Benefits of the Proposed sCO₂ Power Cycles (Brayton Cycles):
- Efficiency (reduced fuel costs & lower emissions)
- Potential Transformational Technology (up to 4% efficiency improvement over Rankin cycle at >700°C)
- Some configurations provide sequestration-ready pure CO₂ stream

Critical Components of sCO₂ Cycles Requiring Materials Development: Recuperators / Heat-Exchangers
- 4-10X heat-duty of Rankin Cycle feedwater heaters
- Unique compact designs
- Expensive alloys required for high temperatures
- Small channels
- Large surface area
- Brazing/diffusion bonding
- Blockage
- Corrosion/oxidation = Unknown

Objective & Impact
- Predict the oxidation/corrosion performance of structural alloys in high-temperature high-pressure supercritical CO₂ (sCO₂)
- Combine laboratory testing & computational modeling including unique attributes of sCO₂ heat exchangers to accomplish this goal
- Improved confidence in materials selection for high-temperature sCO₂ heat-exchangers
- Stream-lined testing and/or improved criteria for materials selection based on oxidation/corrosion
- Possibility to home-in on cost-effective materials and temperature limits

Collaborative Team Approach:
- Review status of technology and likely materials and environments. (EPRI)
- Laboratory testing: 600-750°C, 200bar sCO₂. (DNV-GL)
- Development of oxide growth kinetics, propensity for exfoliation, and comparisons with steam. (EPRI, WrightHT)
- Development of a growth and exfoliation model based on existing model architecture for steam. (ORNL)

Project Status:
- Literature review, final materials selection, and sample machining in progress and on schedule.
  - Gr. 91, 304, and Alloy 740/740H chosen for first tests and comparison with literature
  - Vendor discussion and review of literature to determine key ~7 alloys
- Summary of Proposed Conditions for Recuperators/Heat Exchangers in Various sCO₂ Cycles
- Assembly of high-pressure sCO₂ testing facility complete, and the initial 300-hour shake-down testing has started
- Selection of test conditions for long-term tests ongoing.
  - Key issue is impurities (CO₂ purity, H₂O, hydrocarbons, others) likely in ‘open and semi-open’ fossil systems
  - Review of conditions for many different configurations is complete
- Review of literature indicates some useful kinetic data are available for corrosion in sCO₂ and comparison with steam.
  - Major deficiency, little useful data on oxide thickness and morphology.

Cycle Type | Thermal Resource | Max Temp. (°C) | Pressure (MPa) | sCO₂ Purity | H₂O | Others
---|---|---|---|---|---|---
Closed | Wastehatch | 485 | 23.3 | High | Near zero | 
Nuclear | 545 | 20 | 
Solar | 700 | ~30 | 
N. Gas | 750 | 
Coal | 700 | 27.6 | 
Open | N. Gas / Coal | ~700 | 30 | 95% | 2% | O₂, Ar, NOₓ, SO₂ |