Performance and Cost Targets for sCO_2 Heat Exchangers

Panel Introduction

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NETL-EPRI Workshop on Heat Exchangers for Supercritical CO_2 Power Cycles
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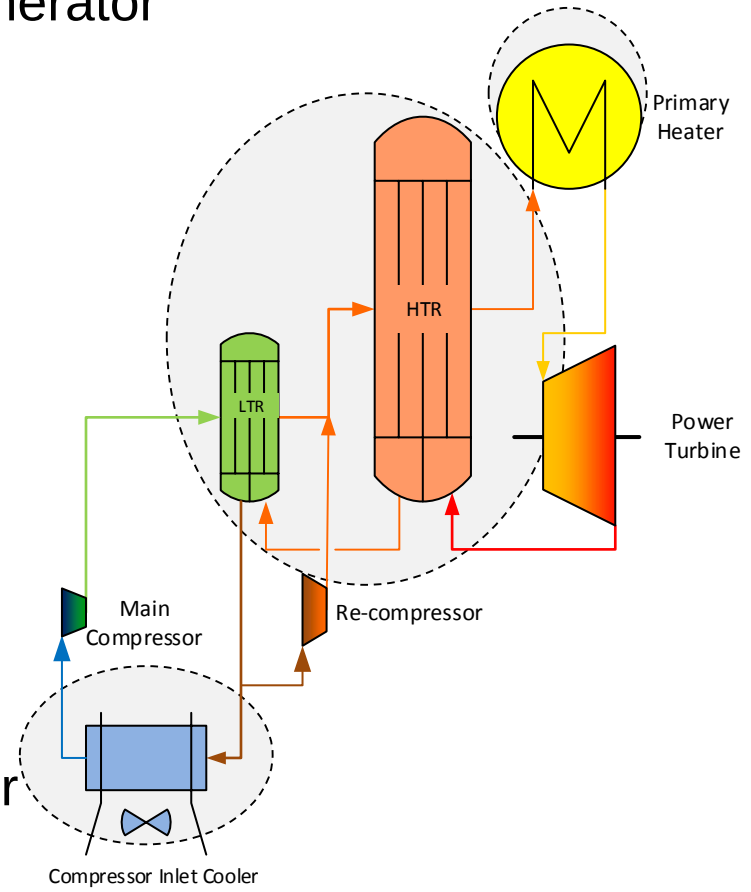
sCO_2 Brayton Cycle Heat Exchanger Classes

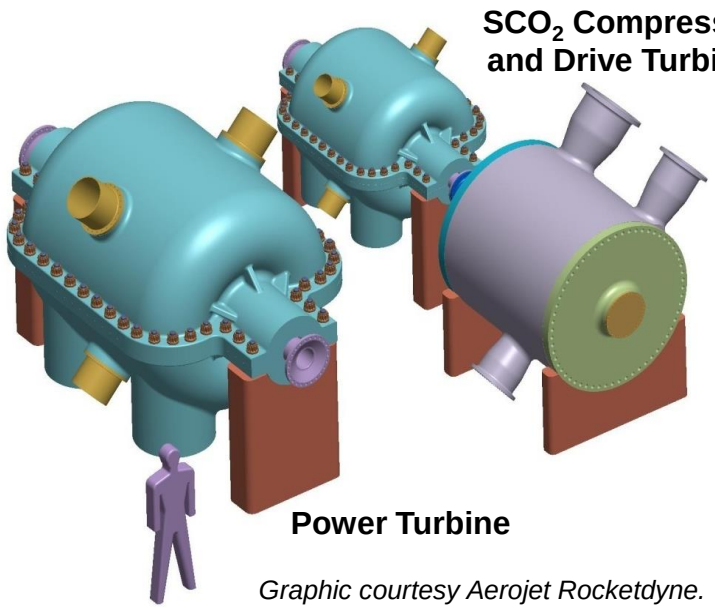
- Primary Heater
  - Cognate to Rankine cycle steam generator
- Low-Temperature and High Temperature Recuperators
  - Cognate to Rankine cycle feedwater heaters
- Compressor Inlet Cooler
  - Cognate to Rankine cycle condenser



Similar components for cascading and direct-fired Brayton power cycle configurations

Generally Good News about Turbomachinery

- sCO_2 power turbine is approximately 1/5 the overall size (length) of a comparable output steam turbine.
- sCO_2 compressor(s) are approximately 3 times the size of feedwater pumps



