Sandia National Laboratories

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Design and Construction of a 1 MW_{th} sCO2 Thermal Loop Heated by Particle-Based Concentrating Solar Power

Sandia National Laboratories

8^{th} sCO2 Symposium 2024 – San Antonio, Texas

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U.S. DEPARTMENT OF ENERGY NNSA

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Overview

sCO2 loop design

- Thermal design
- Operational strategy

Construction status at Sandia

- Ground based testing
- CSP Integration and construction

Conclusions and path forward

- Benefits and Challenges
- Future Technology Development

sCO2 loop design

Thermal design

Operational strategy

Thermal Design

sCO2 flow loop heat rejection

Heating with concentrating solar power

- Particles heated with concentrated solar flux
- Hot particles heat up sCO2

Air-cooled heat exchanger for heat rejection

- Heat rejection to atmosphere
- Chiller for cooling critical components

Thermal energy storage integration

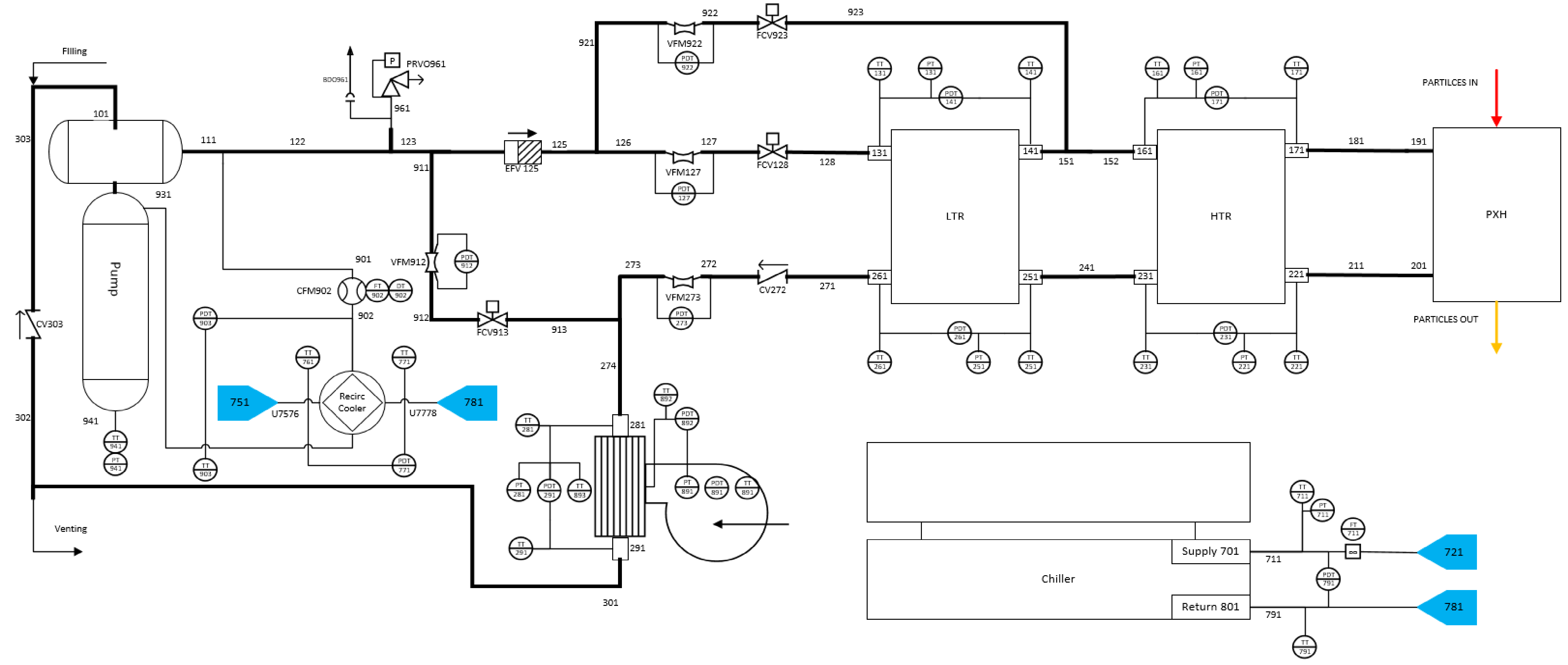
- Energy stored in solid medium - indirect
- High temperature rated sand-like particles

Design Specifications

Description	Value	Unit
Heat rejection	1	MW_{th}
sCO_2 mass flow rate	5	kg/s
Primary outlet temperature	715	°C
Operating pressure	262 (3800)	bar (psi)

