Technology Development of Modular, Low-Cost, High-Temperature Recuperators for Supercritical CO2 Power Cycles

DE-FE0026273 Kickoff Meeting

November 12, 2015

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Southwest Research Institute

Outline

- Project Participants
- Project and Technical Overview
  - sCO_2 Power Cycle
  - sCO_2 Heat Exchangers
  - sCO_2 Recuperators
- Proposed Scope
  - Objectives
  - Work Breakdown
- Project Management

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Project Participants

- Thar Energy, LLC
- Southwest Research Institute
- Oak Ridge National Labs
- Georgia Institute of Technology

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Project Participant Roles

Thar Energy
- Prime contractor
- Technical gap assessment
- Design for manufacturing
  - Focus manufacturability & cost
  - Multiple design analysis
- Design for operability, prototyping, & fabrication
  - Down select
- Final Design for manufacturability
- Recuperator fabrication

SwRI
- Combined system engineering design
- Thermodynamic analysis
- FEA Modeling

ORNL
- Materials science
  - Long-term corrosion resistance
  - Creep resistance
  - New alloy and/or coating formulation

Georgia Institute of Technology
- CFD simulation & analysis of heat exchanger concepts

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Delivering clean energy solutions - rooted in natures' design

- Advanced Systems for Power Generation
- Advanced Heat Exchanger Technology
- Sustainable Heating & Cooling Solutions
- Cost Effective Water Processing

Core competencies:

- 25+ years commercializing "Green" supercritical fluid technologies (SCF)
- Designer and developer of supercritical fluid processes, systems & major components
- Industrial scale 24/7/365 installations, world wide:
  - Food
  - Chemicals
  - Nutraceutical
  - Pharmaceutical
- Heat exchangers for high pressure, high temperature application

ThareEnergy

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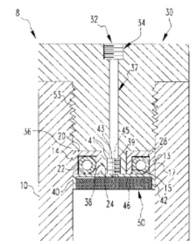
Thar has a history of successfully designing & commercializing Green Products using recycled Carbon Dioxide.

Launch Suprex

Suprex sold to Teledyne Isco

Launch Thar Brand

Pressurized Vessel with Self-Energizing Seal



ThareProcess

Thar Instruments

Spin out operating divisions

1982

Carnegie Mellon University

Chemical Engineering

1985

Earn PhD

U.S. Patents 4,814,089 & 4,871,453
Chromatographic Separation Method and Associated Apparatus

1990

Approached DOE with sCO_2 Brayton Cycle Concept

Launch Operating Div.
- Thar Instruments
- Thar Process
- Thar Pharma

Products and Processes Commercialized
Awards & Patents Received
U.S. Patents #5,336,869, #5,461,648, #5,694,973, #5,850,934, #5,879,081, #5,886,293, #6,908,557, #7,091,366, #6,698,214. ……

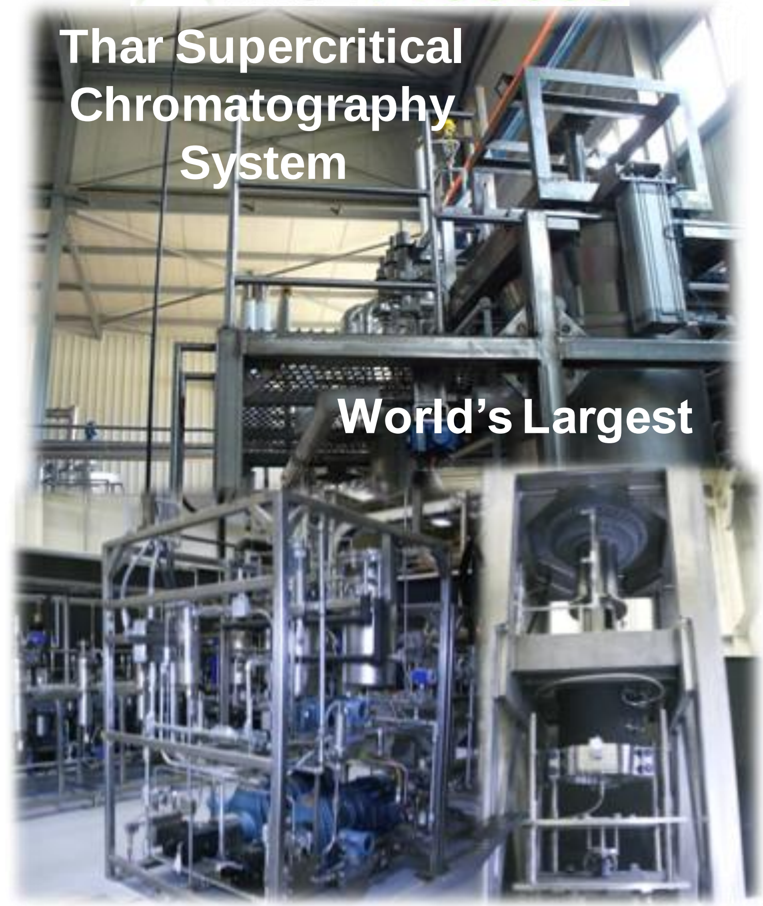
2007

Acquired Berger from Metler Toledo

2001, 2002 Governor's Export Excellence Award Finalist
2002 National Small Business Exporter of the Year
2002 NIST ATP Awardee (Microrefrigeration)
2002, 2003 Top 25 Biotech Companies
2002, 2003 Top 100 Fastest Growing Companies
2003 Fastest Growing Small Manufacturer Award
2004 Manufacturer of the Year

Sales, Design-Build, Install and Service

Over 5,000 green installations world wide



Over 20 Industrial green installations world wide

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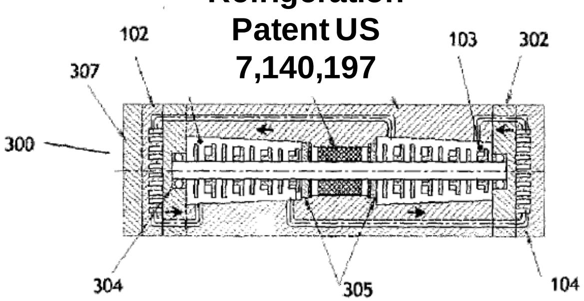
Thar Timeline (cont.)

2002

NIST funds micro-refrigeration project

2005

Micro Refrigeration Patent US 7,140,197



2009

1st R744 Geothermal Cooling Demonstration

Validated potential for R744 DX heat pump cycle

Thar Instruments, ~125 strong, Offices worldwide, Sold to Waters THE SCIENCE OF WHAT'S POSSIBLE.

2010

Launch TharGeothermal

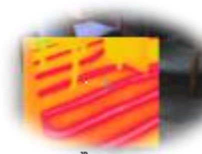
Evaluation of Commercial Drill Technology

Laboratory testing and component development

2012

Vertical and Horizontal well fields installed

Radiant Floor



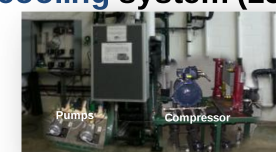
Geothermal Energy System Patent US 8,468,845

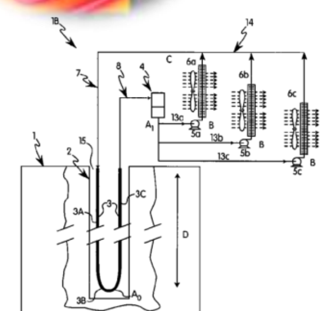
2014

High Pressure sCO_2 Pumps

Advanced Heat Exchanger Technology Demonstration

Demonstrations at commercial scale - geothermal heating & cooling system (15-20 ton)





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Southwest Research Institute

- Independent, nonprofit applied research and development organization founded in 1947
- Eleven technical divisions
  - Aerospace Electronics, Systems Engineering & Training
  - Applied Physics
  - Applied Power
  - Automation & Data Systems
  - Chemistry & Chemical Engineering
  - Engine, Emissions & Vehicle Research
  - Fuels & Lubricants Research
  - Geosciences & Engineering
  - Mechanical Engineering
  - Signal Exploitation & Geolocation
  - Space Science & Engineering
- Total 2013 revenue of $592 million
  - 38% Industry, 36% Govt., 26% Govt. Sub
  - $6.7 million was reinvested for internal research and development
- Over 2,800 staff
  - 275 PhD's / 499 Master's / 762 Bachelor's

- Over 1,200 acres facility in San Antonio, Texas
  - 200+ buildings, 2.2 million sq. ft of laboratories & offices
  - Pressurized Closed Flow Loops
  - Subsea and High Altitude Test Chambers
  - Race Oval and Crash Test Track
  - Explosives and Ballistics Ranges
  - Radar and Antenna Ranges
  - Fire testing buildings
  - Turbomachinery labs

Benefiting government, industry and the public through innovative science and technology

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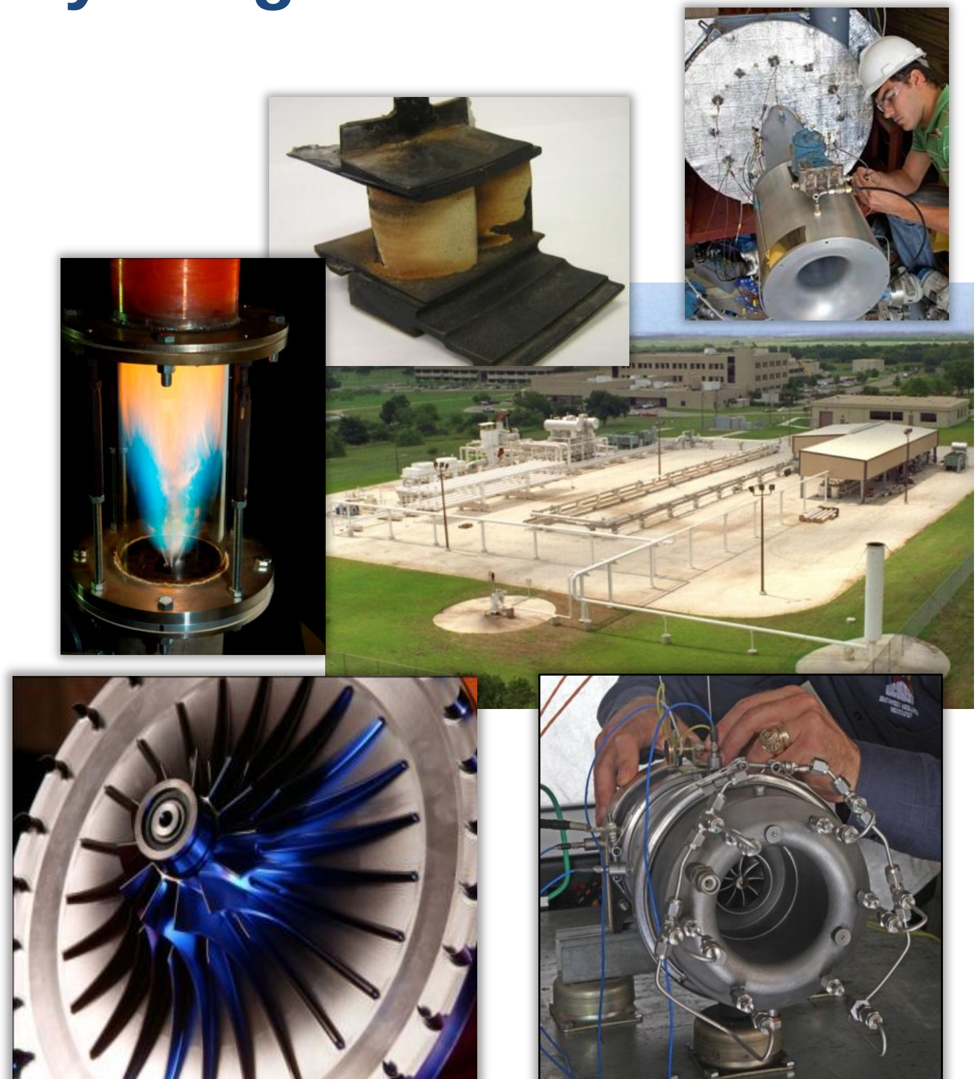
Machinery Program