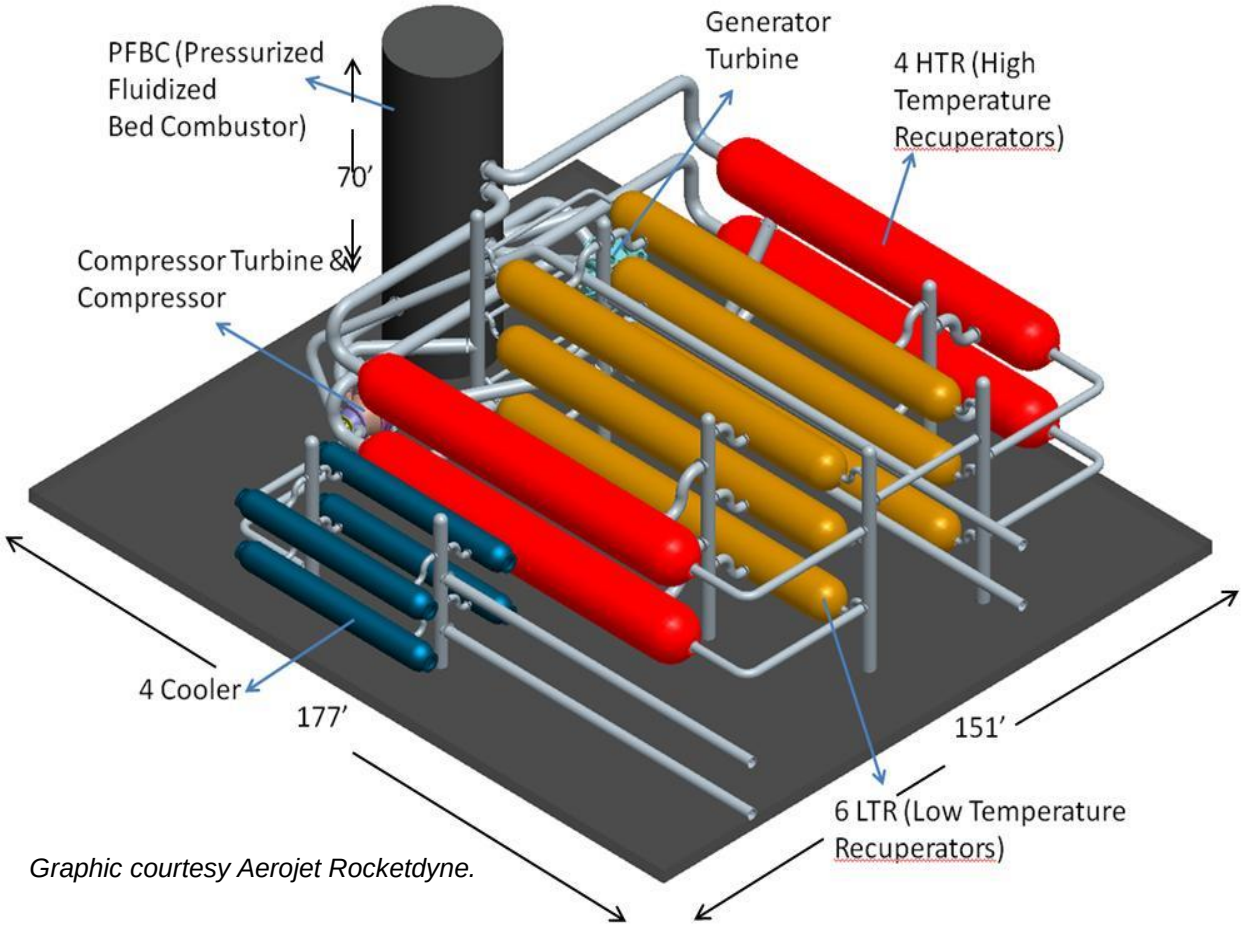
Graphic courtesy Aerojet Rocketdyne.

