Testing- and Model- Based Optimization of Coal-fired Primary Heater Design for Indirect Supercritical CO_2 Power Cycles

DOE Award: DE-FE0031928

Andrew Fry (PI), Rajarshi Roy, Brian Schooff
Brigham Young University

Andrew Chiodo, Zhonghua Zhan, Xiaolong Li
Reaction Engineering International

Bradley Damstedt
Linde

Jason Miller, Tim Held, Kyle Sedlacko, Brett Bowan
Echogen Power Systems

Arman Ahrabi, Michael Johnson
Riley Power

Scott Montgomery
San Rafael Energy Research Center

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Project Overview

- *Objective*: To perform the R&D necessary to mitigate the risk associated with the design of the primary heater by utilizing large lab-scale / small pilot-scale testing and advanced modeling to optimize the conceptual design process for a coal-fired heater intended for use in an indirectly fired sCO2 power cycle

- *Period*: October 1, 2020 through September 30, 2024

Project Crux – Managing heat flux profile on a radiant HX surface where no phase change is occurring

ECHOGEN power systems

REACTION ENGINEERING INTERNATIONAL

SAN RAFAEL Energy Research Center

Riley Power a Babcock Power Inc. company

PRAXAIR Linde

BRIGHAM YOUNG UNIVERSITY FOUNDED BYU 1875 PROVO, UTAH

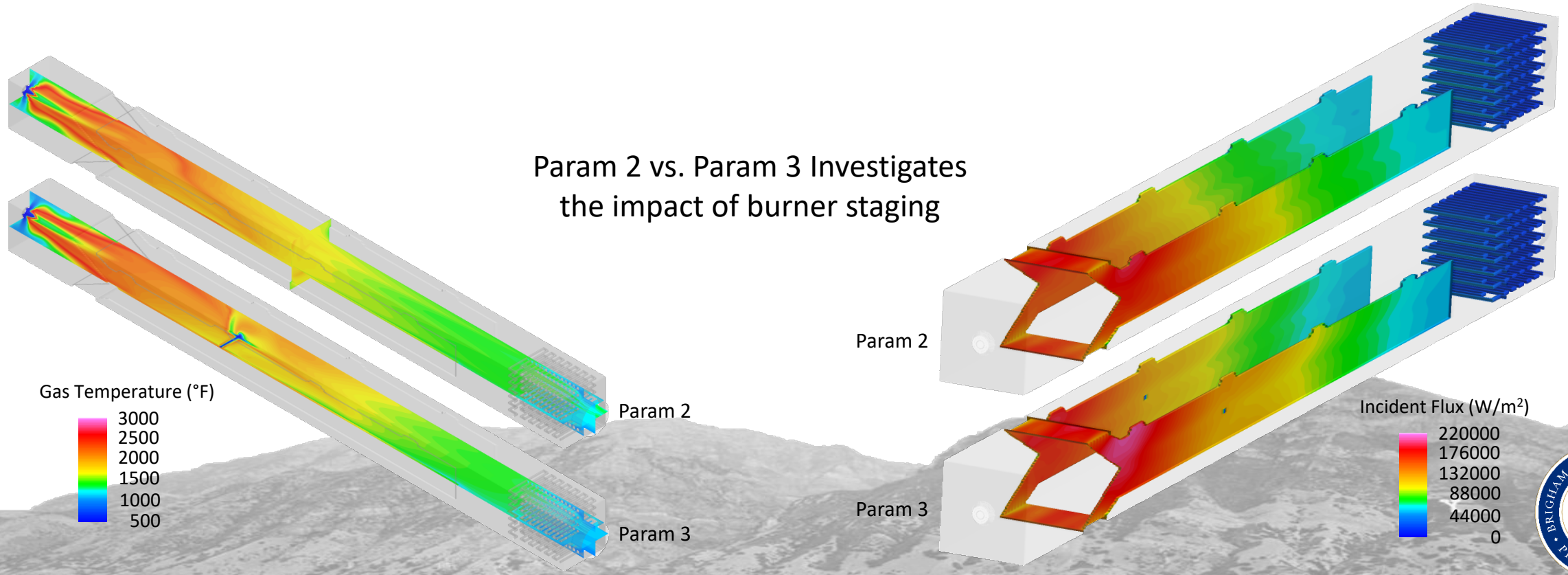
Project Tasks

1. Project Management and Planning
2. Advanced Coupled Modeling Tool Development
3. Refurbishment and Integration of a Recuperative sCO_2 Loop
4. Design, Construction and Installation of a Pilot-scale Primary Heater
5. sCO_2 Primary Heater Pilot-scale Testing
6. Scale-up and Technoeconomic Analysis