- Fluids & Machinery Engineering Department
  - – Mechanical Engineering Division (18)
- Specialties
  - – Turbomachinery component design and testing
  - – Root cause failure analysis
  - – Rotordynamic design/audit
  - – Pipeline/plant simulation
  - – CFD and FEA analysis
  - – Test stand design
  - – Performance testing



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ORNL is providing material support

- Bruce Pint, Group Leader of Corrosion group
  - ~30 years experience in high temp. oxidation
  - Fellow of NACE International and ASM International
- Relevant prior experience
  - Thin-walled heat exchangers for gas turbines (1995-2015)
  - Materials for 760°C (1400°F) supercritical steam (2002-2015)
  - Alloy selection for numerous high temperature applications
  - Extensive commercial alloy corrosion performance database
- On-going supercritical CO_2 compatibility work
  - Fossil Energy (400-750°C)
  - Concentrated Solar Power (700°-800°C)

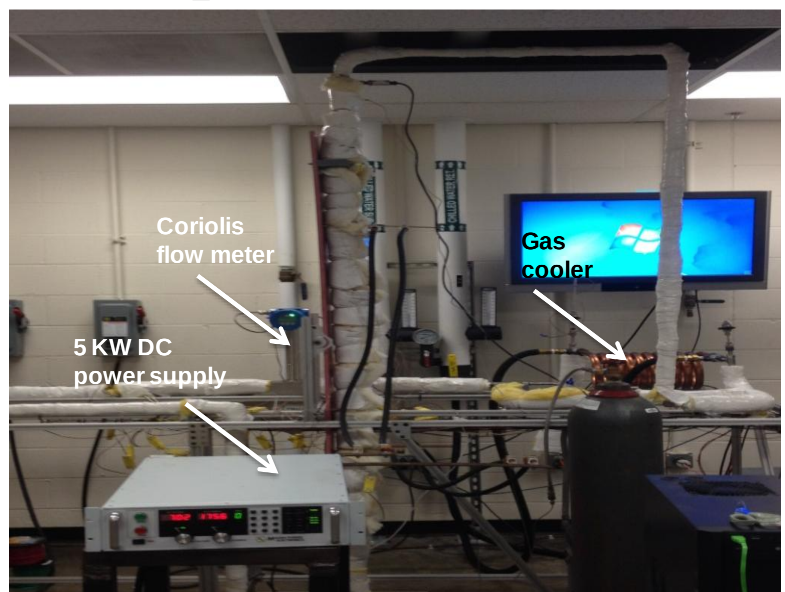
Georgia Institute of Technology

STAML
Shock Tube & Advanced Mixing Laboratory

Devesh Ranjan, Associate Professor, Mechanical Engineering

- **Expertise: Thermal-Hydraulics of Supercritical Fluids, Turbulent Mixing**
- **Current Active Projects: sCO_2 oxy-combustion, ceramic heat exchanger design, & nucleation study in sCO_2 flows**

Heat Exchanger Test Facility



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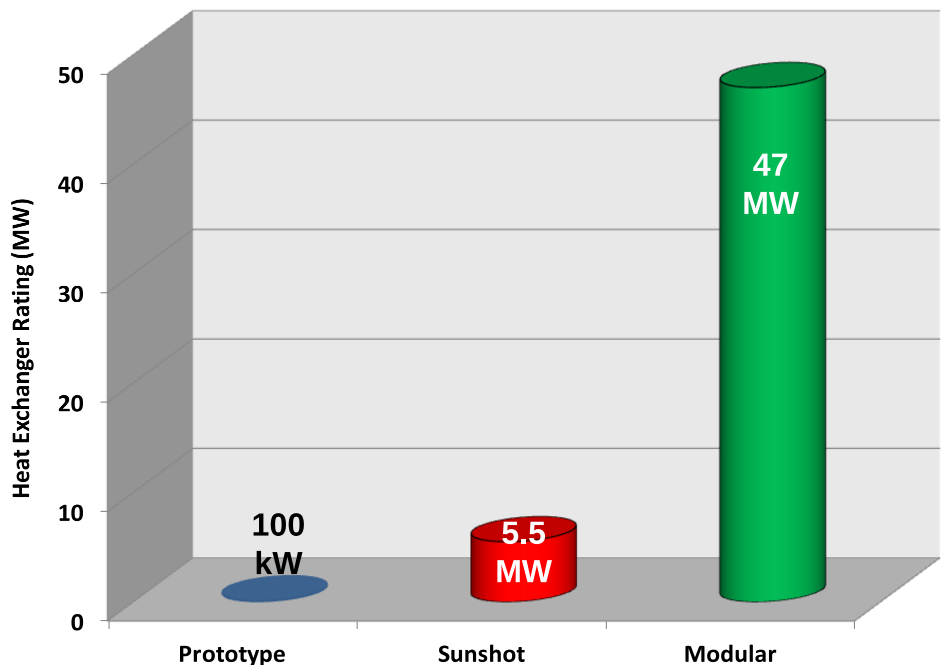
Current DOE sCO_2 Projects

PROJECTS	2014	2nd	3rd	4th	2015	2nd	3rd	4th	2016	2nd	3rd	4th	2017	2nd	3rd
Sunshot - 5.5 MW Recuperator 1st Generation	SwRI + Thar														
High T High Delta P - 100 kW Recuperator - 2nd Generation				Thar + SwRI											
Modular - 47 MW Recuperator 3rd Generation								Thar + SwRI + ORNL + GT						Phase 2 Two years	
Sunshot - 2.5 MW Heater 1st Generation	SwRI + Thar														
Oxy Combustion sCO2 Power Cycles				SwRI + Thar											
Absorption/Desorption sCO2 Power Cycles								SwRI + Thar							



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Project and Technology Overview

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Objective:

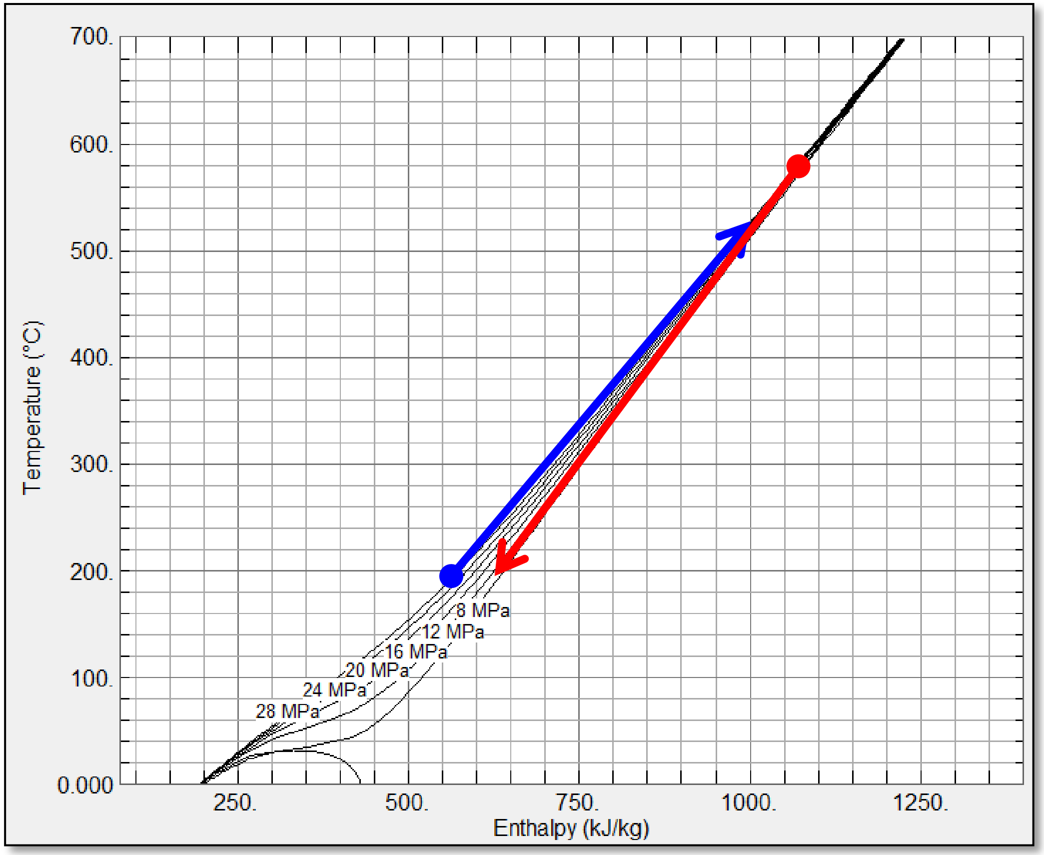
- Advance high-temperature, high-differential-pressure recuperator technologies suitable for use in sCO_2 Recompression Brayton Cycle (RCBC)
- Evaluate, advance, and demonstrate recuperator concepts, materials, and fabrication methods that facilitate the commercial availability of compact and low cost recuperators for RCBC conditions (e.g. temperatures exceeding 700°C and differential pressures on the order of 200 bar)
- Emphasis placed on scalable solutions able to accommodate plant sizes from 10 - 1,000 MWe.

