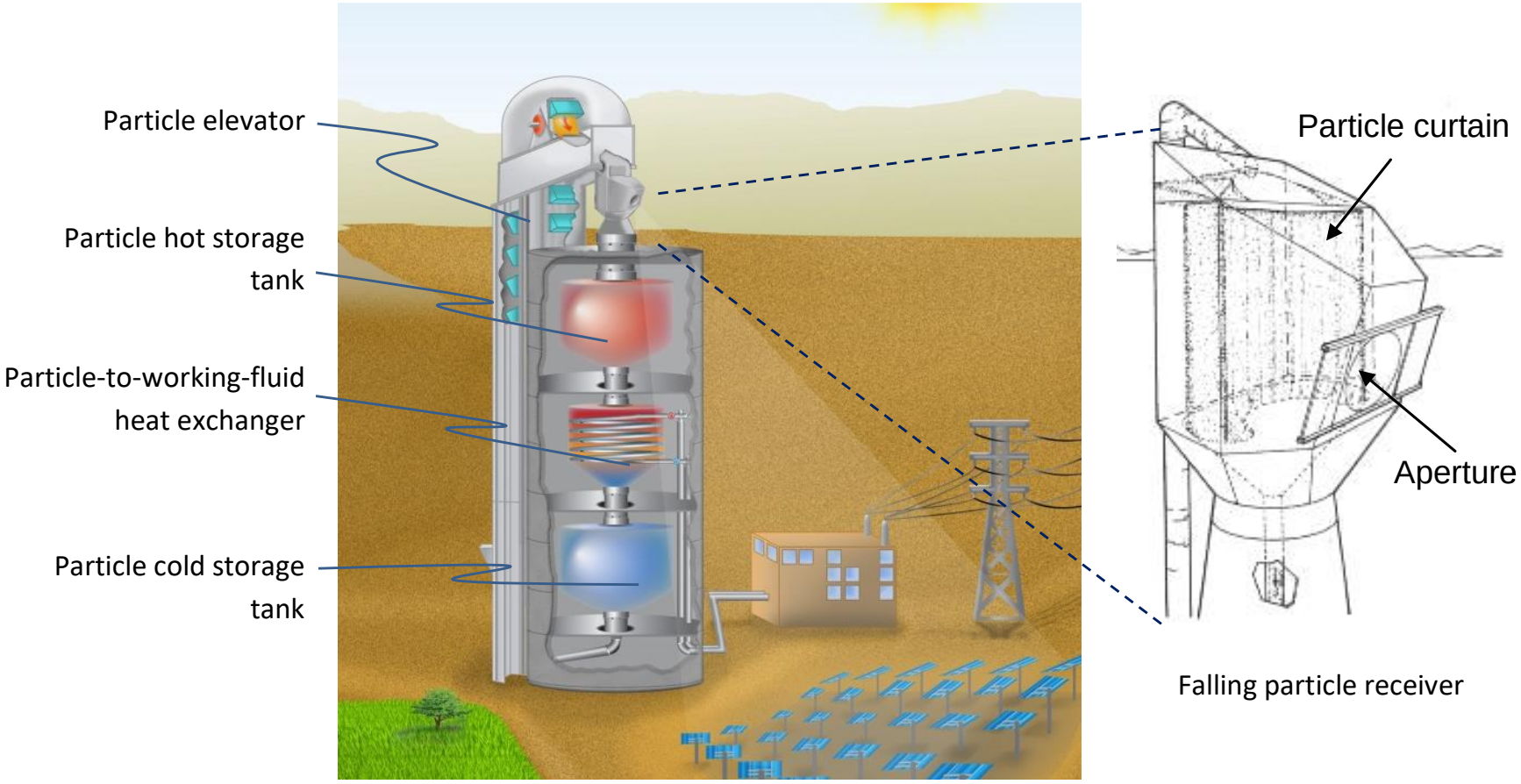
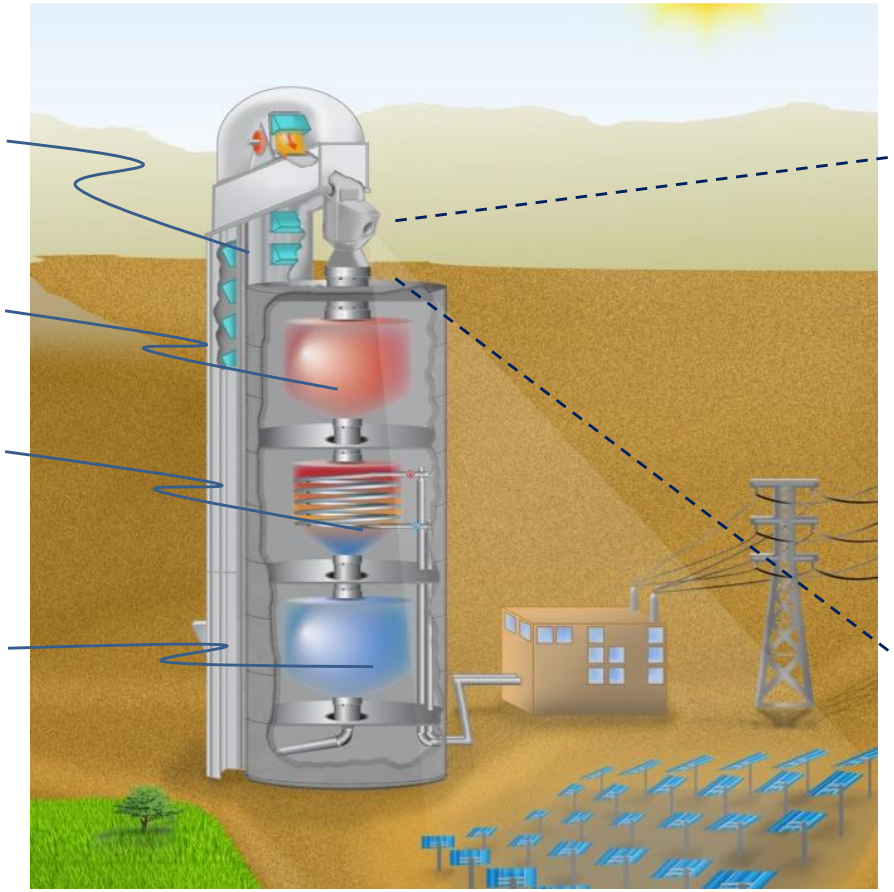
Moving Particle-Bed Storage – Concentrating Solar Power