Task 2: Advanced Coupled Modeling Tool Development

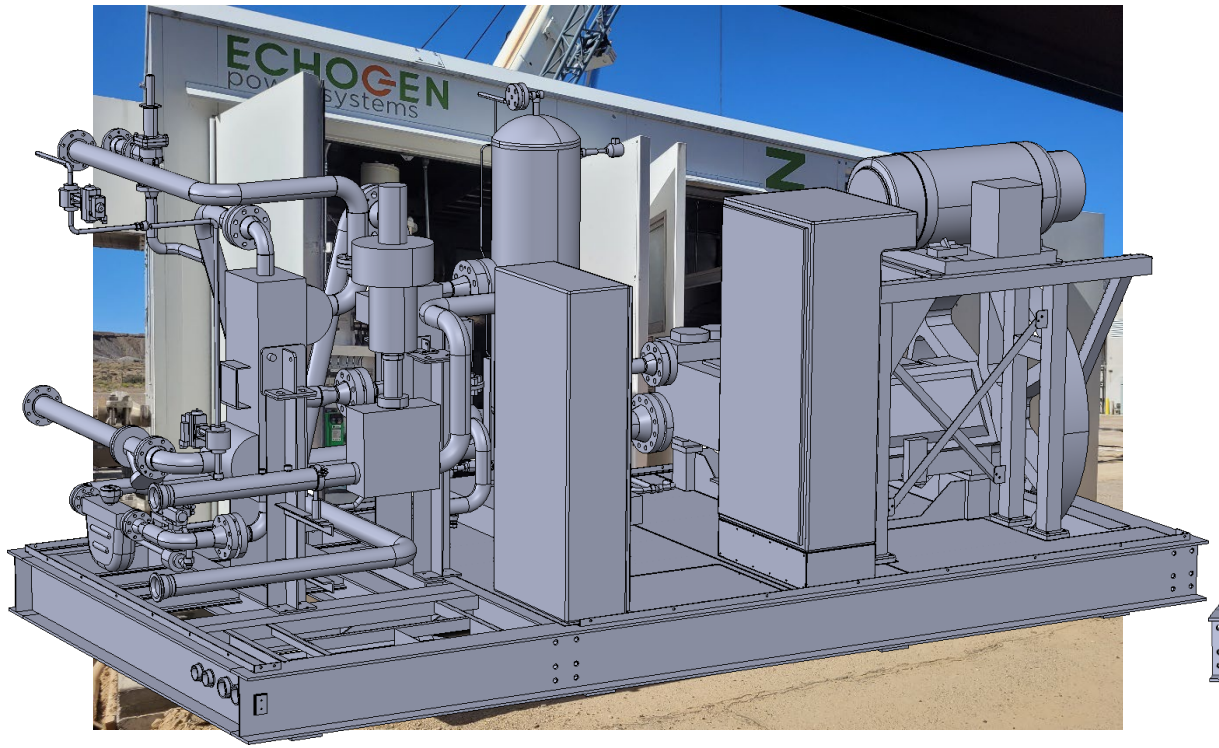
REI Modeling Tools

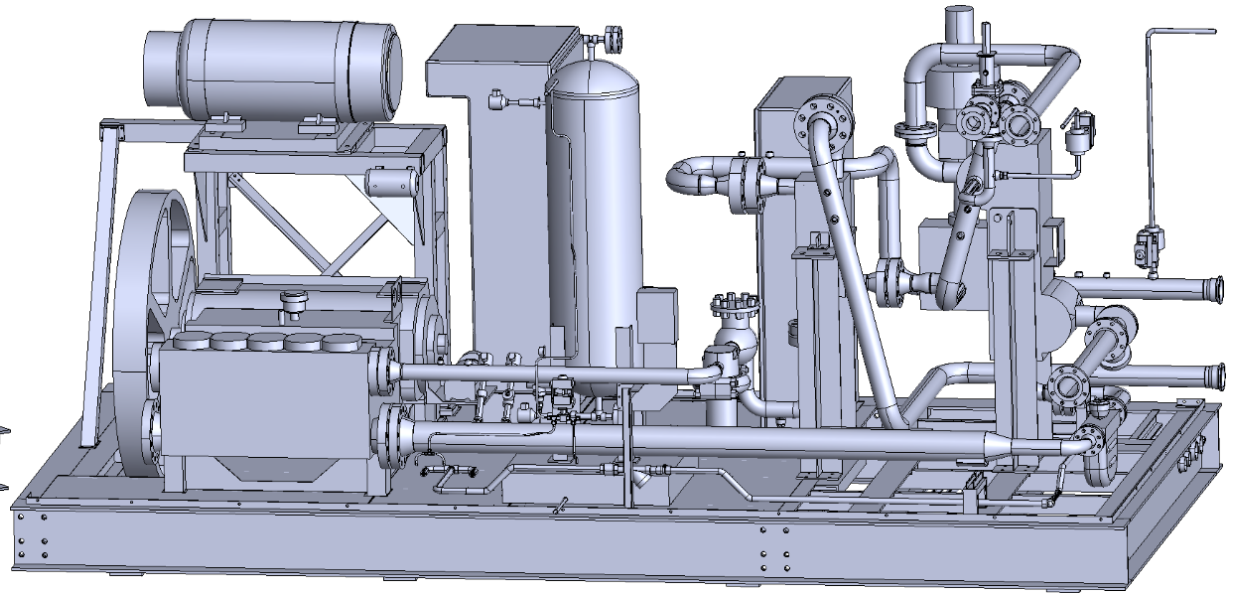
- Reaction Engineering International (REI) internally developed CFD tool:
  - GLACIER – extensive track record for multi-phase reacting flows
  - Updated with appropriate thermal properties for sCO_2
- sCO_2 thermophysical properties included in tube-side calculations within REI's SteamGen Expert (SGE) framework coupled with the Glacier CFD model
  - High fidelity radiant heat flux predictions from CFD model feed into process model of overall power cycle