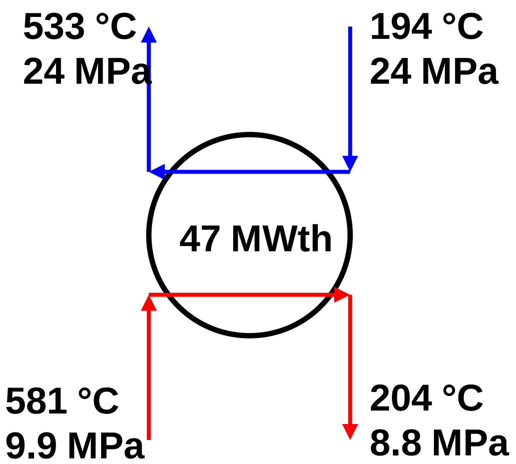
Program will:

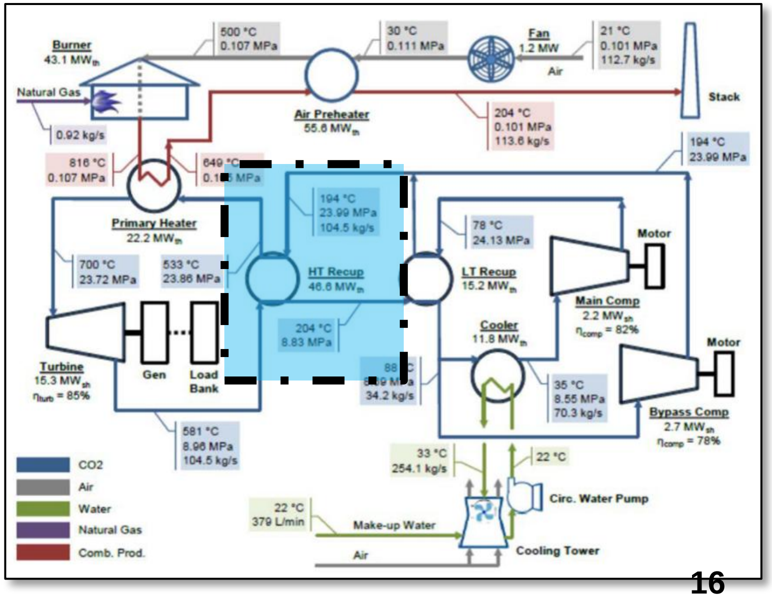
(1) Address critical design, materials, and fabrication challenges

(2) Significant impact on recuperator cost, performance, and scalability

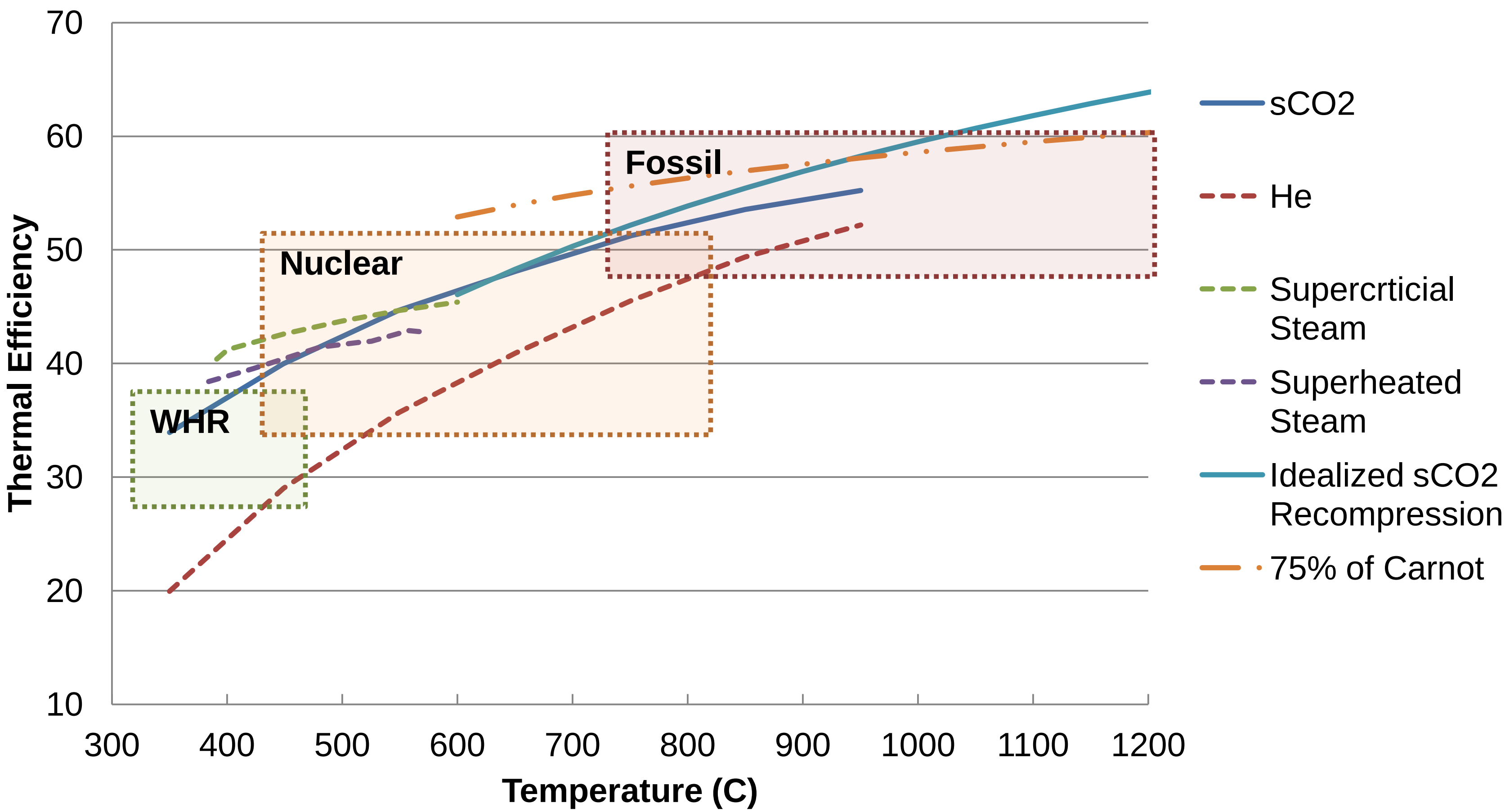
Develop a scalable, high temperature recuperator for STEP facility conditions







Why sCO_2?



sCO2, He, Supercritical Steam, and Superheated Steam are from Driscol MIT-GFR-045, 2008

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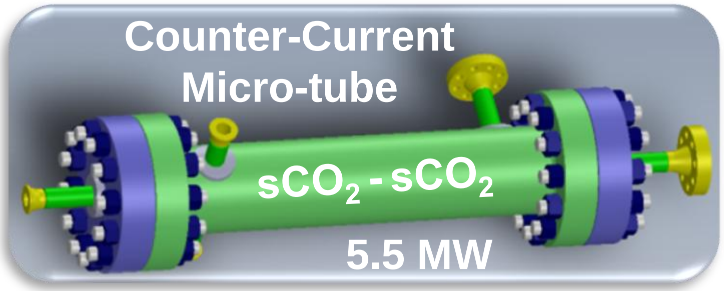
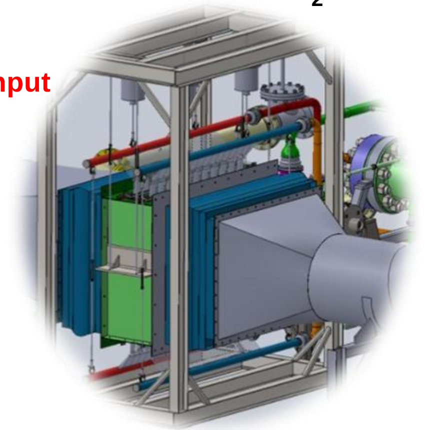
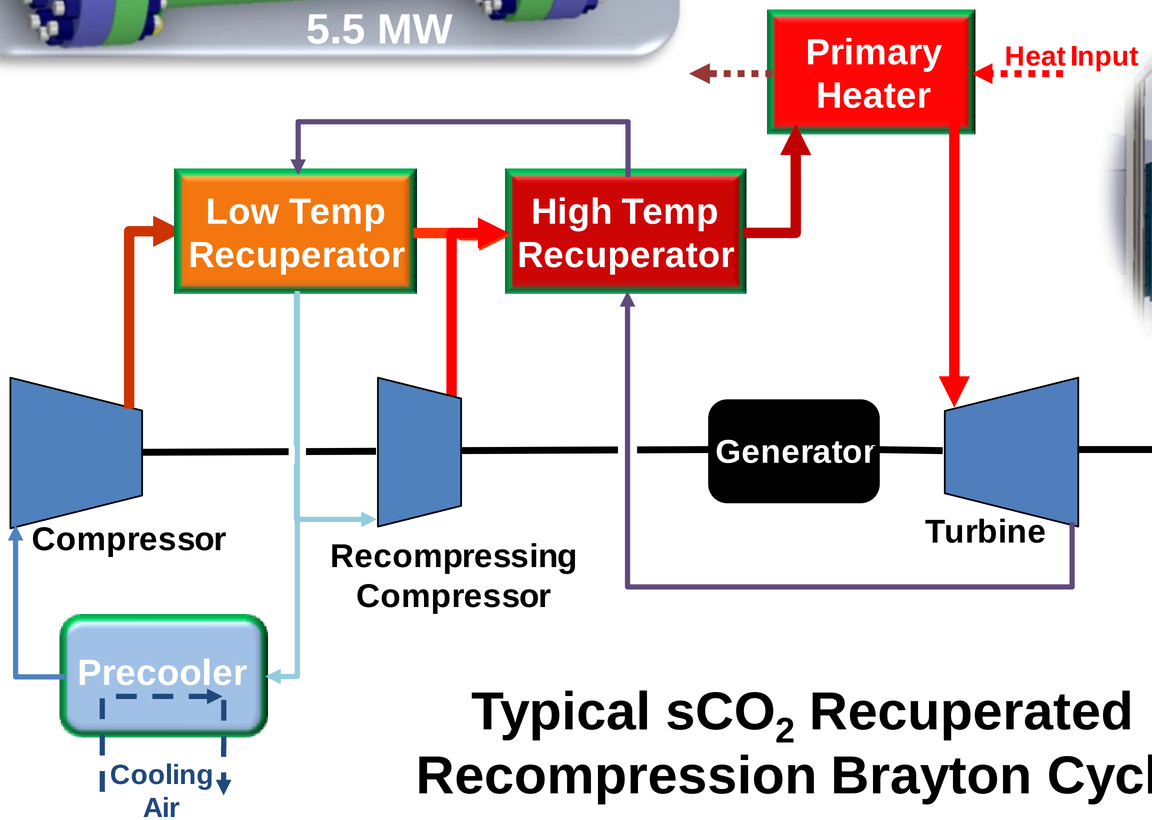
Thar Energy sCO_2
Recuperators, Heater HXs & Precooler HXs