Thermal Design

P&ID



Graphics: Matthew Carlson, Francisco Alvarez, Luke McLaughlin, Henk Laubscher

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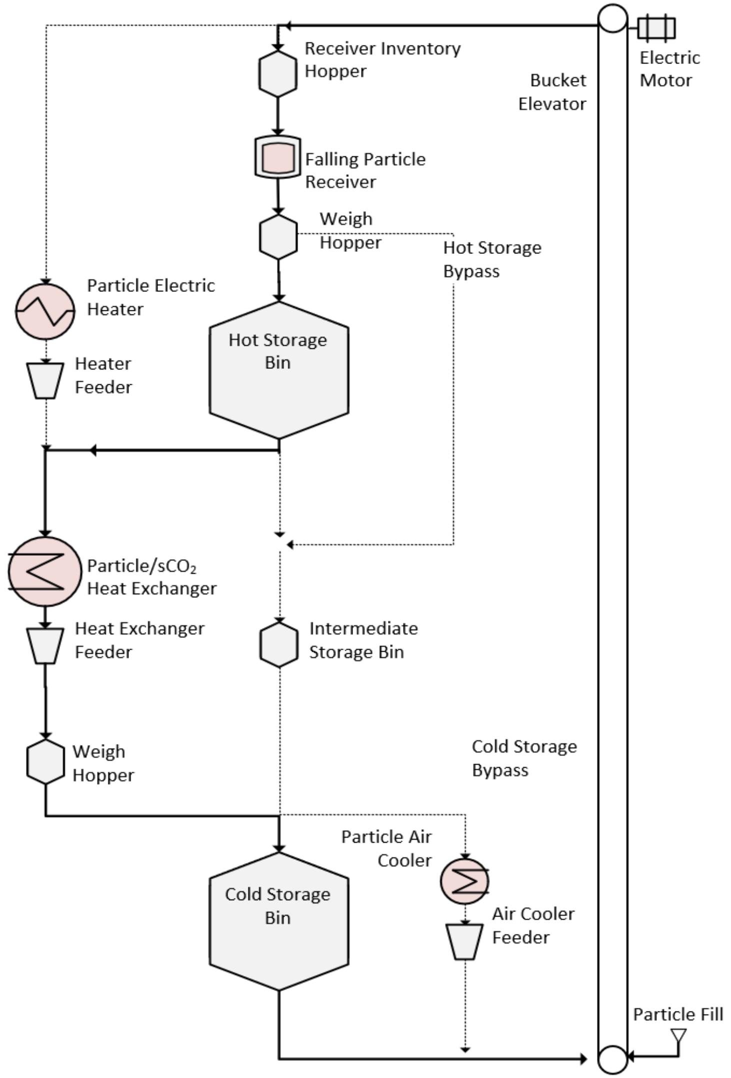
Energy Flow



Graphics: Albrecht et.al

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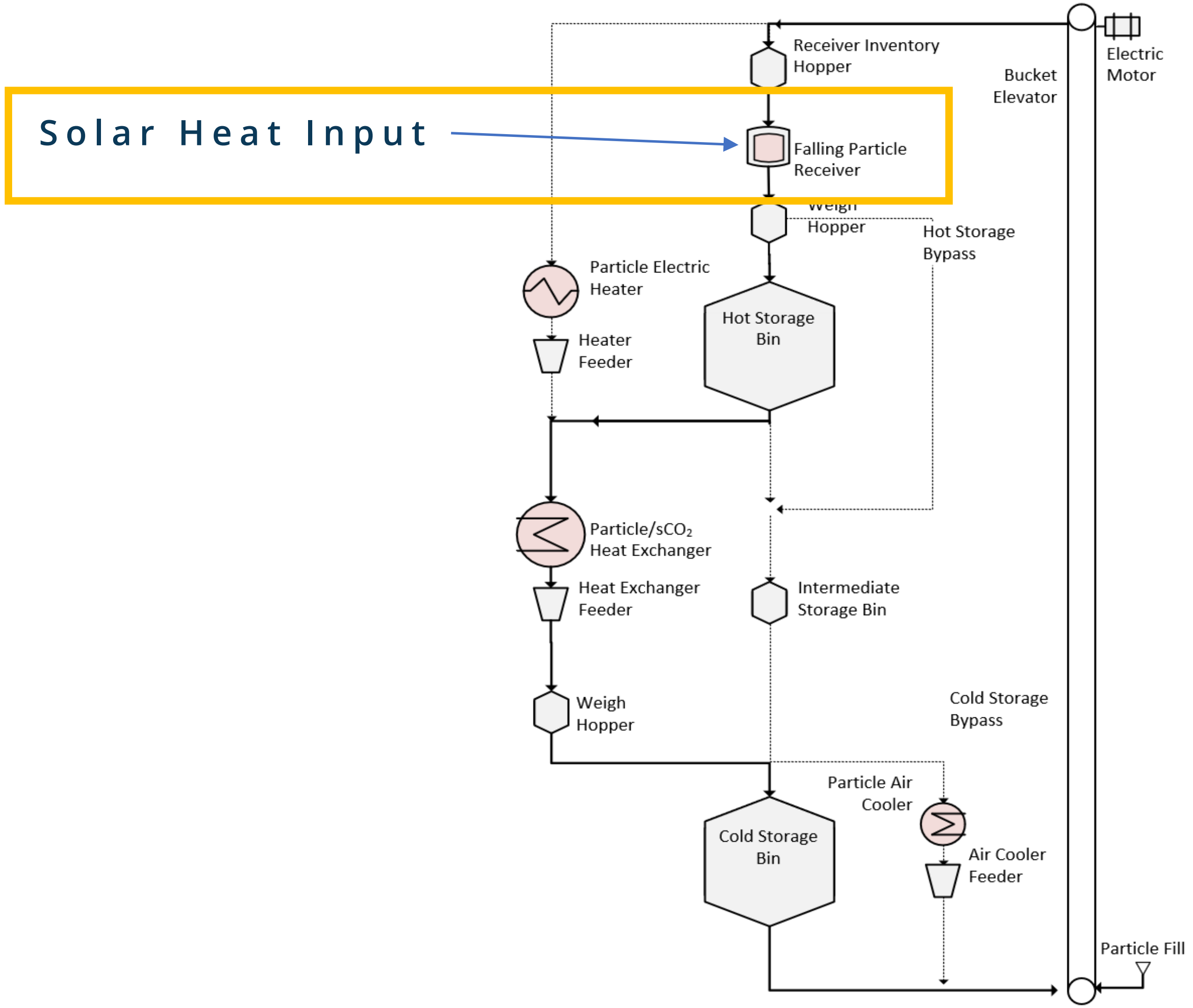
Primary Energy Input