Task 3: Refurb. & Integration Recuperative sCO_2 Loop

Refurbishment of EPS 5 kg/s sCO2 Test Loop





Task 4: Design, Const. & Install of Pilot-scale Primary Heater

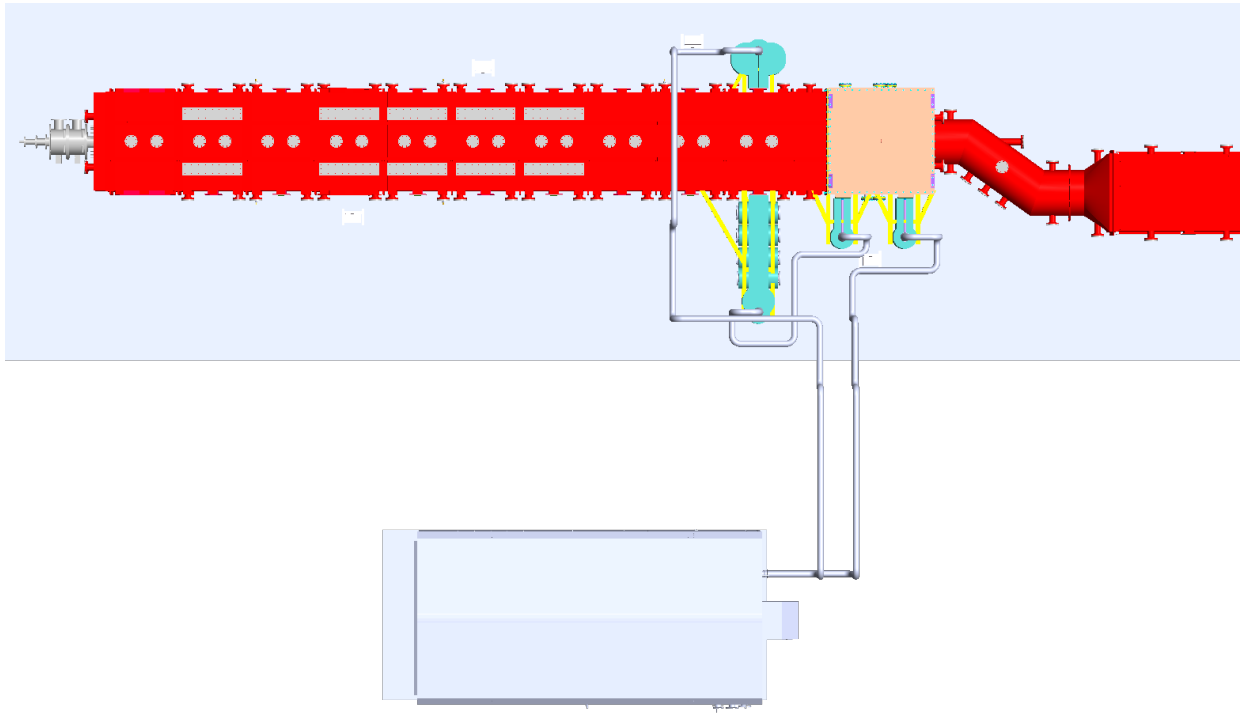
Design and Fabrication of the PHX

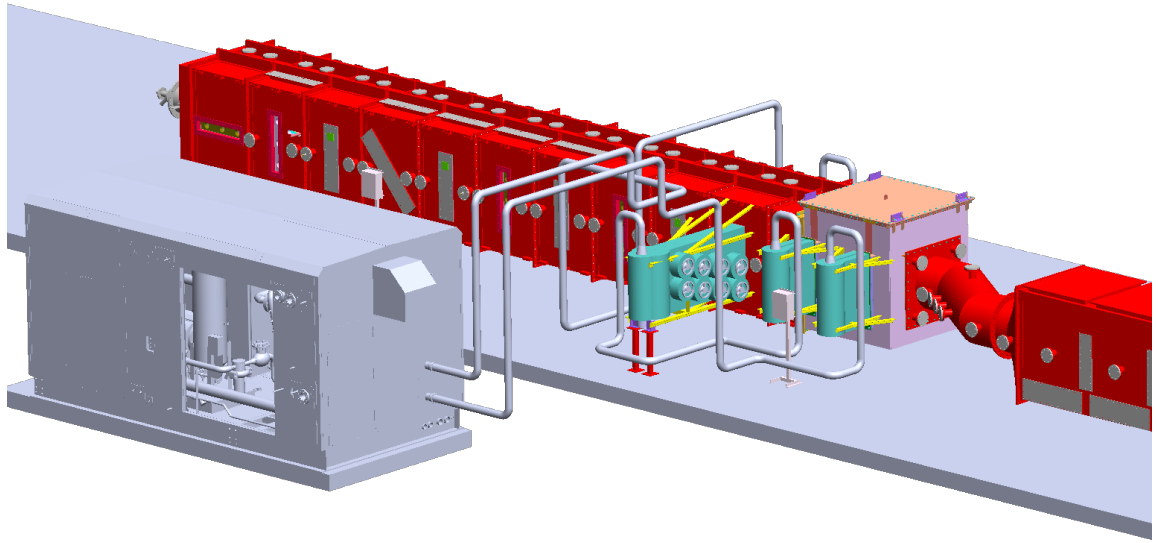
Task 4: Design, Const. & Install of Pilot-scale Primary Heater

Rigging of Radiative Section

Task 4: Design, Const. & Install of Pilot-scale Primary Heater

Integrated System (SolidWorks)