2.5 MW Inconel 740H
Hot Air–sCO_2 HX





Typical sCO_2 Recuperated
Recompression Brayton Cycle

Microchannel
sCO_2
Gas
Cooler

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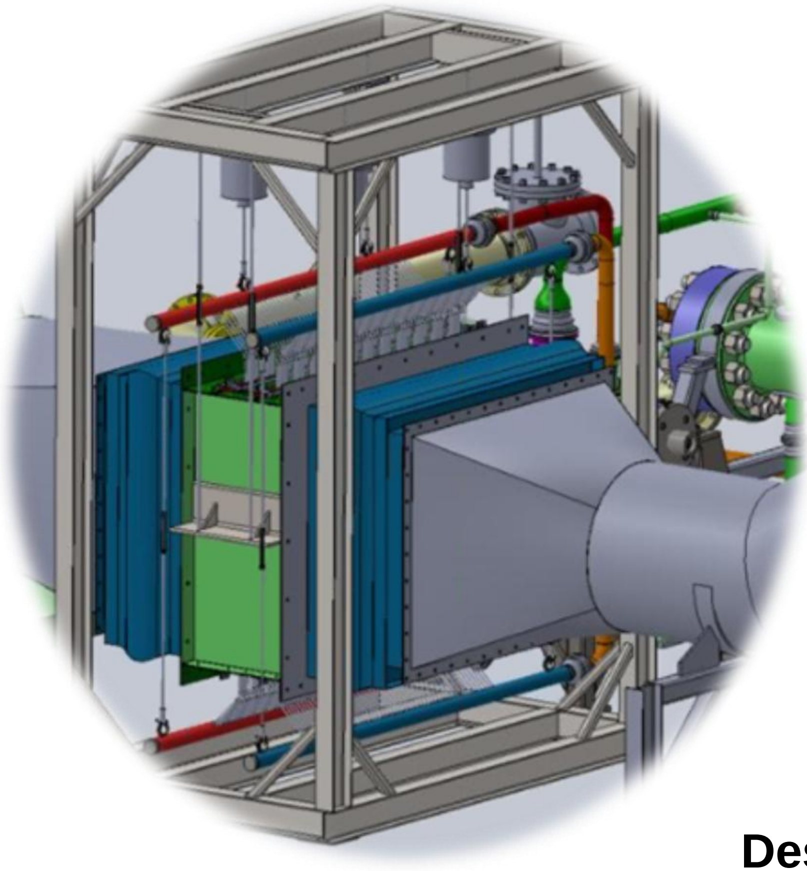
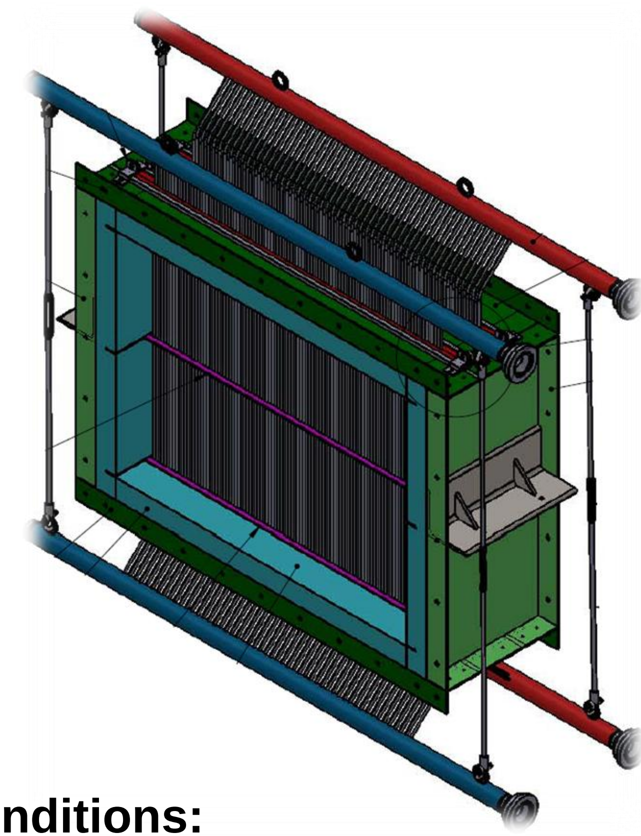
Sunshot Heater HX Design – 2.5 MW

Hot Gas to sCO_2 HX
Inconel 740H Construction





Design Conditions:

Gas Fired Burner/Blower Outlet Temperature: 870°C

sCO_2 Outlet Temperature: 715°C

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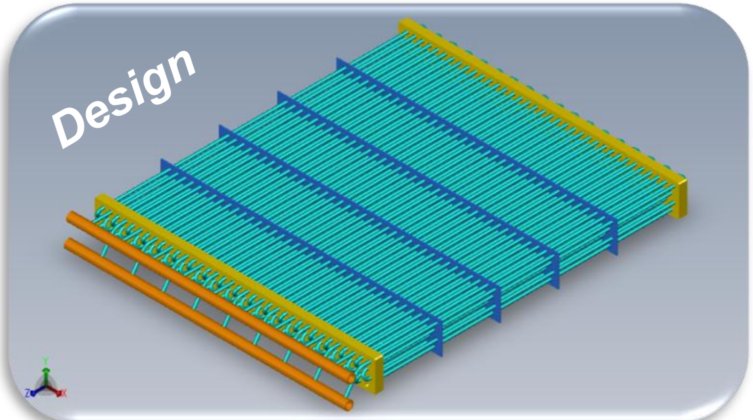
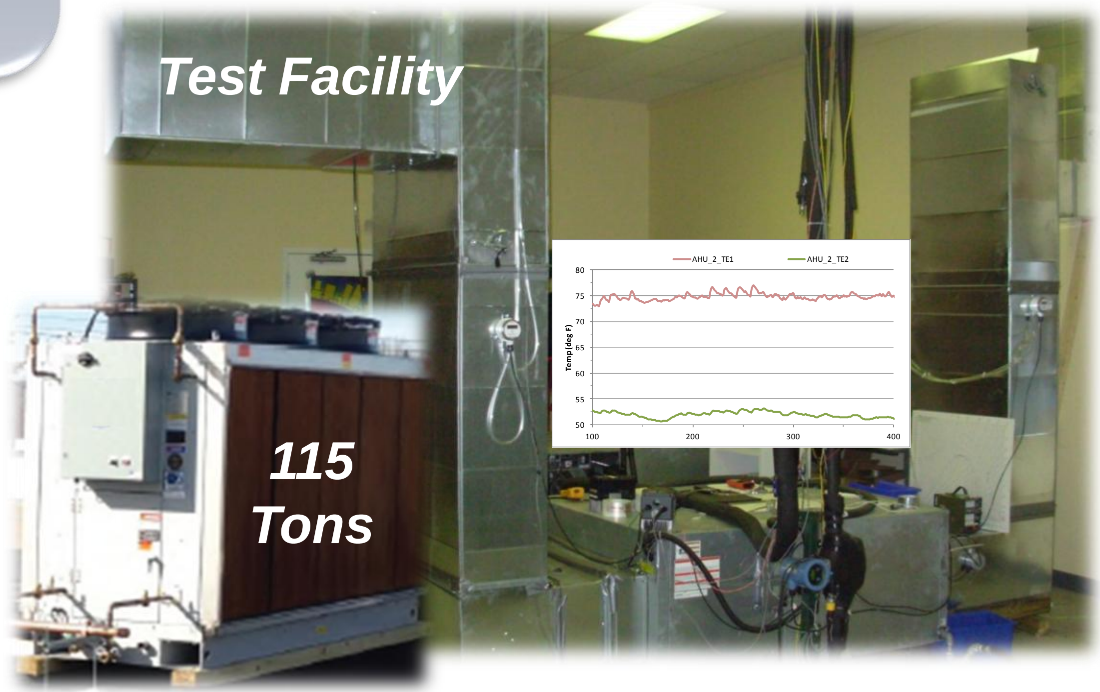
sCO_2 Gas Cooler HXs
35-500 kW



CO_2-Air Approach Temperature as Low as 2°C



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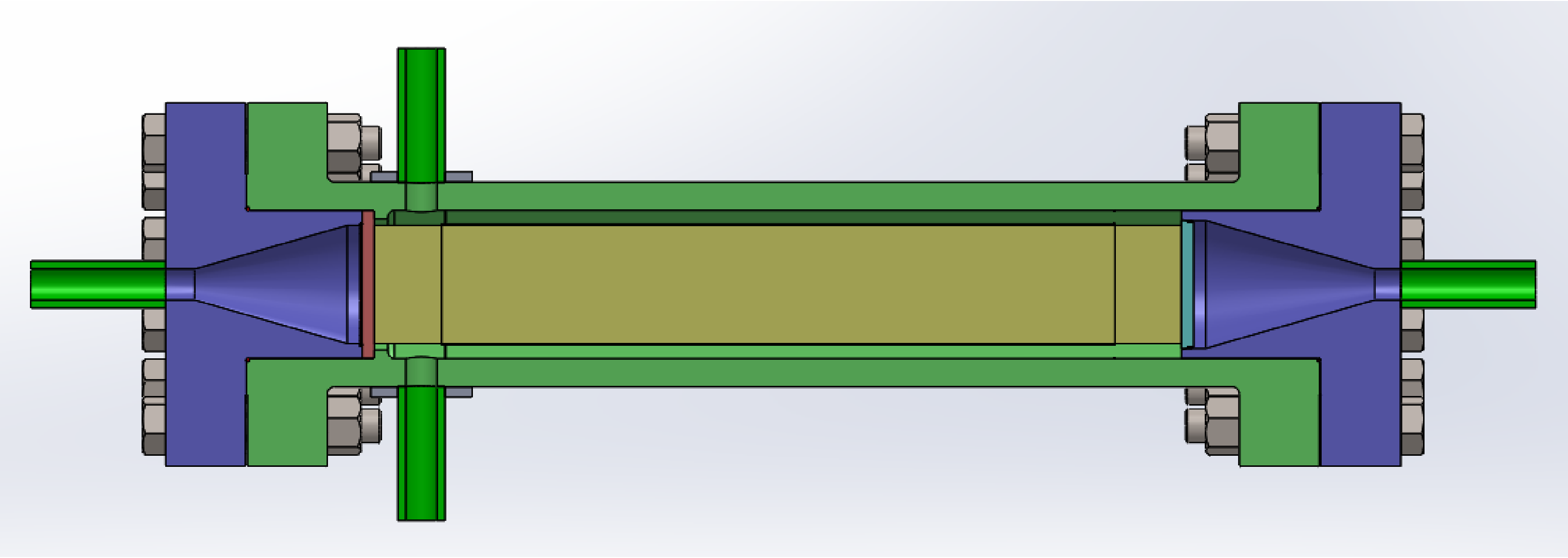
1st Generation Recuperator Design



sCO_2 counter-current - microchannel heat exchanger

- Over 5 MW Capacity
- Operating Conditions: 567°C and 255 bar
- Design Conditions: 575°C @ 280 bar
- Floating Head Design
- Serviceability and Maintenance
- Replaceable Tube Bundle
- Easier to manufacture and assemble