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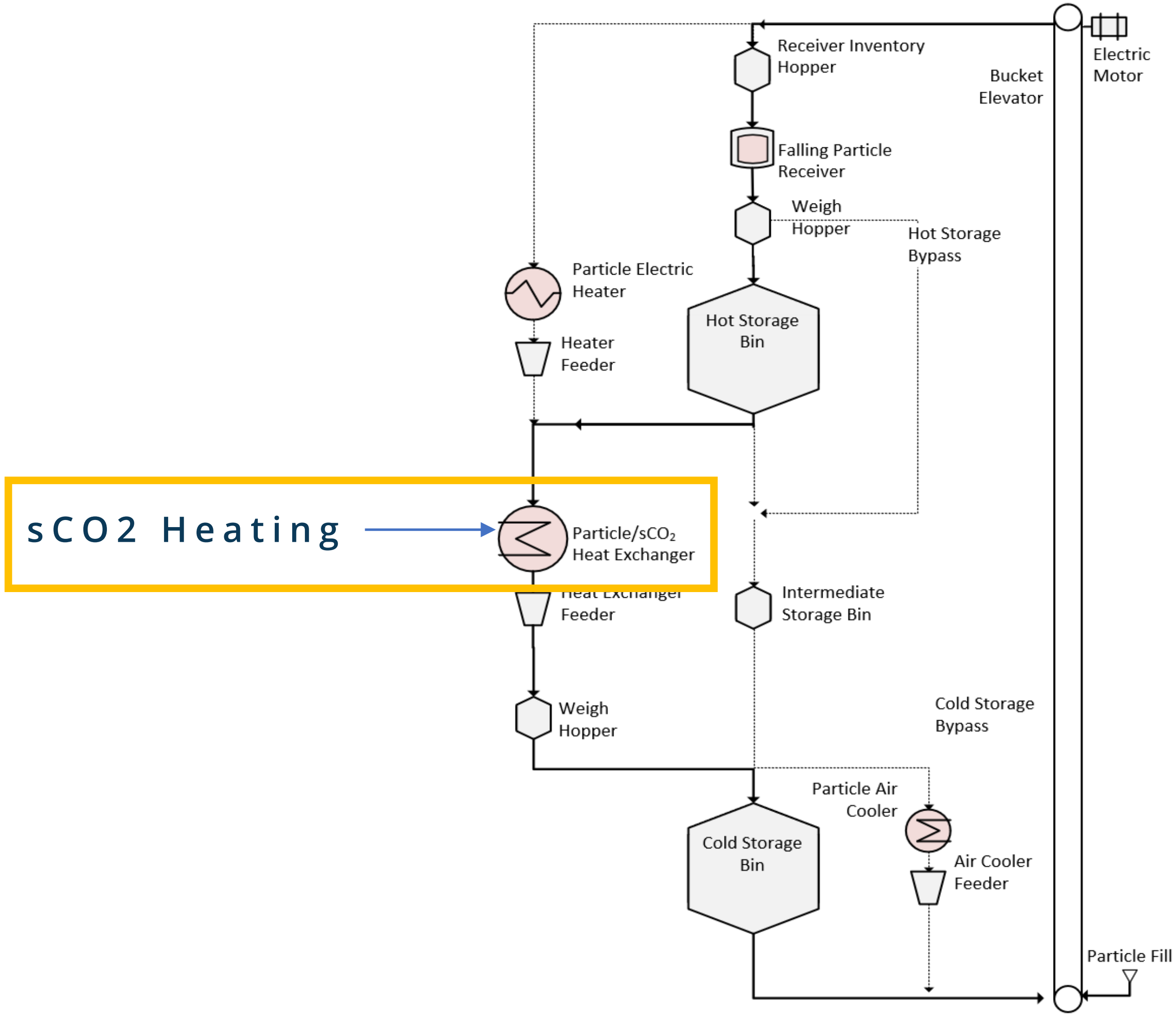
Primary Heat Exchanger