Task 4: Design, Const. & Install of Pilot-scale Primary Heater

Integrated System

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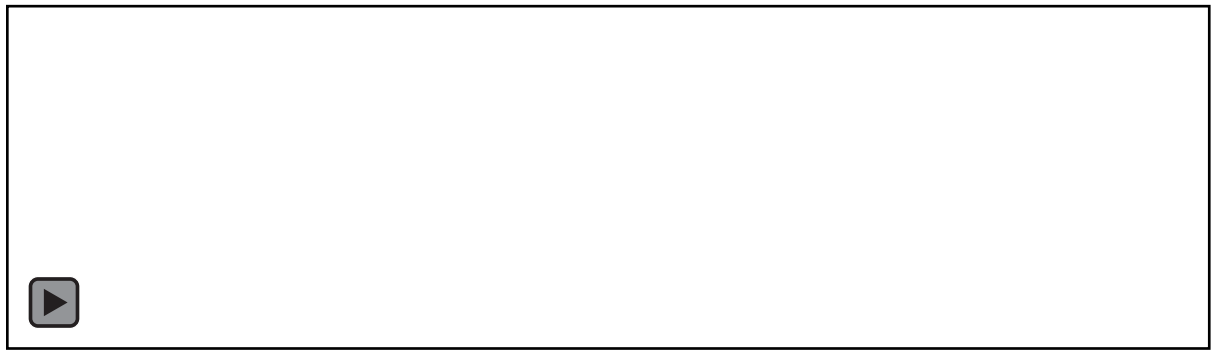
Integrated System

Task 5: sCO_2 Primary Heater Pilot-scale Testing

Testing Overview

- Shakedown testing commenced on May 30, 2023
- We have completed 150 hours of operation
- Furnace has been fired on Natural Gas and Western Bituminous Coal

1.5 MW_{th} Pulverized Coal Flame in the L1500



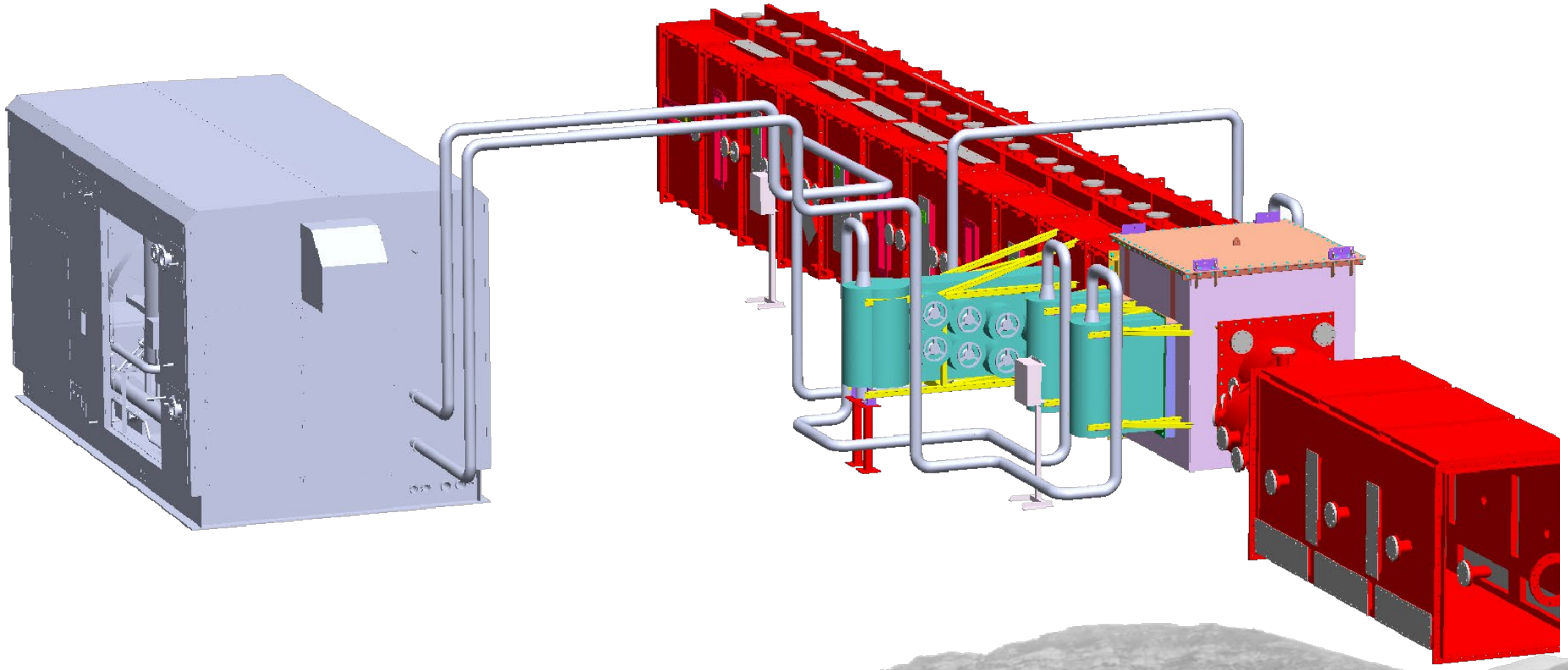
Variable	Target	Reached
Firing Rate (MW_{th})	1.7	1.6
PHX Heat Adsorption (MW_{th})	1.2	1.2
CO_2 Temperature (°C)	600	568
CO_2 Pressure (MPa)	20.5	19.5