Designed per ASME Sec VIII, Div 1

Sunshot Recuperator Tube Bundle

Micro-tubes
High Pressure **sCO_2**

Cross-sectional
diagram redacted - g

Annular Space
Low Pressure **sCO_2**

> [tube count redacted]

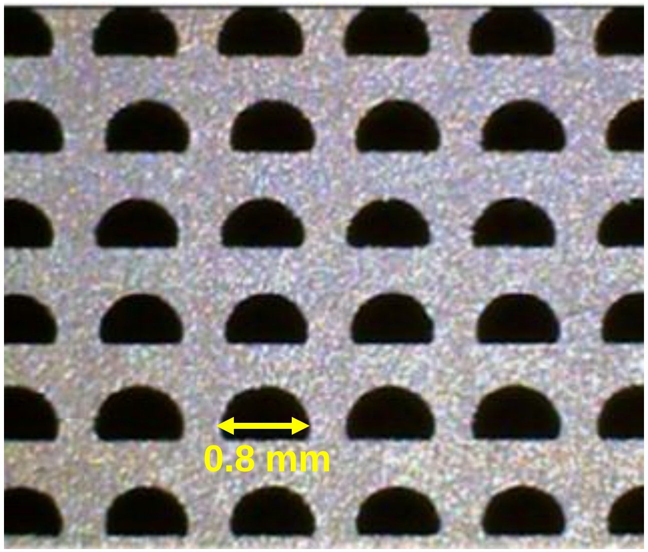
Tube Bundle
4,500 m^2/m^3

Cross-sectional
diagram redacted - g

Recuperator Tube Bundle Cross Section

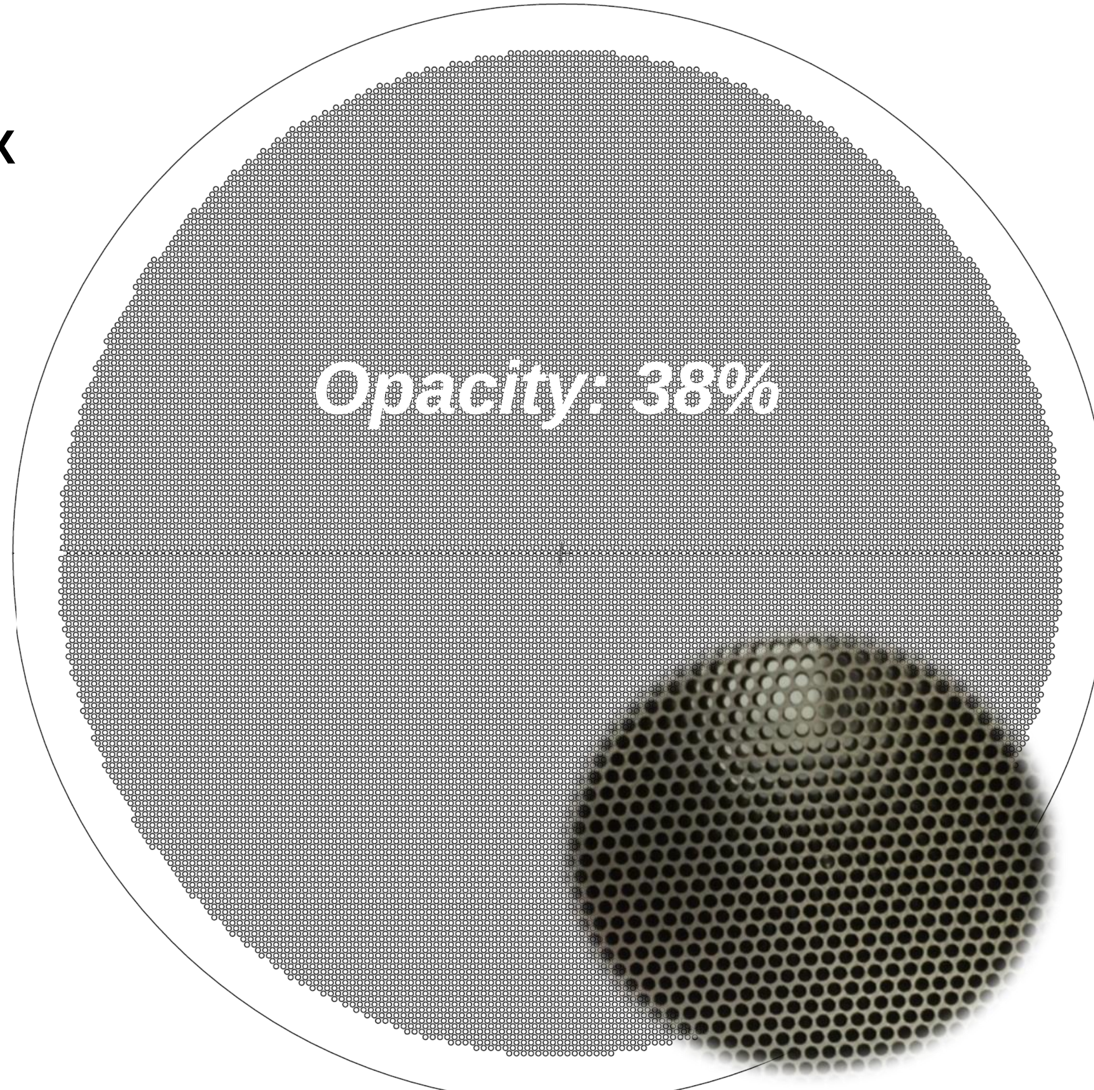
9” diameter, over [count redacted – g] micro-tubes

Microchannel Printed Circuit HX



Entropy ***2015, 17, 3438-3457; doi:10.3390/e17053438***

Opacity: 74%



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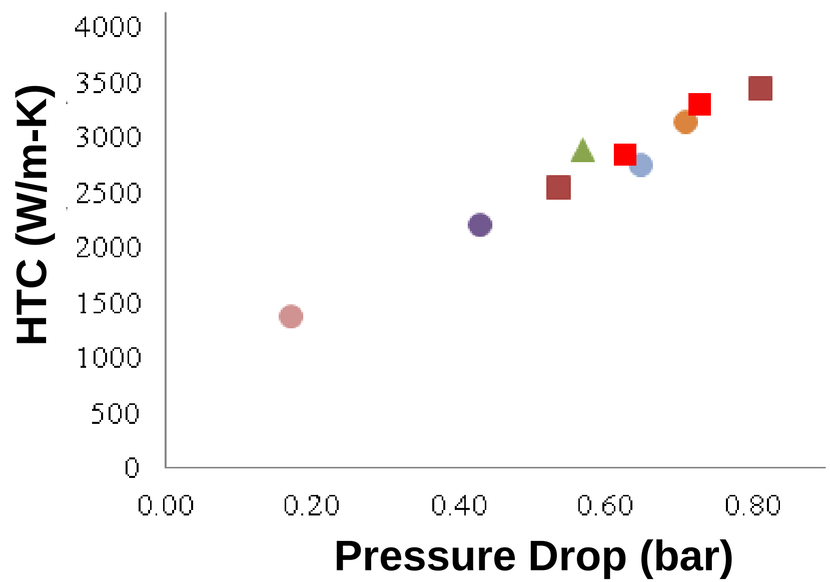
Improving HTC

[Detail drawings redacted – g]

~23% increase HTC &
~7% increase Pressure Drop



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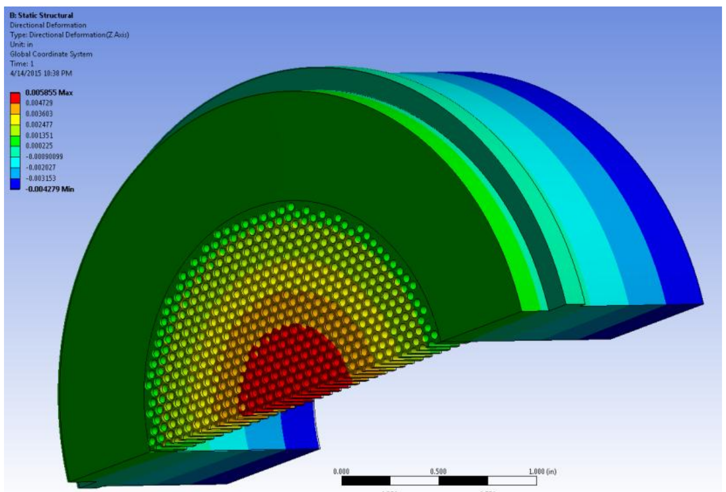
Software Tools to Enhance Design

- CFD models for enhanced design strategies for the inlet and outlet manifolds
- Heat transfer models
- FEA analysis of the floating end tube-sheet

Tube-sheet FEA



CFD Flow simulation

Redacted - g

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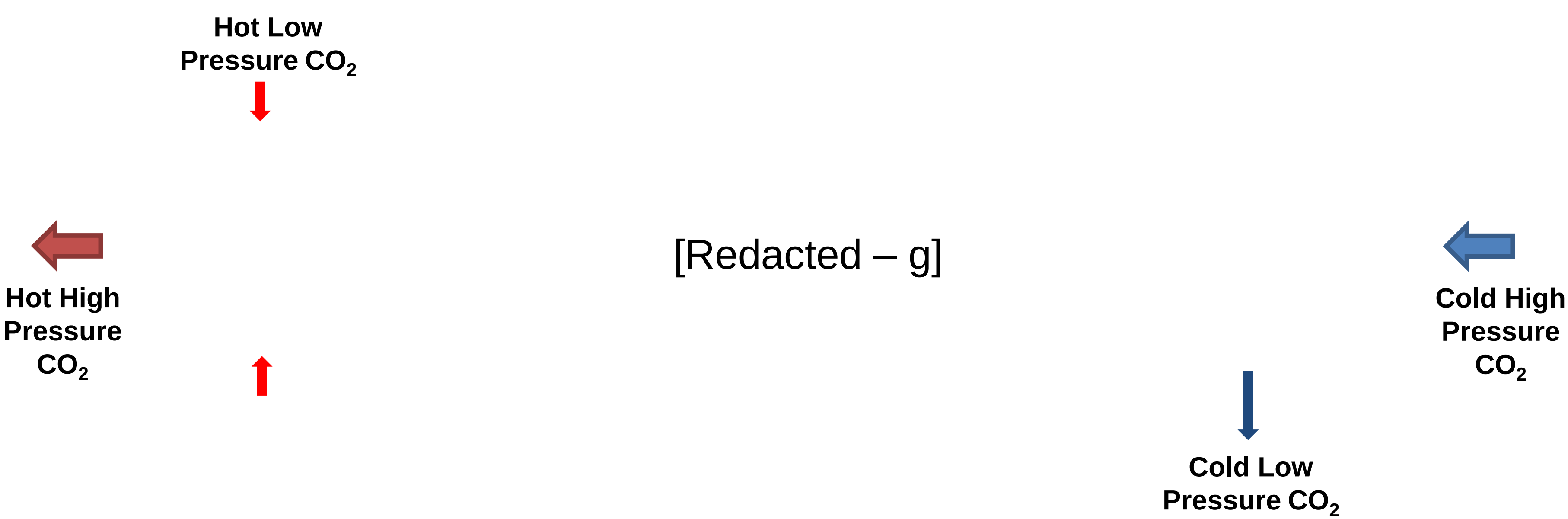
2nd Generation – [redacted] Flange Design