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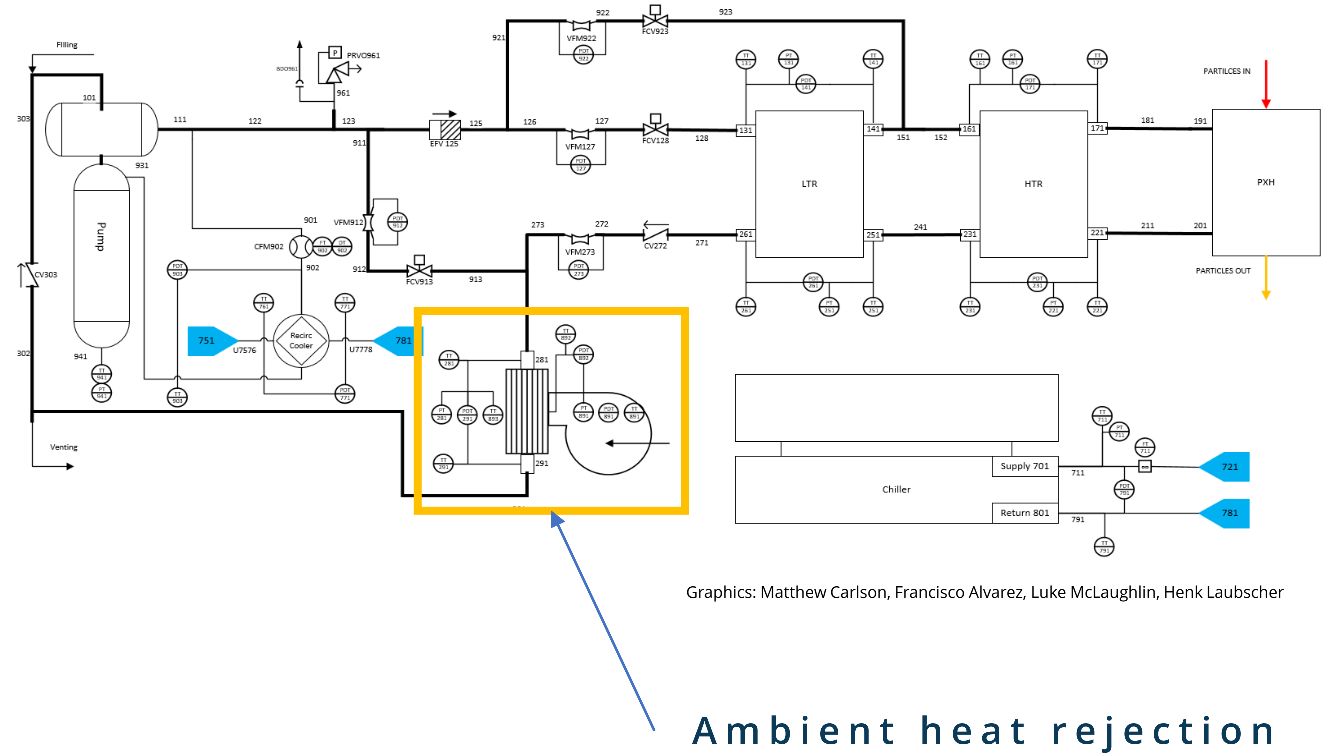
Heat Rejection



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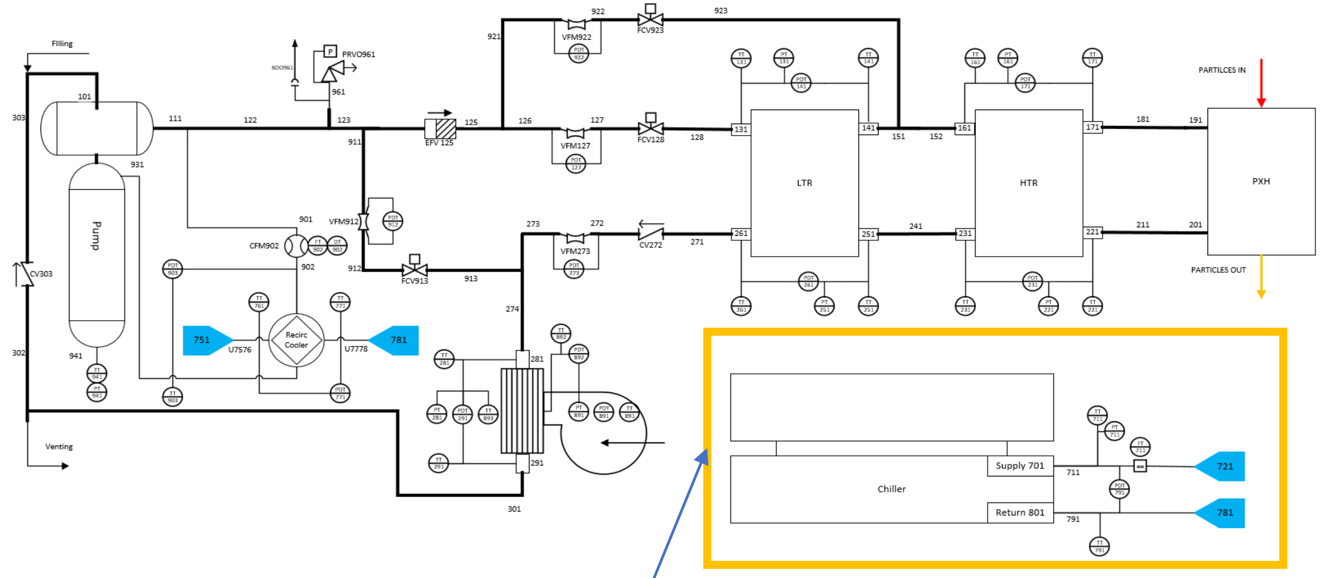
Component Cooling



