sCO₂ Symposium
Overview of SwRI sCO₂ Power Cycle R&D

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Ongoing sCO₂ Projects at SwRI

• Currently $100M+ in sCO₂ R&D projects
• 25 active projects
• Topics include:
  – Component design and testing
  – Oxyfuel combustion
  – Cycle optimization
  – Pilot plants
  – Gas physical properties
• Testing activities
  – 1 MW Sunshot loop operational
  – 10 MW STEP loop in design phase
  – Additional seals, compressor, and compander testing in the queue
One MW DOE sCO₂ Pilot Loop (SwRI, GE, Thar, + for DOE EERE)

• Demonstrate Utility-Scale sCO₂ Components
• Objective: MW-scale sCO₂ turbo-expander and heat exchanger are a critical step in increasing energy conversion efficiency to >50%, while reducing power block costs
• 1 MW simple recuperated sCO₂ closed loop
• >715 C heat source (fired NG heater)
• Part of $12M DOE SunShot program
• Designed for testing of key MW-sized critical plant components:
  – Equipment (turbine, recuperator)
  – Cycle dynamics and sequencing (startup, shutdown, upsets)
Ultra High Efficiency Integrally-Geared sCO₂ Compander (SwRI, Hanwa for DOE EERE)

• Design a sCO₂ integrally geared compander (IGC)
  – Combining compression and expansion stages into a single integrally geared housing connected to a low speed motor/generator.

• Benefits:
  – Reduced footprint
  – Potential cost reduction up to 35%
  – Utilizes a low speed commercially available driver/generator
  – Modular (Small Industrial [5MW] to Small Utility [50 MW])
  – High efficiency over a range of operating conditions
  – Improved cycle controllability
  – Reduced mechanical complexity ➞ improved reliability and reduced maintenance
GE-Apollo High-Efficiency sCO2 Centrifugal Compressor Development (GE, SwRI for DOE EERE)

PROJECT OBJECTIVES
• Develop high-efficiency sCO2 compression system
  – Main Compressor Efficiency of 80%
  – Preliminary Design completion June 2016
  – Go/no-go decision point after Phase 1 (June 2017)
• High efficiency centrifugal impeller
• Variable IGV/OGV

KEY RESULTS AND OUTCOMES
• Full scale testing of a 10 MWe SCO2 Compressors
• Extended flow range to accommodate swings in ambient temperature
• Advanced aerodynamic design provided by GE will be implemented into the detail compressor design provided by SwRI.

• SwRI SCO2 Test Facility will provide verify compressor mechanical and aerodynamic performance over a range of operating conditions
Advancing High Temperature Recuperator Technology (Thar, SwRI, ORNL, Georgia Tech for DOE NETL)

- Developing a 47MWth compact, high-temperature recuperator for the 10MWe STEP Facility
- Address critical design, materials, and fabrication challenges
  - Target 96% thermal effectiveness
- Significantly improve the recuperator cost, performance, and scalability
  - Scalable from 10 to 1,000 MWe cycle configurations
10 MW DOE STEP Pilot Plant Project
Demonstrate Utility-Scale sCO₂ Plant

- Pilot and demonstration plant located at SwRI
- Partnering with GE and GTI
- Six year project valued $113 million ($80M DOE, $33M Industry)
- Scheduled to be operational 2020
- Testing both 550C and >700C temperature operation
STEP 10 MW Test Facility to Support Long Term sCO₂ Technology Development

- Open access facility operated by an industry neutral entity
- sCO₂ subject matter experts available on site to support design, testing, and operation
- Long term access to facility for re-use after project completion for further R&D
- Space available for facility expansion and modification
- Utilities and grid interconnect with local utility
High Inlet Temperature Combustor for Direct Fired Supercritical Oxy-Combustion (SwRI, Thar for DOE NETL)

- Detailed design of supercritical oxy-fuel combustor from initial Phase I design
  - Design of water separation from combustion products
- Fabricated and assemble combustor test loop utilizing existing hardware at SwRI
- Test campaign to understand combustion processes and combustor performance
Flameless Pressurized Oxy-Combustion Pilot Plant Planning (SwRI, ITEA for DOE NETL)

- Pressurized atmosphere of water and CO₂ prevents traditional flame fronts
  - FPO combustion is more locally controllable with more uniform temperatures and improved efficiency
- Almost zero carbon content in incombustible products
  - Traditional: flying and falling ash particles must be filtered and collected from gas stream
  - FPO: slag with near-zero carbon content drains out the bottom of the combustor
- Development of a 50 MWth pilot power plant
  - Team from ITEA, EPRI, GE Global Research, and Jacobs
  - Site selection, preliminary drawings and cost estimates for pilot plant
  - Scale up from existing pilot technology
  - Design of a durable turbomachine in atmosphere of CO₂ and water
  - Design of an efficient once-through steam generator