- 645 MWe Power Turbine
- 253 MW Compressor Turbine

  (comparable feedwater pump turbine drive is ~45 MW)

Not So Much Good News for Heat Exchangers

Recuperators Dominate the Footprint



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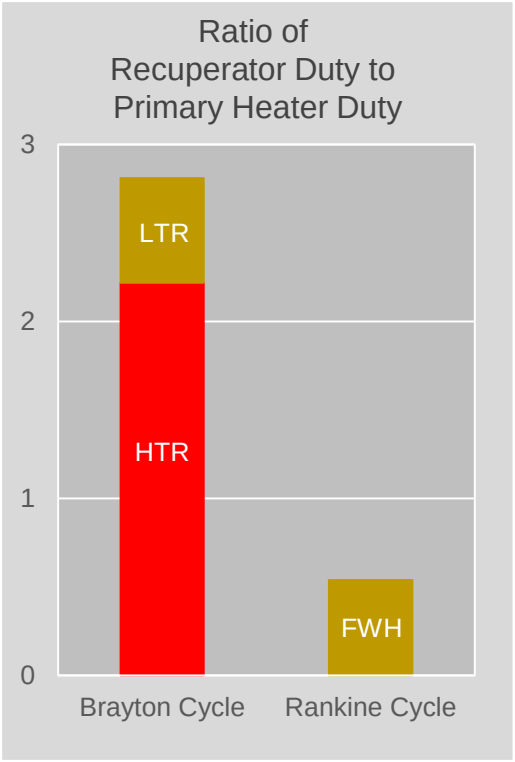


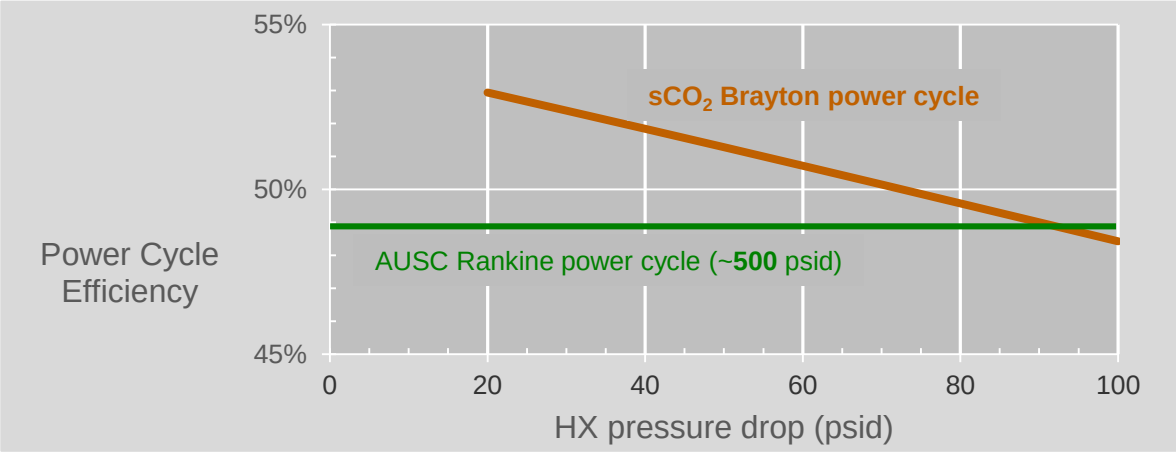
Compressor Inlet Cooler

- Similar in design to compressor inter-coolers
  - Coolant is the on shell side compared with tube-side coolant in Rankine cycles
- Direct-fired cycles include condensation/water removal. Acidic condensate due to H_2CO_3, H_2SO_4, HNO_3, HCL.