Chiller component cooling

Graphics: Matthew Carlson, Francisco Alvarez, Luke McLaughlin, Henk Laubscher

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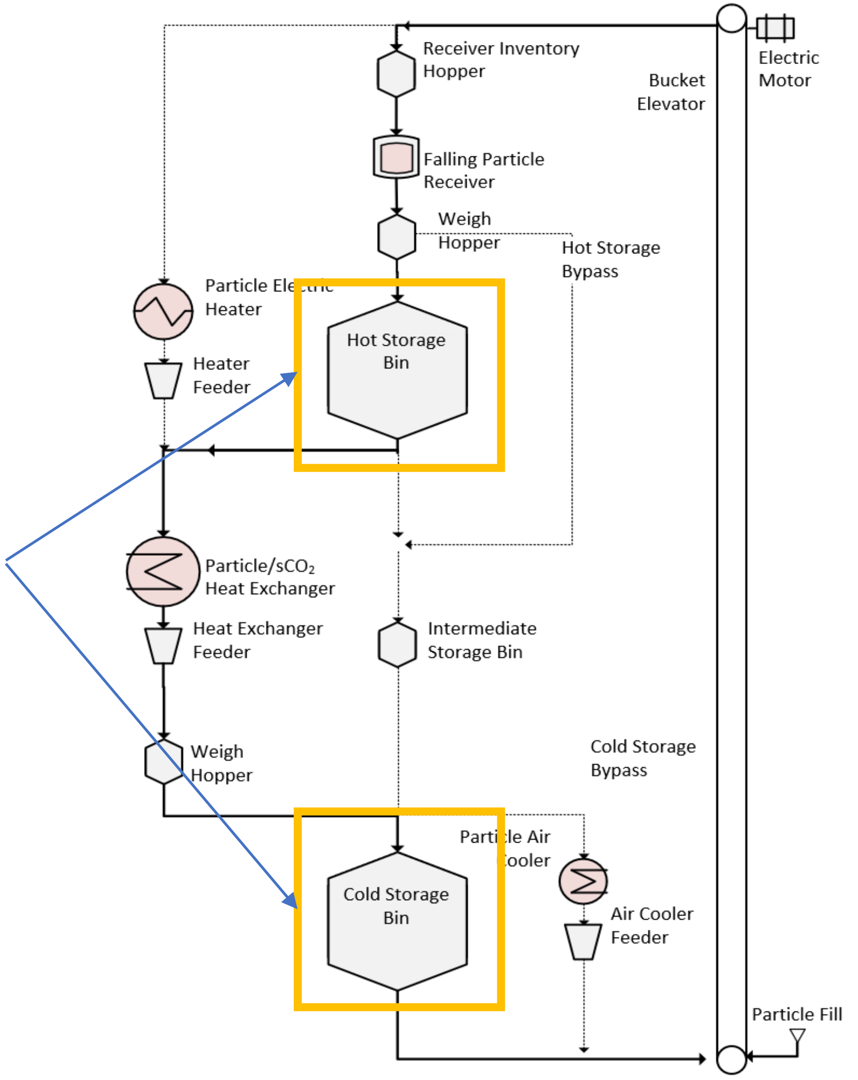
Energy Storage Integration

Thermal storage



Graphics: Albrecht et.al

Status update at Sandia

Ground based testing

CSP Integration and construction

Ground based testing

Cold flow loop commissioning

Pump control and commissioning

- High pressure rated pump casing
- Radial vane impeller design
- No seals in the pump