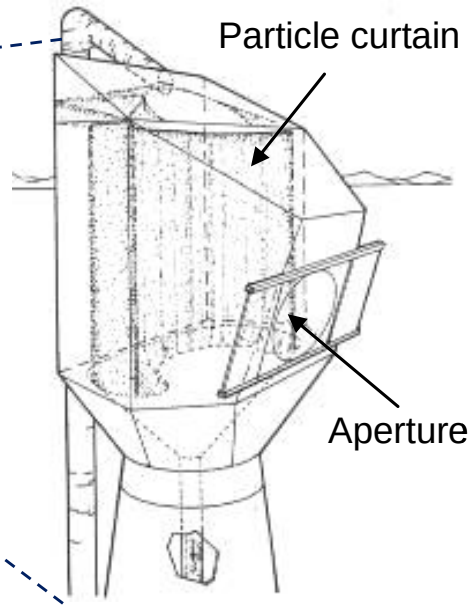
High-Temperature Particle-Based CSP



Background and Introduction

High-Temperature Particle-Based CSP



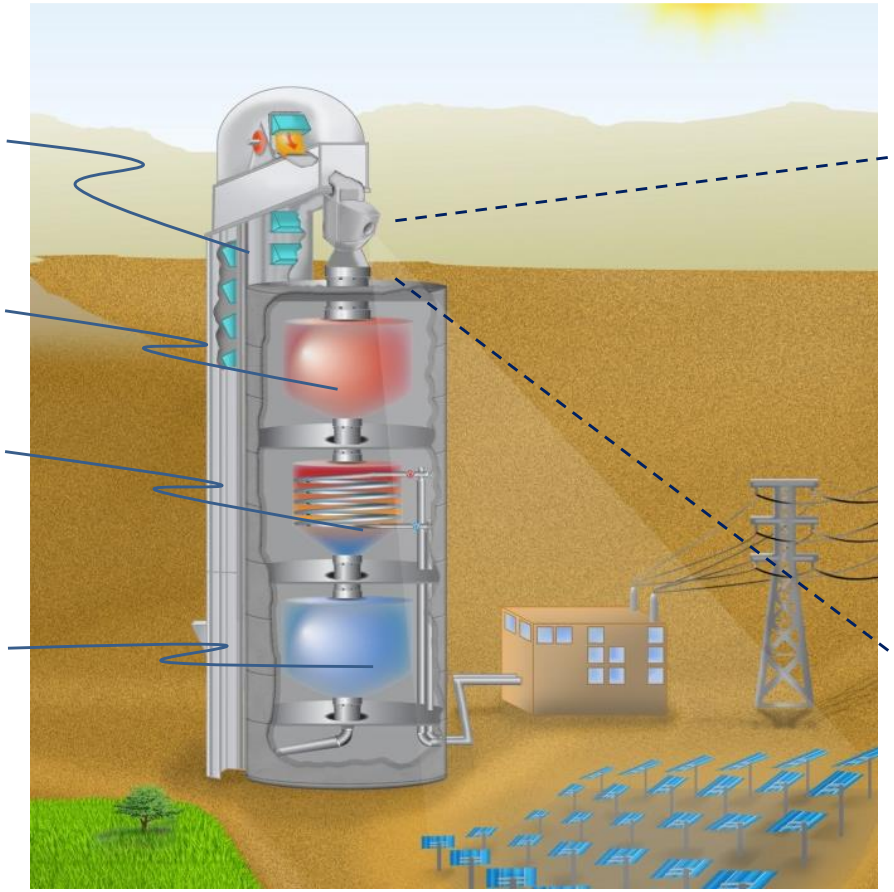


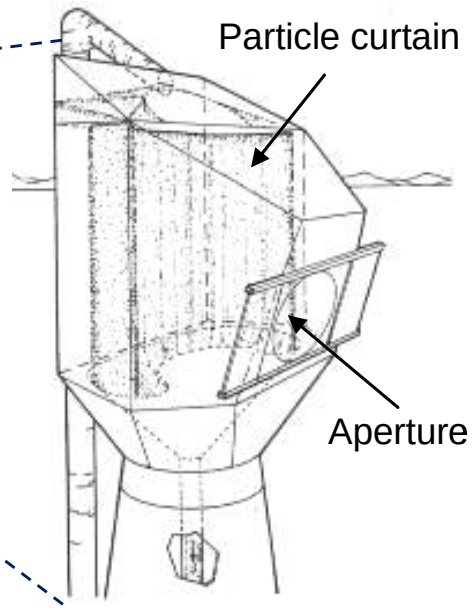
Falling particle receiver

National Solar Thermal Test Facility
Sandia National Laboratories

Background and Introduction

High-Temperature Particle-Based CSP