[redacted -g] Tube Sheet:

- ASME section VIII, Div 1, UHX-14 [redacted – g] tube-sheet calculations by Thar verified SwRI's simulation.
- Tube-sheet can handle unbalanced forces
- Hot side tube-sheet welded to vessel end caps



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2nd Generation – [redacted –g] Flange Design Benefits

- New, [redacted – g] Flange Design
- Improve Performance/Cost Ratio
- Optimized materials' use for hot and cold sides
- Improved reliability with fewer metal seals & bolts
- Easier to assemble

Inconel 625

[Redacted – g]

316 Stainless

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5.5 MW Recuperator, Generation #1
Cost Estimates

Itemized table
redacted – b, f, g i]

Major costs

- **Machining**
- **Materials**
- **Labor**

Project Overview

- Engineering Assessment of Advanced Recuperator Concepts
  - Critical enabling technologies or components
  - Manufacturability of the proposed concepts
  - Potential n^{th} of a kind production cost
  - Anticipated recuperator performance with respect to current state of the art

- Prototype Fabrication, Testing and Evaluation

- Down Select and Fabrication of 47 MWt Recuperator

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Criteria for Modular, Low-Cost, High-Temperature Recuperators

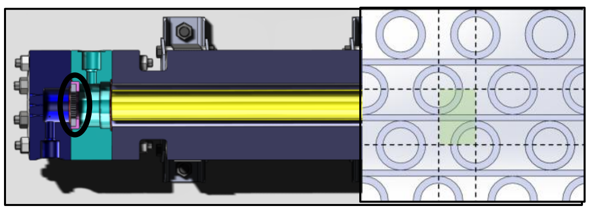
- **Performance**
  - Temperatures ≥ 575°C
  - Differential pressures ~200 bar
  - Lifetime (corrosion, creep, etc.)
  - Ease of maintenance
- **Scalability**
  - 10 - 1,000 MWe Facilities
  - Transport
- **Cost < $100/kWt**
  - Materials Selection
  - Manufacturability

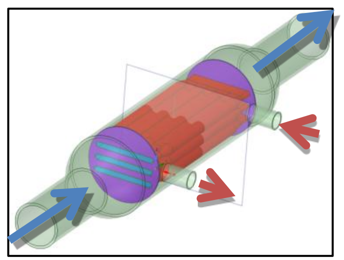
SOPO Tasks

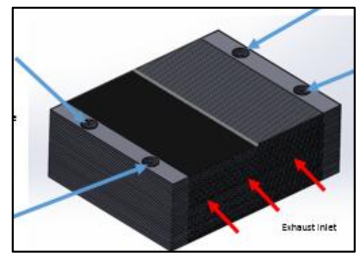
A scaled prototype will verify the design process and technology before designing for 47 MWt

Task 1.0 Project Management and Planning

Task 2.0 Engineering Assessment of Advanced Recuperator Concepts







Other Concepts from brainstorm

Task 3.0 Preliminary design (detail design of 100 kWt prototype)

Task 4.0 100 kWt prototype fabrication and testing

Go/No-Go Milestone for Budget Period 2

Task 5.0 Detail design of 47 MWt recuperator

Task 6.0 Fabrication of 47 MWt recuperator

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Recuperator concepts will be generated and ranked based on performance and TRL

2.1 Concept review and new concept development

- Review literature and hold a brainstorm session for additional concepts
- Evaluate concepts by: effectiveness, manufacturability, and production cost

2.2 Concept technical gap assessment

- Assign TRL based on engineering analysis, literature, and industry knowledge

2.3 Recuperator development plan

- Outline development plan for each concept to achieve the operating requirements of the high temperature recuperator while minimizing cost

2.4 Component concept performance evaluation

- *Techno-Economic Analysis and rank concepts on performance, TRL, cost, and manufacturing challenges (Project specific deliverable)*
- Select critical technologies and one or more concepts for preliminary design

2.5 Critical components selection

- Design review and risk mitigation plan for critical technologies in the concept
- Conduct lab-scale efforts as needed to reduce risk for preliminary design stage

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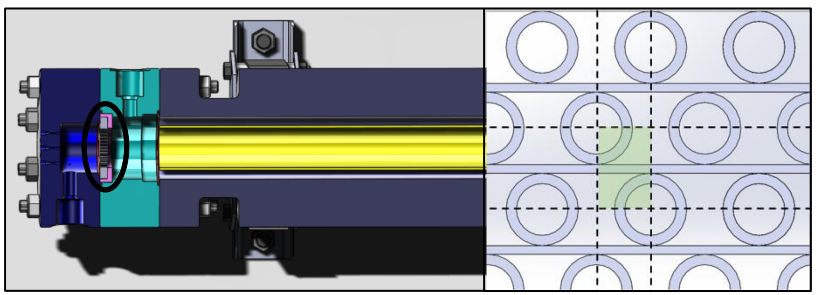
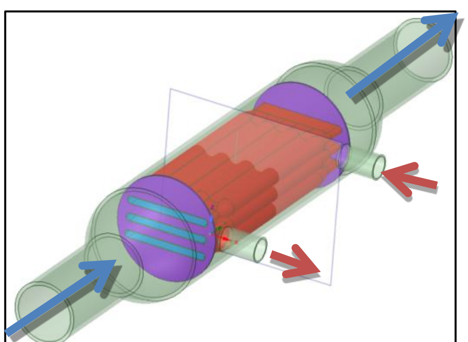
At least three concepts are compared for performance, cost, risk, &TRL

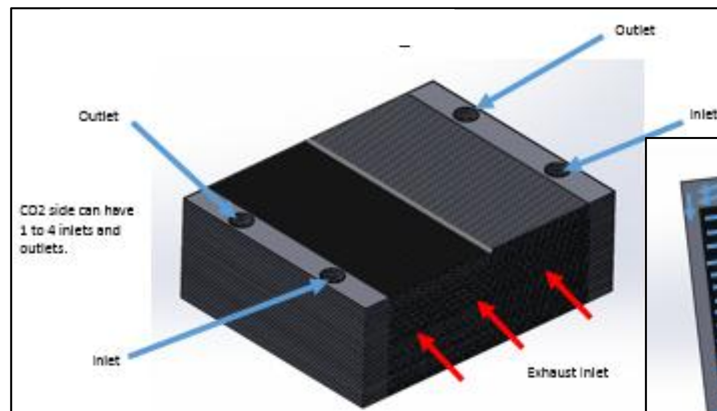
Each concept evaluated to identify:

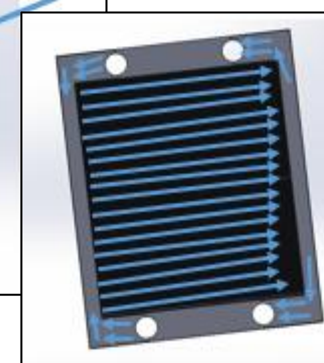
- Critical enabling technology/components (assign TRL)
- Manufacturability (assign TRL)
- Expected performance compared to current state-of-the-art
- Assign overall TRL

Performance of each concept estimated with low fidelity modeling (i.e. one-dimensional)









Other Concepts from brainstorm

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Potential Design Concepts

- Corrosion-- Look at Coatings (e.g. Ag/Au - 90 Angstroms)
- Material: Sandvik, half the cost – comparable to Inconel 625
- HTC enhancements with little effect on Delta P (e.g. air foil concept)
- Integrate End Cap with Tube-sheet
- Reduce Short Circuiting Issues with Flange Design