CSP Integration

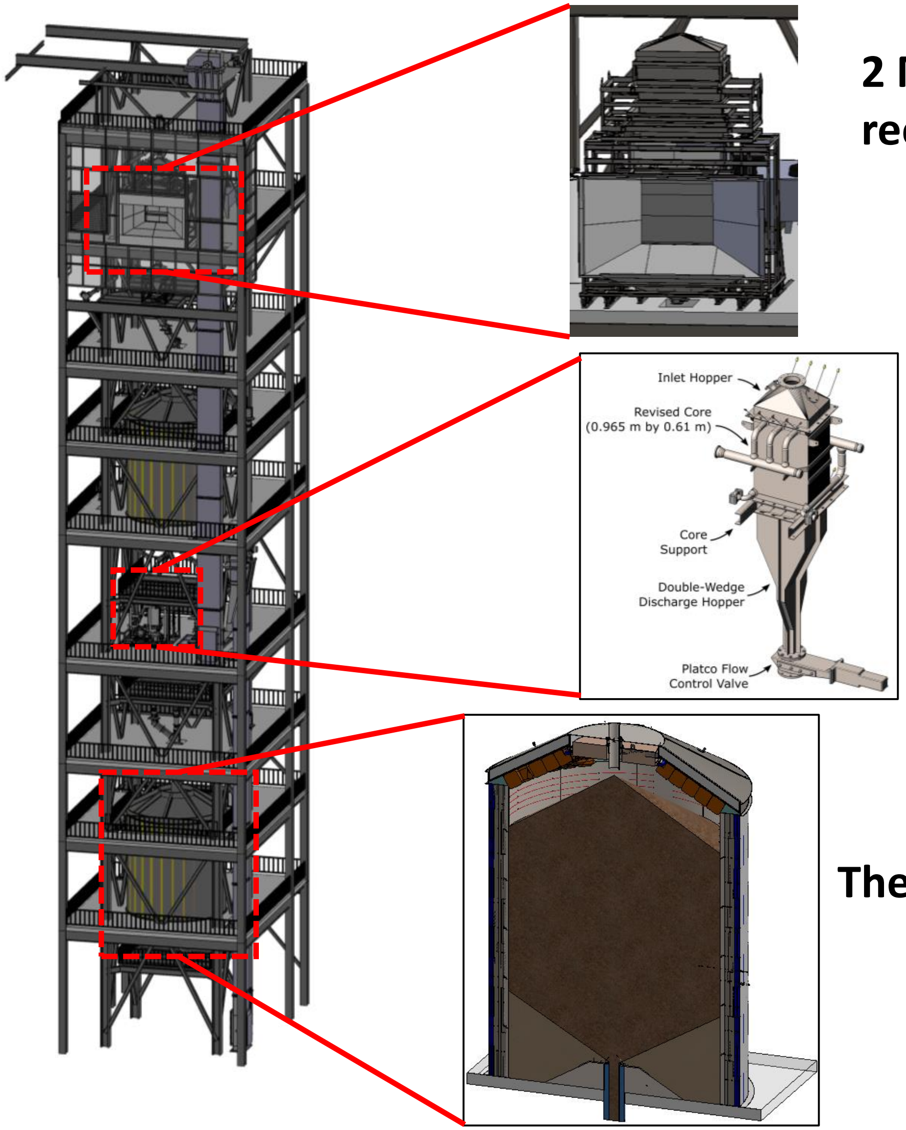
Project specifications – G3P3 USA

- 6 MWh_{th} of thermal storage at ~765 °C
- 2 MWh_{th} solar receiver
- 1 MWh_{th} sCO2 heat rejection loop
- Vertical transportation – bucket elevator
- Tower height – ~180 ft (~55 m)

Project specifications – G3P3 KSA

- 6-7 MW_{th} receiver
- 3 MWh_{th} air heat rejection loop
- Vertical transportation – skip hoist

G3P3 project Summary



2 MW_{th} particle receiver

1 MW_{th} particle-to-sCO_2 heat exchanger

Thermal Storage Tank

CSP Integration

Project specifications – G3P3 USA

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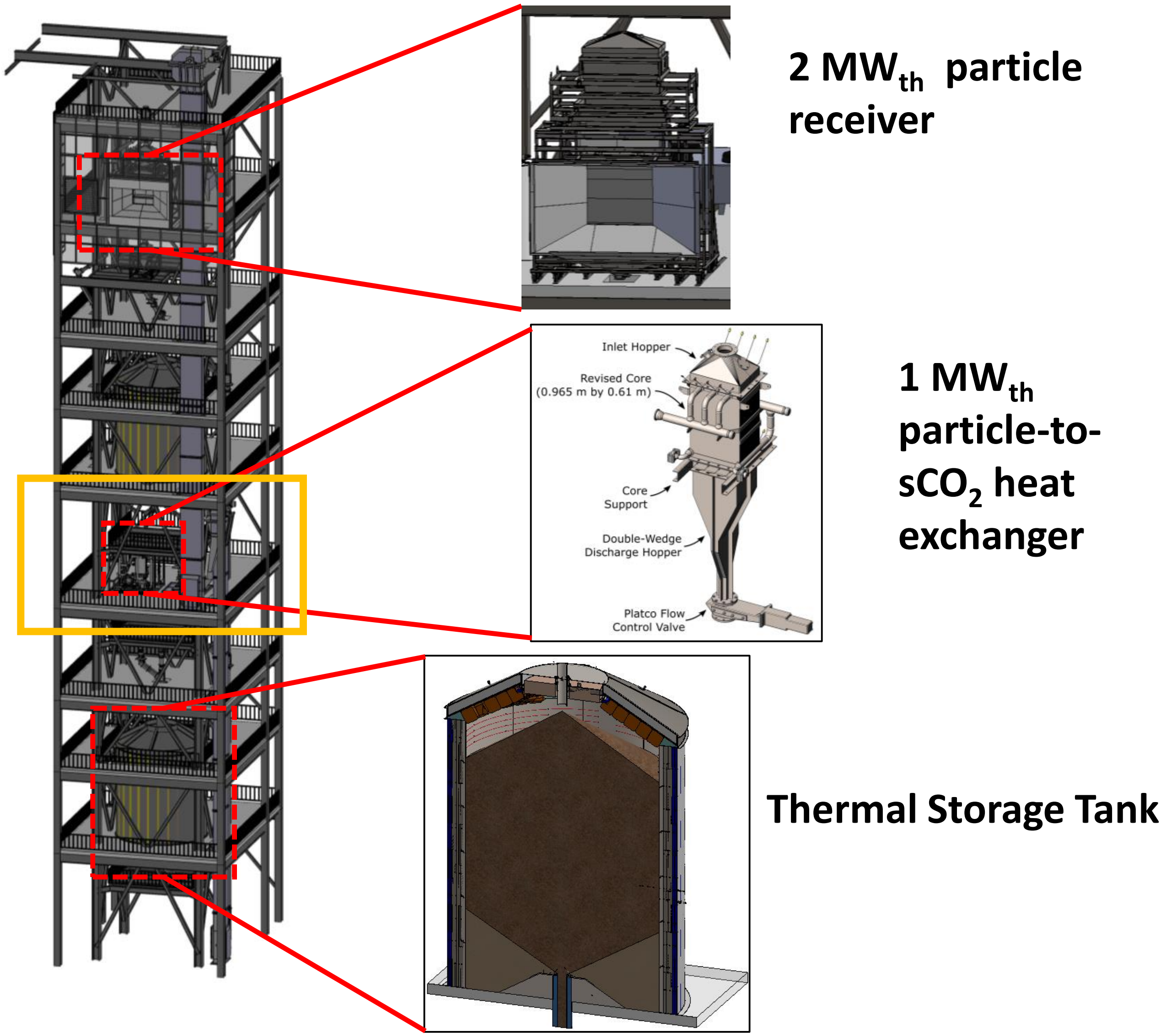