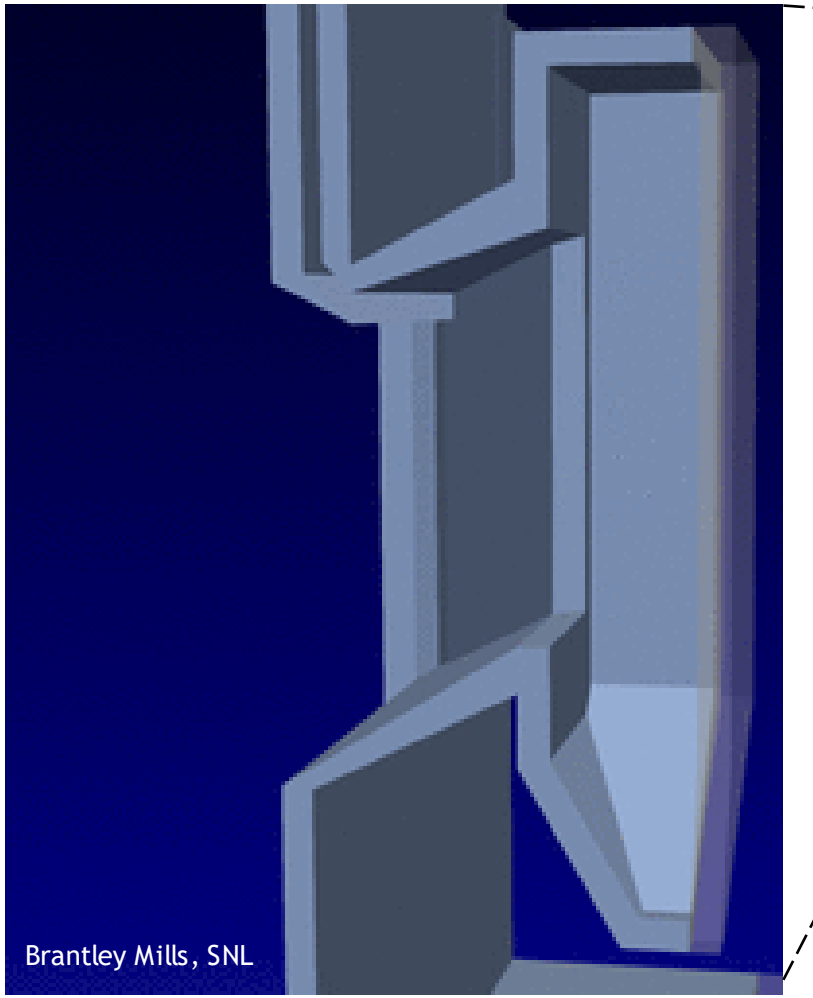


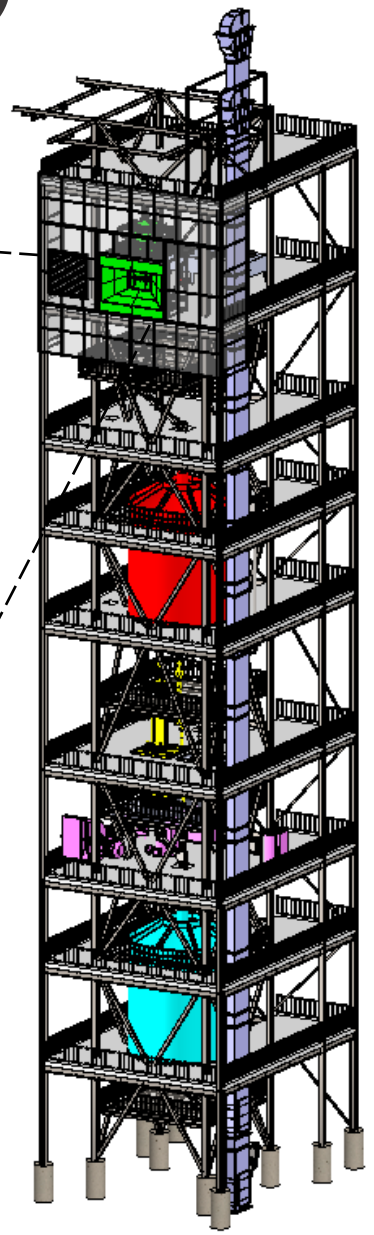
Falling particle receiver

- Higher temperatures (>1000 °C) than molten nitrate salts
- Direct heating of particles vs. indirect heating of tubes
- No freezing or decomposition
  - Avoids costly heat tracing
- Direct storage of hot particles

Gen3 Particle Pilot Plant (G3P3)