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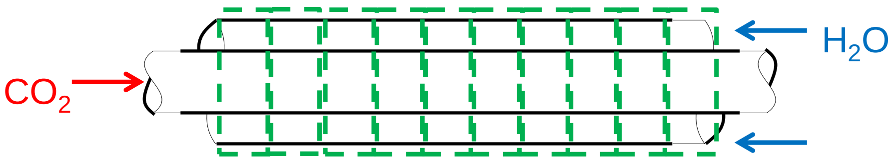
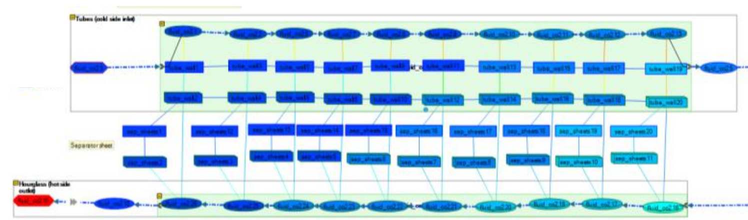
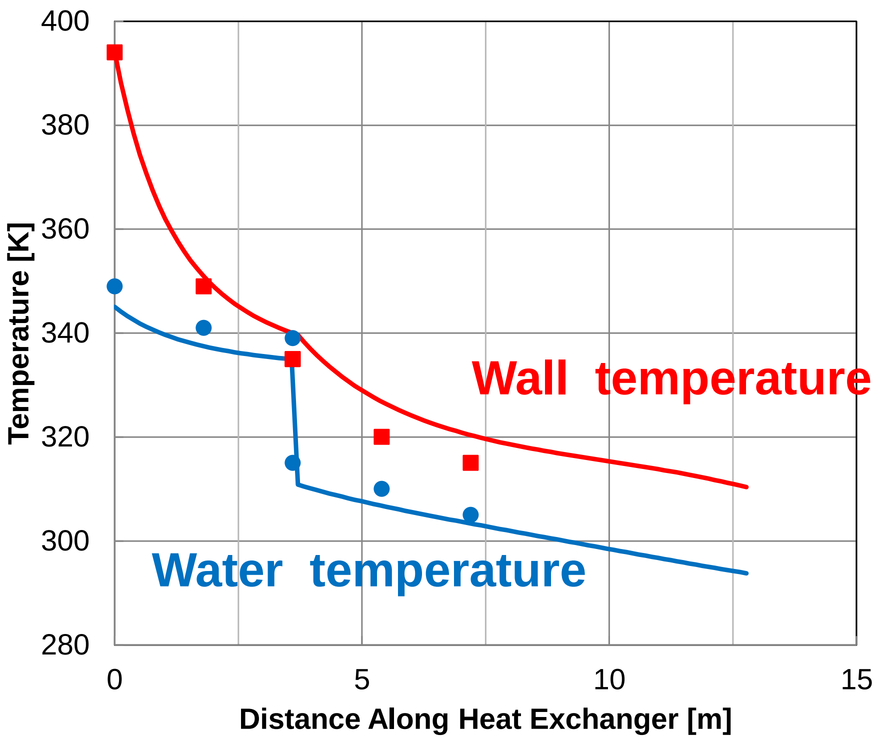
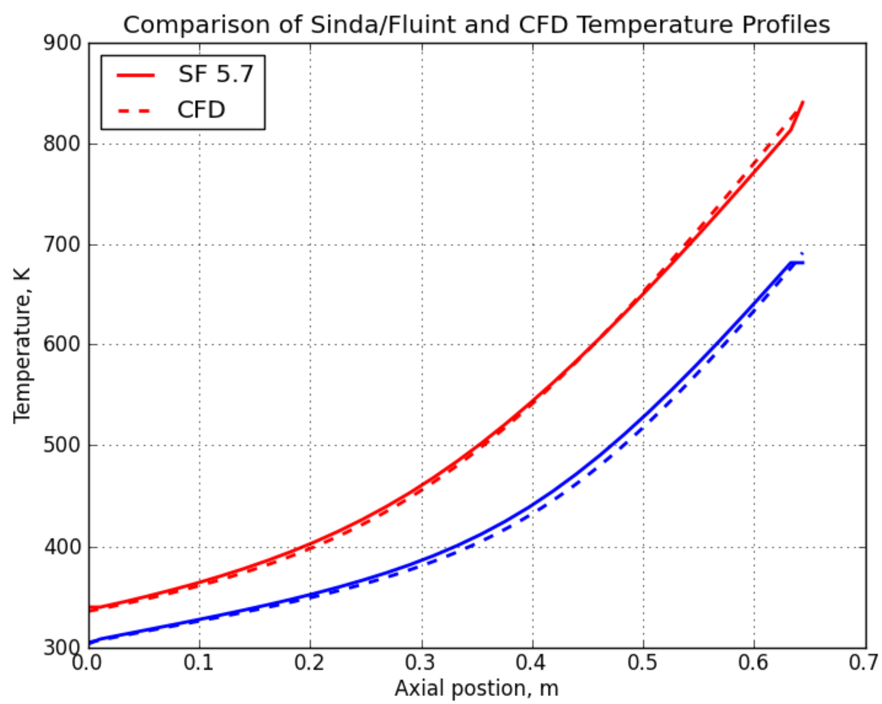
Concept performance is estimated with proven, low fidelity models









Counter-flow tube-in-tube heat exchanger - Data from Pitla 2001

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For each concept selected

3.1 Initial recuperator layout and sizing
- One-dimensional fluid-thermal network or FEA to estimate performance
- System level analysis to investigate modular configurations and scalability

3.2 Feature analysis
- Detailed models of specific features using computational tools (CFD, CHT, FEA)
- Demonstrate the design meets STEP facility targets for effectiveness and ΔP

3.3 Initial material selection
- Material selection in accordance with ASME code for STEP facility conditions
- Stress analysis of critical features and pressure containment

3.4 Structural/Mechanical design
- Stress analysis considering the recuperator layout, flow path, and joints

3.5 Design for manufacturing and operability
- Consider sealing and manufacturing methods for the materials selected in 3.3
- Operability considerations: corrosion, maintenance, inspection, assembly

3.6 System level design and optimization
- Evaluate modularity and scalability on recuperator design, considering maintenance and performance over a range of thermal duty

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Computational models are used to assess local variations in fluid-thermal performance

3.2 Feature analysis

- Detailed models of specific features using computational tools (CFD, CHT)
- Demonstrate the design meets STEP facility targets for effectiveness and ΔP

CFD diagrams redacted - g

Source: DE-FE0024012 : "High Temperature Heat Exchanger Design and Fabrication for Systems with Large Pressure Differentials"

3.3 Initial material selection

Allowable Stress vs. Temperature

Allowable Stress -2/3 Yield* (MPa)

Temperature (°C)

Allowable Stress*

(a) The allowable stress at design temperature for most materials is the lessor of 1/3.5 the minimum effective tensile strength or 2/3 the minimum yield stress of the material for temperatures below the creep and rupture values.

(b) At temperatures in the range where creep and stress rupture strength govern the selection of stresses, the maximum allowable stress value for all materials is established by the Committee not to exceed the lowest of the following: (1) 100% of the average stress to produce a creep rate of 0.01%/1,000 h (2) 100Favg% of the average stress to cause rupture at the end of 100,000 h (3) 80% of the minimum stress to cause rupture at the end of 100 ,000 h

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3.3 Initial material selection

Rupture Stress vs. Temperature

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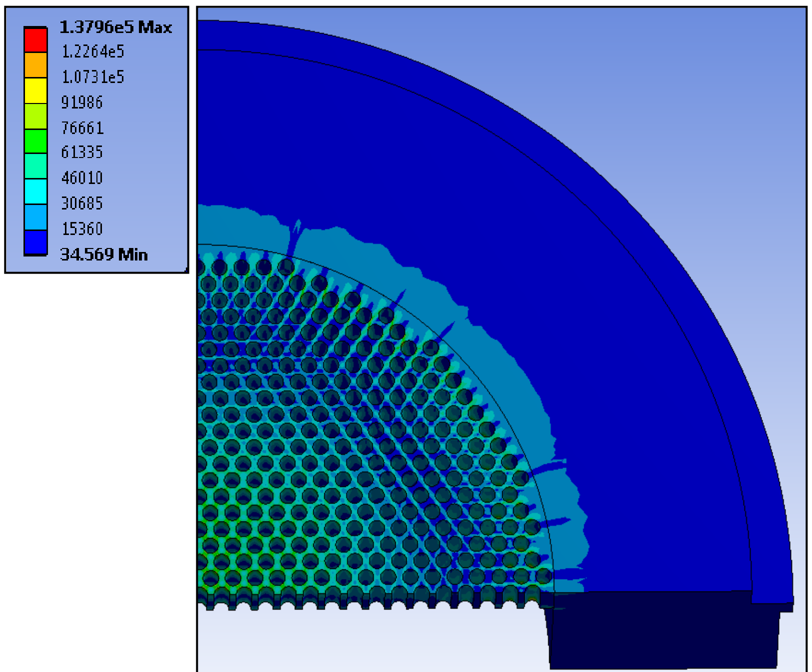
Finite element analysis is used to estimate mechanical stresses and deflections

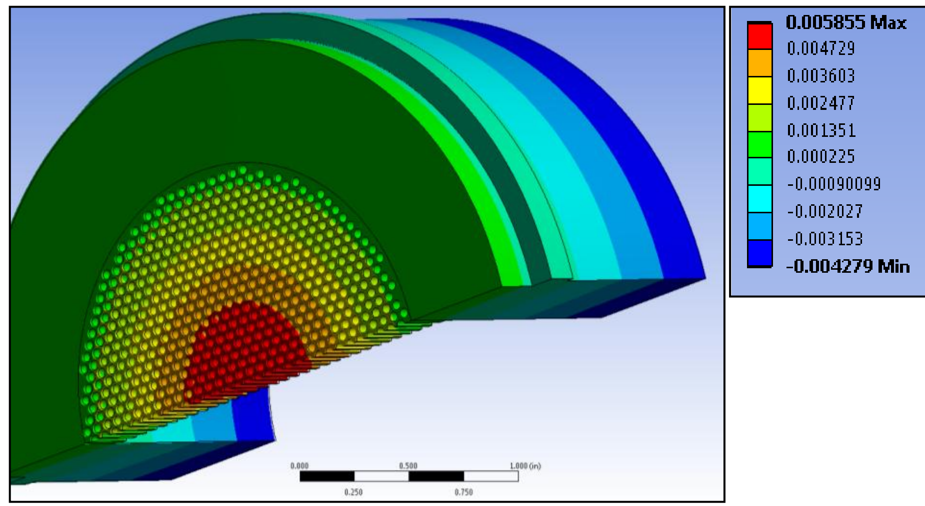
3.4 Structural/Mechanical design

- Stress analysis considering the recuperator layout, flow path, and joints

Stress [psi]



Displacement [in]



Source: DE-FE0024012 : "High Temperature Heat Exchanger Design and Fabrication for Systems with Large Pressure Differentials"

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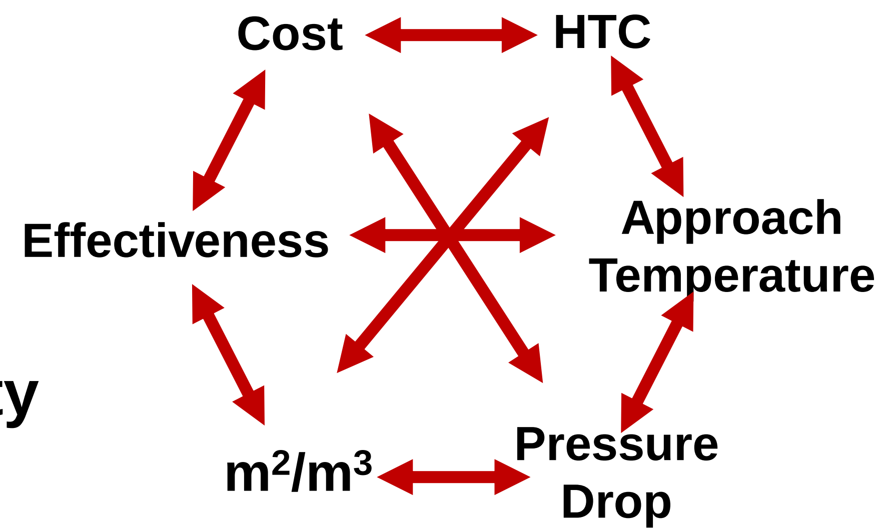
3.5 Design for manufacturing and operability
- Consider sealing and manufacturing methods for the materials selected in 3.3
- Operability considerations: corrosion, maintenance, inspection, assembly

3.6 System level design and optimization
- Evaluate modularity and scalability on recuperator design, considering maintenance and performance over a range of thermal duty

- **Performance/Cost Ratio**
- **Optimize Size**
- **Design for Manufacturability**



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Scaled testing is conducted to verify low TRL technology and the recuperator design methods

4.1 Technology selection and test planning

- Bench scale testing of critical, low TRL technologies identified during Task 2.0