Tower Integration

Piping and equipment layout

- Stainless steel piping – intermediate temperature
- Inconel piping – high temperature
  - IN625
  - IN740H

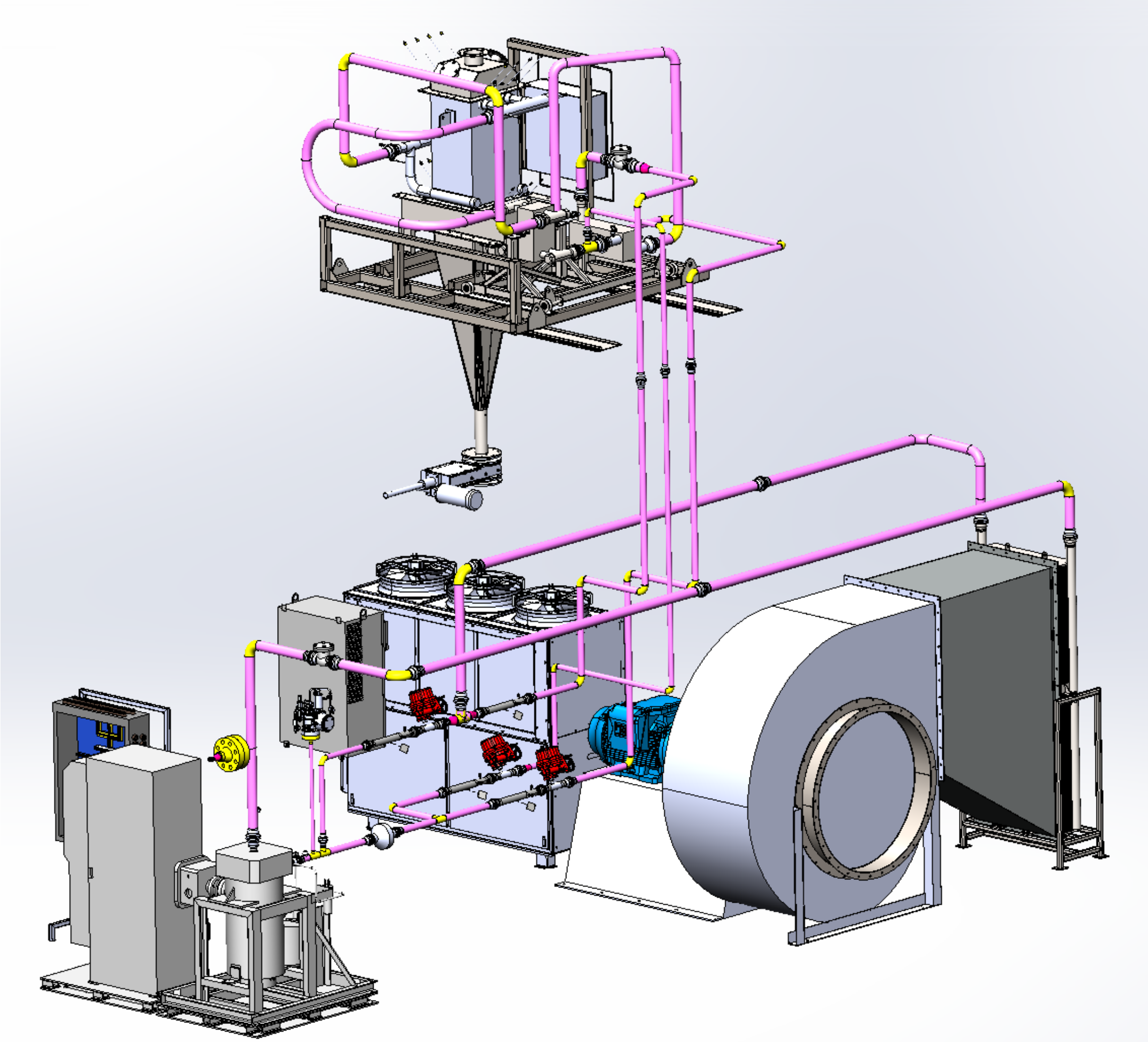
Thermal-mechanical design

- Support and stress analysis
- Skid mounted equipment

Instrumentation specification

- Flow and density
- Temperature
- Condition monitoring

Piping Design Layout



Graphics: Matthew Sandlin et.al

CSP Integration

sCO_2 loop installation – next steps

- Equipment installation
- Piping installation
- Instrumentation and controls
- System commissioning
- Primary heat exchanger integration