Next-Generation High-Temperature Falling Particle Receiver





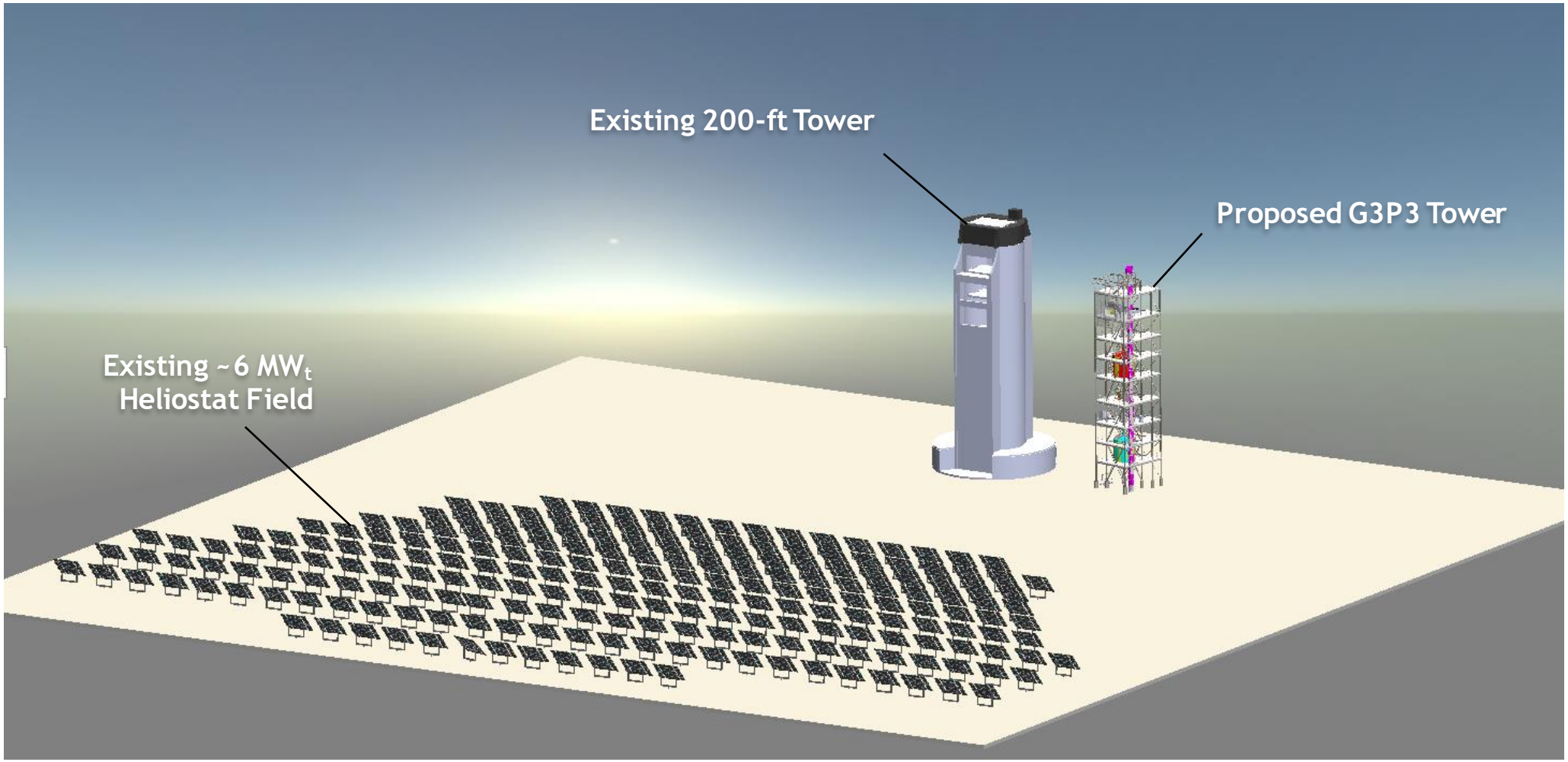
K. Albrecht, SNL

Gen 3 Particle Pilot Plant

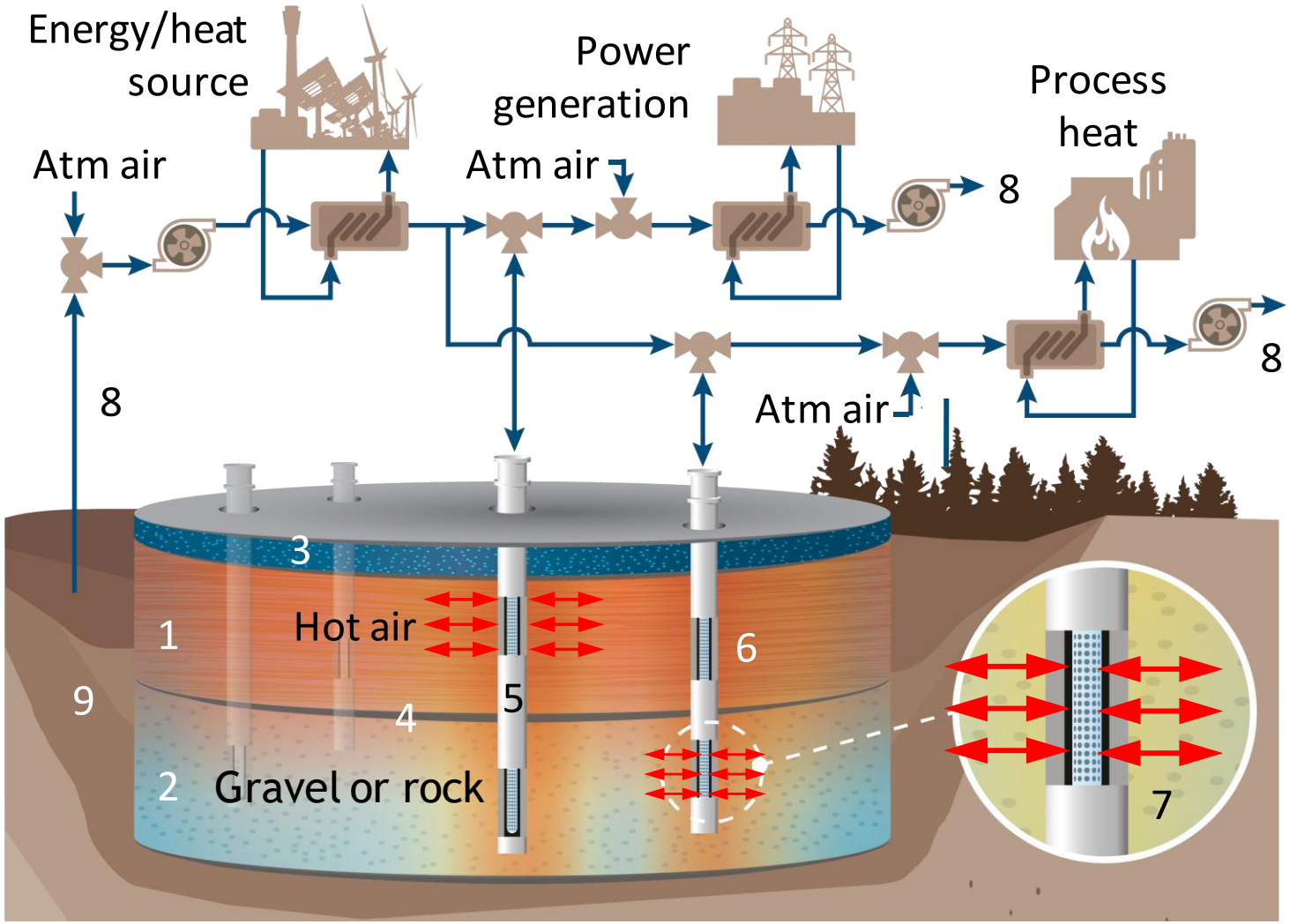
- ~1 – 2 MW_t receiver
- 6 MWh_t storage
- 1 MW_t particle-to-sCO_2 heat exchanger
- ~300 – 400 micron ceramic particles (CARBO HSP 40/70)

Gen 3 Particle Pilot Plant (G3P3)
Integrated System

National Solar Thermal Test Facility (NSTTF), Albuquerque, NM



THERMS – Terrestrial Heat Repository for Months of Storage



THERMS provides low-cost, large-capacity, **long-duration energy storage** for a **carbon-free electrical grid** and high-temperature **process heat.**

Advantages
- Inexpensive storage and heat-transfer media (air)
- Existing commercial equipment and components
- Very low marginal costs of increased size
- Workforce transition (oil and gas well expertise)

Challenges
- Conveyance of hot air
- Large flow rates
- Temperature decay

Ho, C.K., H.F. Laubscher, and P. Gauché, United States Patent Application 17023550, Radial Particle-Based Terrestrial Thermocline for High Temperature Thermal Storage, Sandia National Laboratories, 9/17/20, SD15304.0/S165409.

Initial Use Case for THERMS

Replace burning of coal with “dirt-cheap” heat storage in the ground

Coal plant image source: https://www.power-technology.com/comment/us-clean-coal-research/