4.2 Prototype selection

- Select recuperator concepts from Task 3.0 for testing to verify design methods

4.3 Prototype fabrication

- Fabricate recuperator concepts selected in Task 4.2

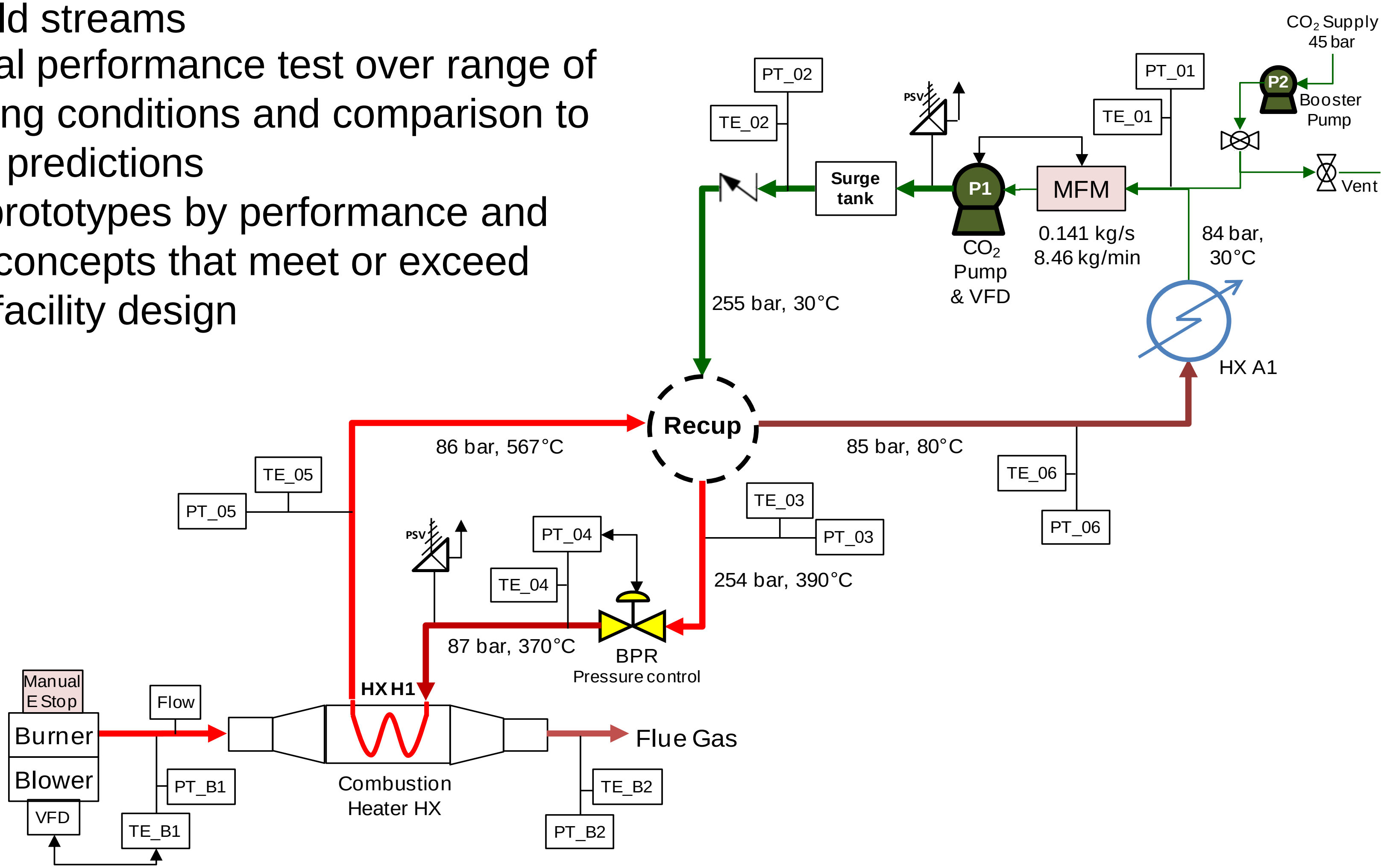
4.4 Prototype pressure and performance testing

- Static pressure testing at STEP facility conditions for mechanical integrity and leakage between hot and cold streams
- Thermal performance test over range of operating conditions and comparison to design predictions
- Rank prototypes by performance and select concepts that meet or exceed STEP facility design

4.4 Prototype pressure and performance testing

- Static pressure testing at STEP facility conditions for mechanical integrity and leakage between hot and cold streams
- Thermal performance test over range of operating conditions and comparison to design predictions
- Rank prototypes by performance and select concepts that meet or exceed STEP facility design

Thar Energy Test Stand Flow Diagram



TASK 5.0

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If decided, the selected concept will be designed for the STEP facility and readied for fabrication

Go/No-Go Milestone for Budget Period 2

5.1 Data exchange and requirements verification
- Technical interchange to ensure the design is compatible with the STEP facility

5.2 System level integration and optimization
- Integrate components (manifolds, thermal core, pressure vessel, etc.) into a single system and optimize for scalability

5.3 Detail component optimization
- Update computational studies as needed for final design and integration
- Demonstrate recuperator performance meets STEP requirements

5.4 Structural/Mechanical design
- Demonstrate the recuperator meets structural requirements

5.5 Design for manufacturing and operability

5.6 Fabrication drawings *(Project specific deliverable)*

5.7 Test planning and system instrumentation
- Detailed test plan and instrumentation list

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Example: Modular Recuperator
(no HTC enhancements)

Cycle specification:	°C	Bar	Del-P psi	Recuperator flow rates, sCO2: 10 MWe / 46.6 MWt kg/s	10 MWe / 46.6 MWt # Units	600 MWe/2796 MWt kg/s	600 MWe/2796 MWt # Units
Hot side inlet	581	89.6	18.9	104.5	1	1254.0	5
Hot side outlet	204	88.3					
Cold side inlet	194	239.9	18.9				
Cold side outlet	533	238.6					

Sizing -a,b:	Units	STEP model	Full-scale model
Microchannel tubular design:			
Overall length	inches	102	217
Tube bundle OD	inches	38.00	118.11

a- Meets 19.5 max pressure drop specification

b- Meets allowable stress

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The 47MWt recuperator is constructed and tested for pressure prior to delivery

6.1 Fabrication and assembly

6.2 Hydrostatic testing

- Demonstrate structural integrity using pressurized water, per ASME code

6.3 Cold flow test

- Leak test between streams using CO_2 at design pressure and low temperature

6.4 Delivery *(Project specific deliverable)*

- Demonstrate the recuperator meets structural requirements

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Program Management

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Project Management Plan Updated

- **Biweekly Tel Con with Team Partners**
- **Additional meetings will be scheduled as needed**

- **Quarterly:**
  - **Milestones Review**
  - **Risks and Mitigation Strategies Review**
  - **Progress Reports**

- **Semi-Annual:**
  - **Briefings to the DOE project officer based on quarterly report**

Overview Timeline

	10/1/15-3/31/17						4/1/17-3/31/19							
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Phase 1														
Phase 2														

Phase I Schedule

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● Milestone
● Go/No-go Milestone

		Budget Period 1 10/1/15-3/31/17					
Tasks & Milestones		Q1	Q2	Q3	Q4	Q5	Q6
Task 1.0 - Project management and planning							
1.1	Coordination of participants (BP1 & BP2)	■					
1.2	Revise Project Management Plan	■					
1.3	Risk Management Plan	■					
Milestones							
1	Submit Project & Risk Management Plans	●					
2	Kickoff meeting	●					
Task 2.0 - Engineering Assessment of Advanced Recuperator Concepts							
2.1	Concept Review and New Concept Development	■	■				
2.2	Concept Technical Gap Assessment	■	■	■			
2.3	Recuperator Development Plan		■	■			
2.4	Component Concept Performance Evaluation		■	■			
2.5	Critical Components Selection		■	■			
Milestones							
3	Complete Techno Economic Analysis for selected recuperator conce			●			
Task 3.0 - Preliminary design							
3.1	Initial Recuperator Layout and Sizing			■	■		
3.2	Feature Analysis			■	■		
3.3	Initial Material Selection			■	■		
3.4	Structural/Mechanical Design			■	■		
3.5	Design for Manufacturing and Operability			■	■		
3.6	System level Design and Optimization			■	■		
Milestones							
4	Complete system level optimization study				●		
5	Complete preliminary designs for prototypes selected for fabrication				●		
Task 4.0 - Prototyping							
4.1	Technology Selection and Test Planning			■	■		
4.2	Prototype selection			■	■		
4.3	Prototype fabrication				■	■	
4.4	Prototype pressure and performance testing					■	■
Milestones							
6	Complete prototype selection				●		
7	Complete prototype fabrication					●	
8	Complete prototype testing						●
9	The availability/accessibility to an appropriate high temperature test facility capable of						●

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Phase 2 Schedule

		Budget Period 2							
	● Milestone ● Go/No-go Milestone	4/1/17-3/31/19							
Tasks & Milestones		Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Task 5.0 - Detail Design									
5.1	Data exchange and requirements verification	■							
5.2	System level integration and optimization	■							
5.3	Detail Component Optimization	■	■						
5.4	Structural/Mechanical Design	■	■						
5.5	Design for Manufacturing and Operability		■						
5.6	Fabrication Drawings		■						
5.7	Test Planning and System Instrumentation		■						
Milestones									
10	Detail Component Optimization		●						
11	Structural/Mechanical Design		●						
12	Design for Manufacturing and Operability		●						
13	Fabrication drawings complete		●						
14	Test Planning and System Instrumentation		●						
Task 6.0 - Recuperator Fabrication									
6.1	Fabrication and Assembly			■	■	■			
6.2	Hydrostatic testing						■		
6.3	Cold flow test							■	
6.4	Delivery								■
Milestones									
15	Fabrication and Assembly					●			
16	Hydrostatic testing						●		
17	Cold flow test							●	
18	Delivery								●

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Budget Breakdown

Participant	Type	Project Budget	Cost Share	POC
Thar Energy LLC	For Profit	$ 990,169	$ 666,292	Lalit Chordia
Southwest Research Institute	Not for Profit	$ 1,575,000	$ -	Grant Musgrove
Oak Ridge National Laboratory	Not for Profit	$ 50,000	$ -	Bruce Pint
Georgia Institute of Technology	Not for Profit	$ 50,000	$ -	Devesh Ranjan
	Project Total - Phase I	**$ 2,665,169**	**$ 666,292**	

Participant	Type	Project Budget	Cost Share	POC
Thar Energy LLC	For Profit	$ 6,029,657	$ 1,682,415	Lalit Chordia
Southwest Research Institute	Not for Profit	$ 700,000	$ -	Grant Musgrove
	Project Total - Phase II	**$ 6,729,657**	**$ 1,682,415**	
	Total Project	**$ 9,394,826**	**$ 2,348,707**	