G3P3 tower construction

Conclusions and path forward

Benefits and Challenges

Future Technology Development

Benefits and Challenges

Benefits

- Higher temperature operation
- High cycle efficiency
- Low water consumption - ideal for CSP
- Compact turbo machinery

Challenges

- Material selection
- Sourcing of materials
- Manufacturing of heat exchangers
- High temperature thermal-mechanical design
- General supply chains

Future development - Electrical Heating Retrofit

Scope/Objectives

- Demonstrate 100 kW_e x 10+ hr PARTICLE system
  - sCO2 power cycle
  - Grid connection

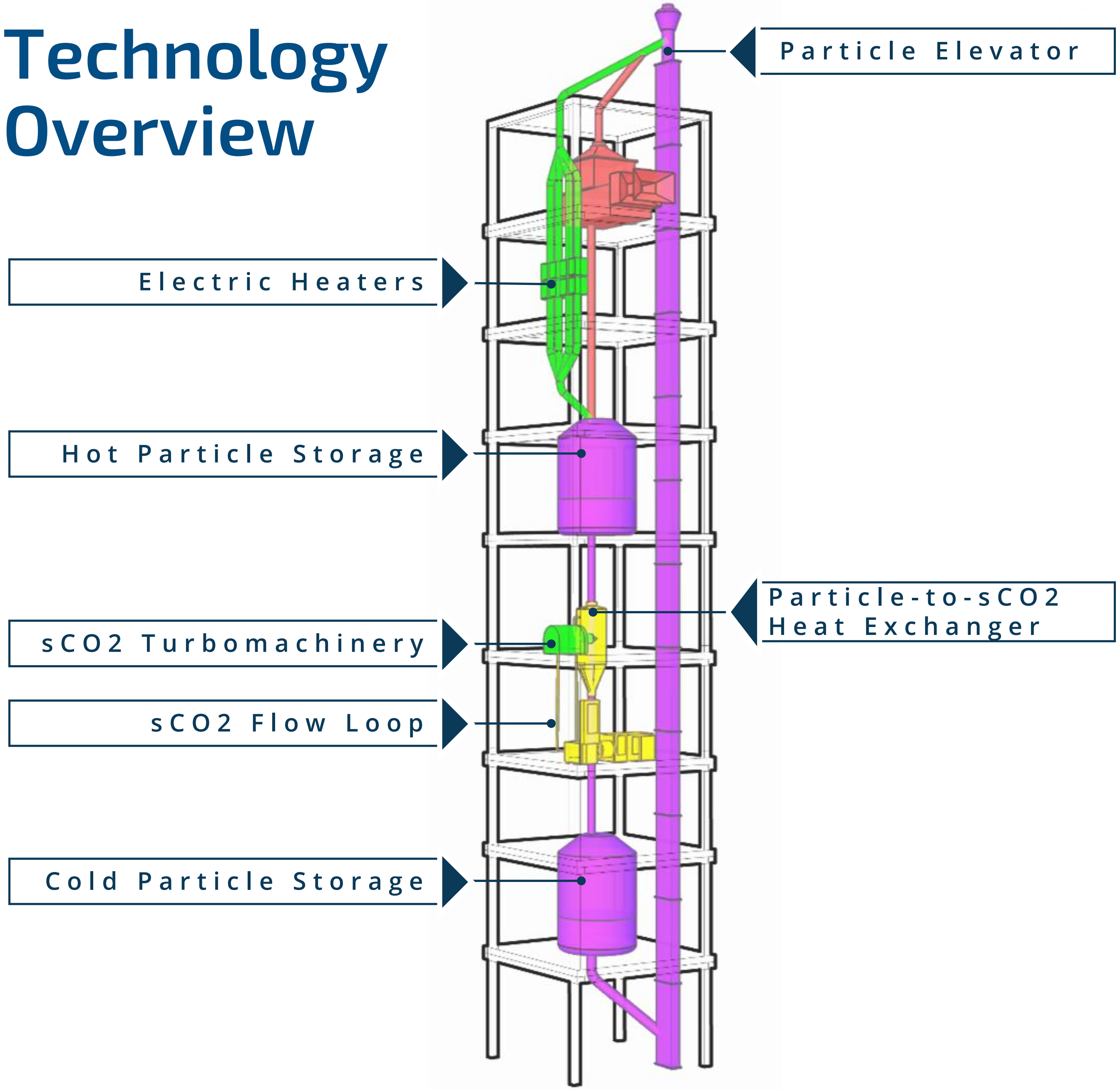
Timeline & Budget:

- 3 year project
- $4M requested

Gen 3 Particle Pilot Plant (G3P3) at Sandia National Laboratories

- State-of-the art concentrated solar facility
- Using existing infrastructure
- Unrivaled moving particle TES demonstration capability

Technology Overview



Questions

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