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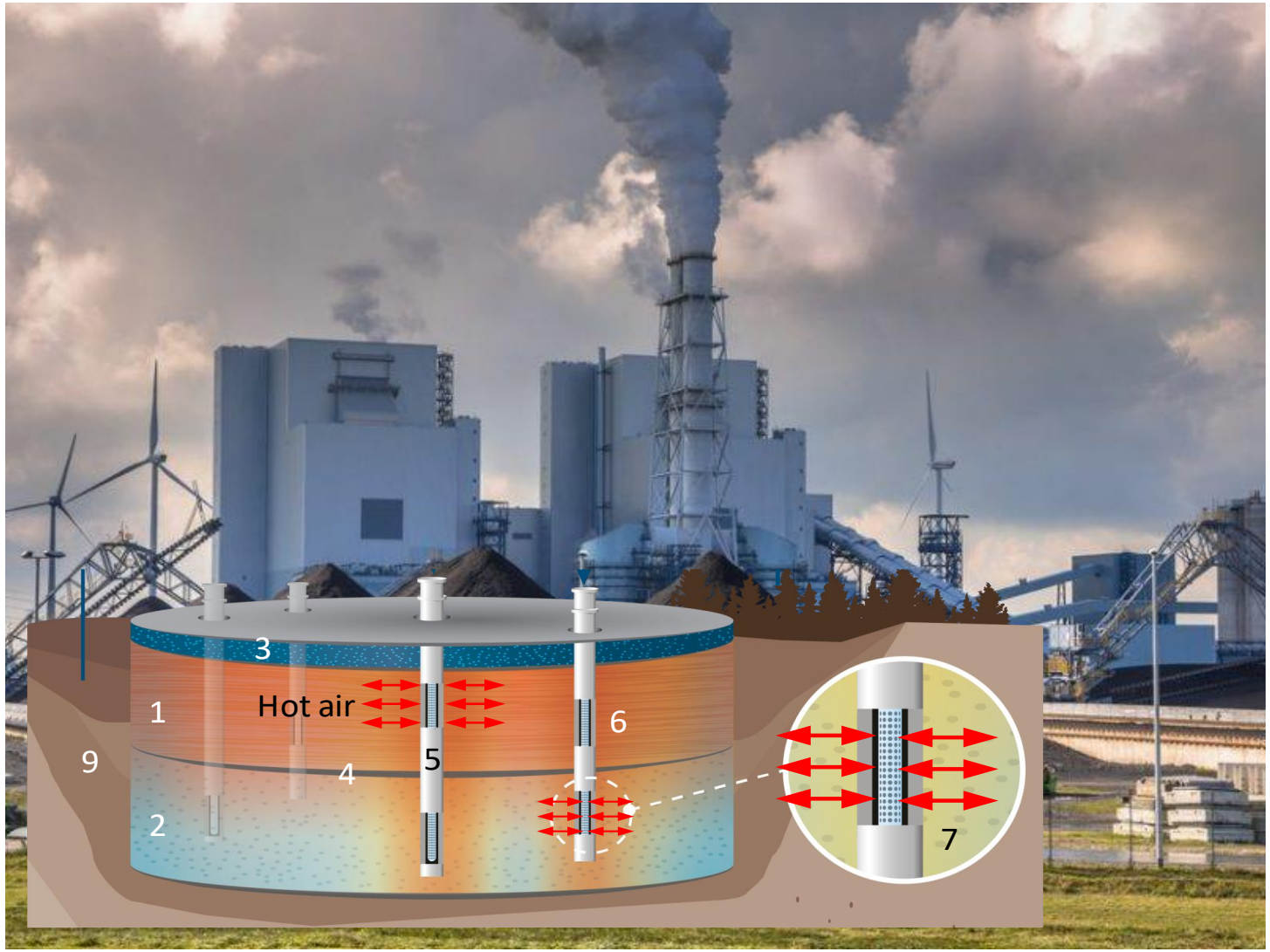