Task 6: Scale-up and Technoeconomic Analysis

- Opportunity
  - Fired heater cost reduction due to reduction of design margin
  - Effect on LCOE

- Baseline Plants
  - DE-FE0025959 (Oxy-combustion / sCO2 integration study)
  - DE-FE0031585 (Large Scale Pilot TEA)
  - Coal FIRST

Add a Turbine and Generator



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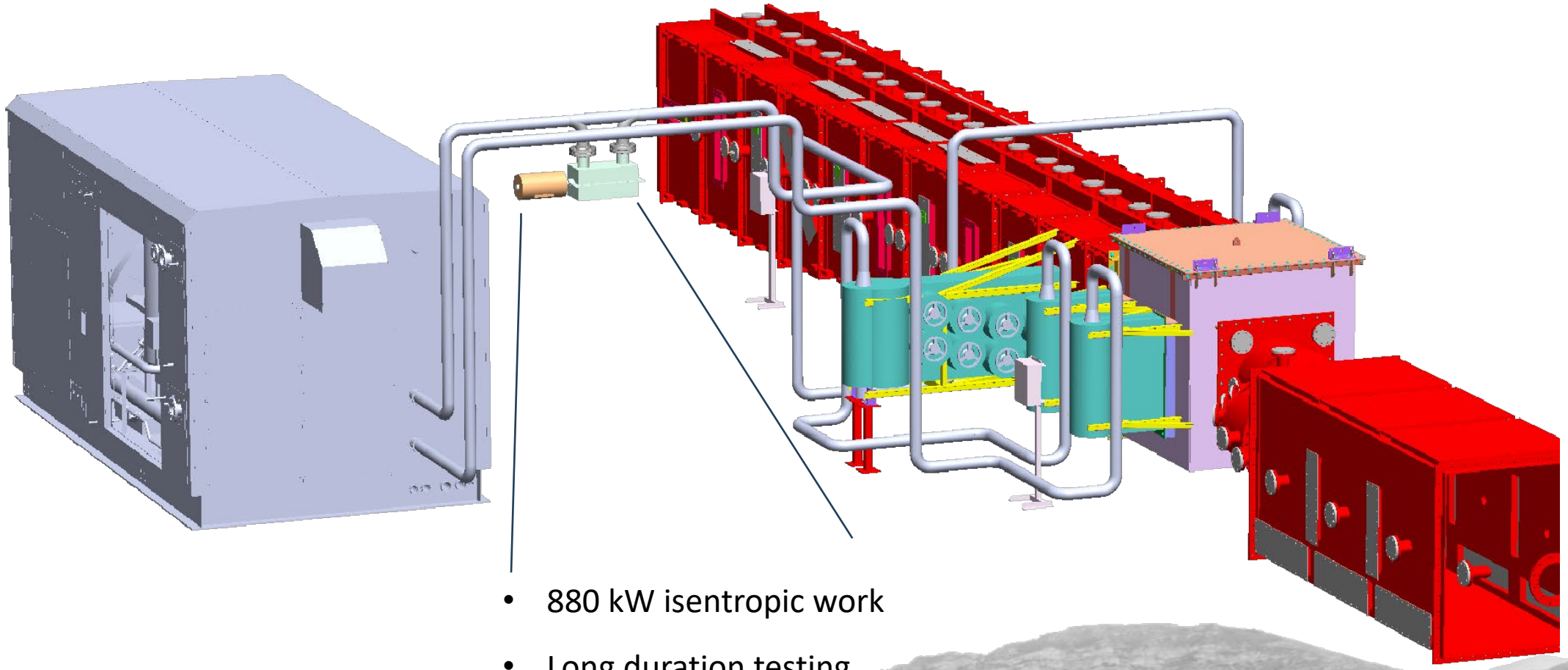
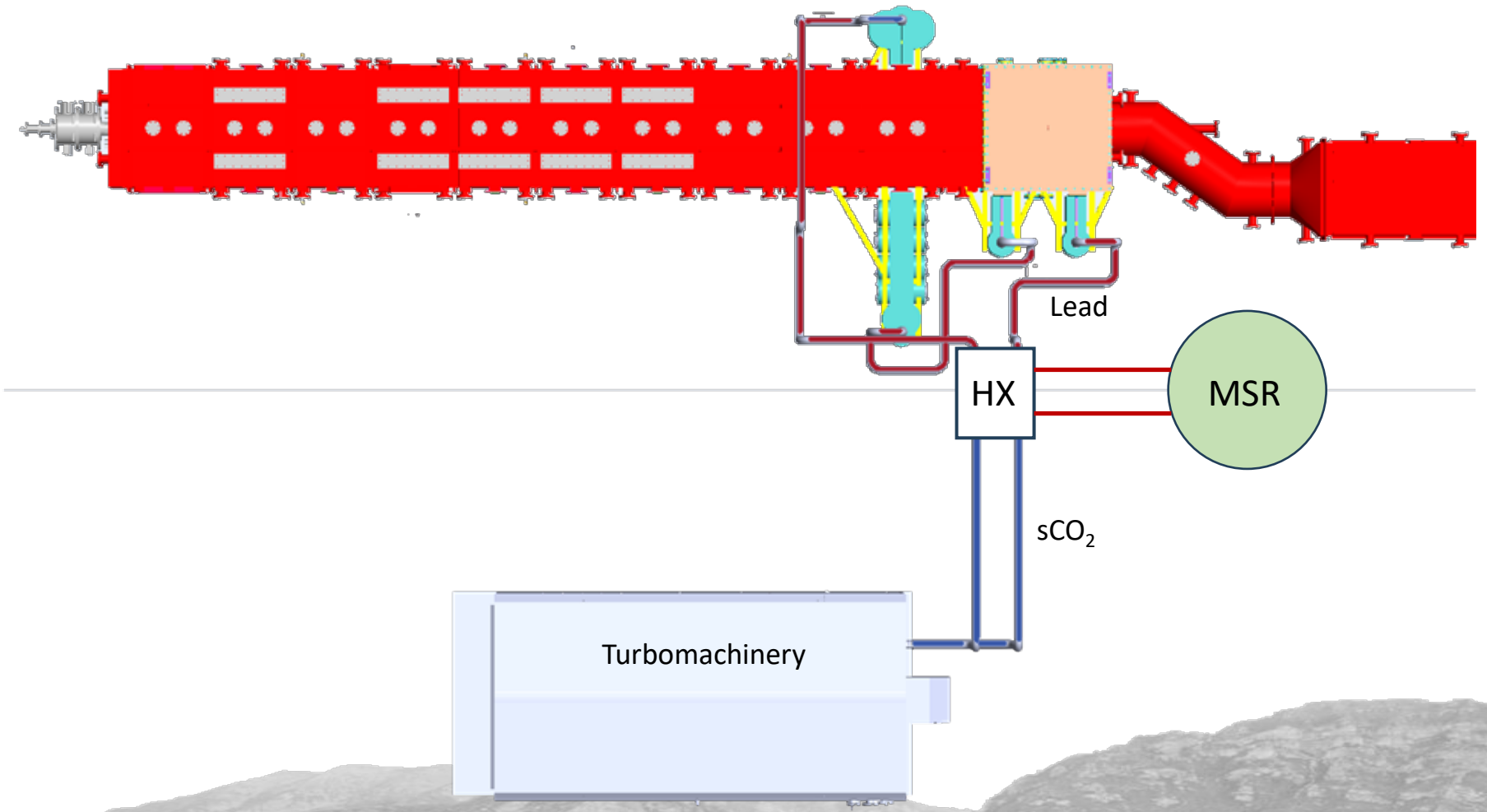


- 880 kW isentropic work
- Long duration testing

Couple with Molten Salt Nuclear Reactor



Questions ?