Primary Heat Exchangers

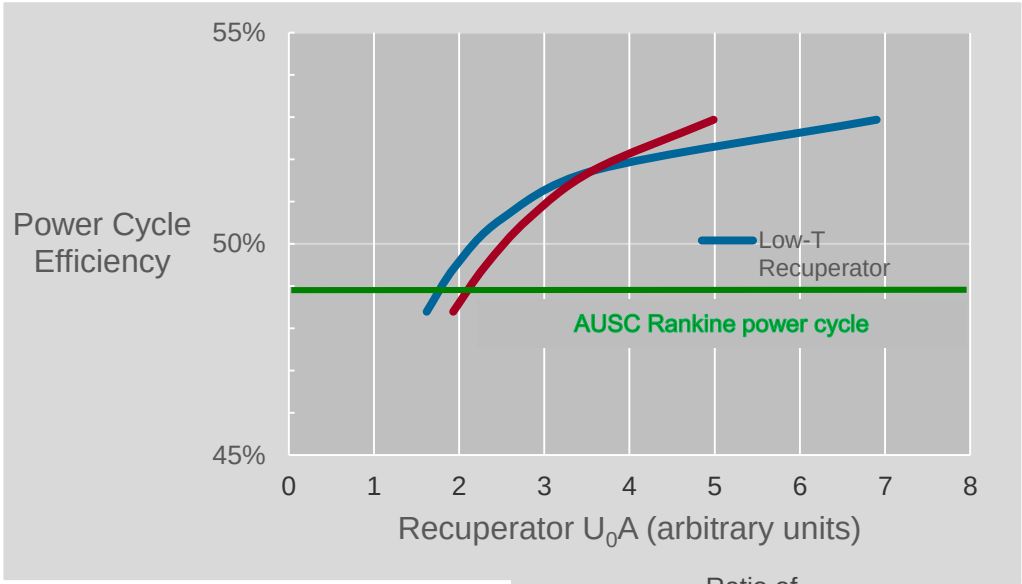
- sCO_2 primary heater heat duty is comparable to Rankine cycle primary heater (steam generator) duty for the same power output.
- Tube-side sCO_2 flow is 5-10 times Rankine cycle feedwater flow with correspondingly lower enthalpy rise.
- Primary heater sCO_2 pressure drop is more costly (~5x in compression/pumping power) than water-side pressure drop in steam generators.

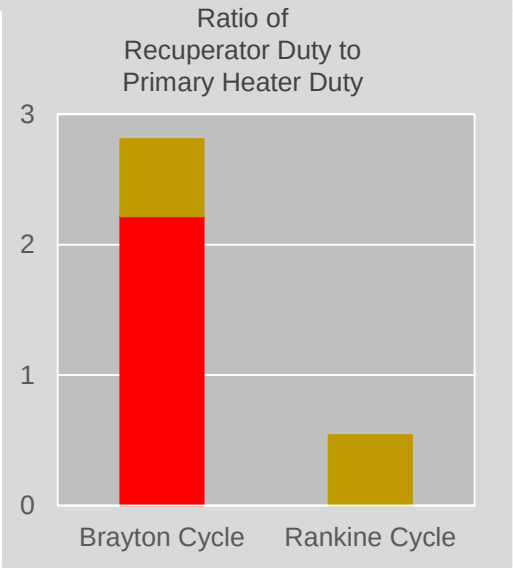
The challenge is to achieve uniform flow/heat absorption for much higher flows and lower allowed pressure drops than steam generators.



Recuperators

- High heat duty makes for large area heat exchangers.
  - Area = $, £, ¥, €
- High cycle efficiency requires high U_0A.
  - Some (limited) opportunities to increase heat transfer coefficient (U_0)
  - Compact heat exchangers reduce weight/U_0A (reducing cost) but are generally associated with higher manufacturing costs.
- High temperature recuperator may require exotic materials ($, £, ¥, €) tending to favor compact heat exchangers (less metal).
- Scaling existing HX designs will be challenging. Parallel recuperators just transfer the challenge to the piping designer.





sCO_2 Brayton Cycle HX Design and Maintenance

- New (to the power industry) compact heat exchangers:
  - What are failure mechanisms?
  - What is mean time to failure/repair?
  - How are they repaired?
- How can use of exotic metals ($, £, ¥, €) be minimized at acceptable reliability and overall cost?
- What are economic trade-offs between HX performance (effectiveness) and resulting cycle performance (efficiency) and capital cost (HX U_0A)?

In Summary

- HX costs are likely to dominate sCO_2 Brayton cycle power heater/power block costs.
- Recuperators will be the primary HX cost adder compared to steam-Rankine power plants.
  - High temperature recuperators are likely to be the greatest design challenge.
  - Least cost approach to recuperation is yet to be demonstrated.
- Primary heater designs confront hydraulic/heat transfer challenges not present in steam generators
- Compressor inlet cooler design will be informed by compressor intercooler design.
  - Compressor inlet coolers for direct-fired sCO_2 Brayton power cycles will confront acid corrosion challenges.

The Panelists

Tim Held	Echogen
David Freed	NET Power
Jeff Moore	Southwest Research Institute
Mike McDowell	Gas Technology Institute

- Brief explanatory questions accepted after each presentation
- General questions concerning HX requirements accepted following all presentations

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