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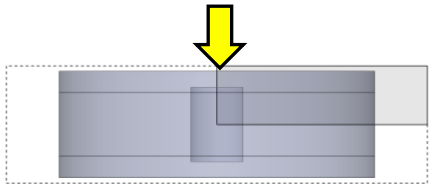
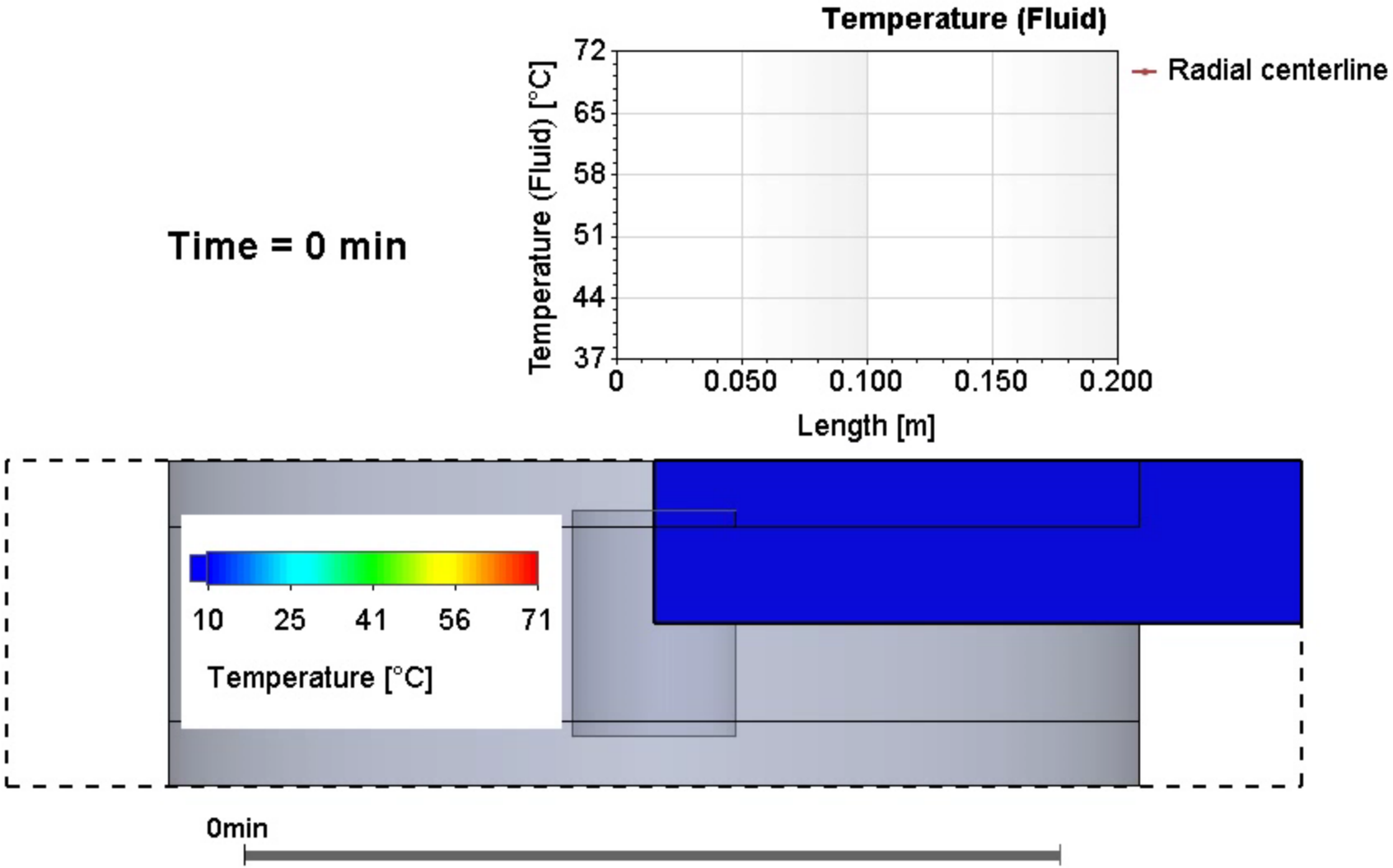
Bench-Scale Testing, Modeling, and Technoeconomics





Ho and Gerstle (2021, ASME ES2021-63066)

Conclusions

- Moving and fixed particle bed energy storage
  - "Dirt cheap"
  - High temperatures (>600 C)
  - Large-capacity, long-duration energy storage (GWh)

- Next Steps
  - DOE Gen 3 CSP award (Gen 3 Particle Pilot Plant – G3P3), FY22 – FY24
  - Technology Commercialization Fund Award, FY22 – FY23
    - Larger-scale testing of THERMS (100 kWh)
    - Technoeconomic analyses

Questions?

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Concentrating Solar Power and Thermal Energy Storage

- Concentrating solar power uses mirrors to concentrate the sun's energy onto a receiver to provide heat to spin a turbine/generator to produce electricity
- **Hot fluid can be stored as thermal energy efficiently and inexpensively** for on-demand electricity production when the sun is not shining